Texas Clean Energy Project

Draft Environmental Impact Statement

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COVER SHEET

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Abstract

This draft environmental impact statement (EIS) provides information about the potential environmental impacts associated with the U.S. Department of Energy's (DOE) proposal to provide limited financial assistance (approximately $450 million), through a cooperative agreement, to Summit Texas Clean Energy, LLC (Summit) for the proposed Texas Clean Energy Project (TCEP). The TCEP would use coal-based integrated gasification combined-cycle technology to generate electric power and would capture carbon dioxide (CO_2) for use in enhanced oil recovery (EOR) and eventual sequestration. The plant would generate 400 megawatts (gross) of electricity, of which 213 megawatts would be provided to the power grid. It would also produce urea, argon, and sulfuric acid for sale in commercial markets. Because of its multiple production capabilities, the plant is referred to as a poly-generation (polygen) plant. DOE would provide approximately 26 percent of the project's total capital cost of at least $1.73 billion (2009 dollars).

The polygen plant would be built on a 600-acre (243-hectare) oil field site in Ector County, Texas, north of the oil community of Penwell. Summit would design and construct the plant to capture approximately 90 percent of its CO_2. During the demonstration phase of the plant's operations, the project would sequester approximately 3 million tons (2.7 million metric tonnes) of CO_2 per year by transporting it in pipelines to existing oil fields in the Permian Basin of West Texas for use in EOR operations by third-party buyers of the CO_2. Following the demonstration phase, the polygen plant would continue in commercial operation for 30 to 50 years.

DOE determined that the proposed TCEP constitutes a major federal action within the meaning of the National Environmental Policy Act of 1969, as amended. The *Federal Register* "Notice of Intent To Prepare an Environmental Impact Statement for Texas Clean Energy Project, Ector County,

Texas" was published on June 2, 2010 (75 *Federal Register* 30800). DOE held a public scoping meeting at Odessa College in Odessa, Texas on June 17, 2010.

This draft EIS provides an evaluation of the environmental consequences that may result from Summit's proposed project, including potential impacts on air quality and greenhouse gas emissions; climate; soils, geology, and mineral resources; ground water resources; surface water resources; biological resources; aesthetics; cultural resources; land use; socioeconomics; environmental justice; community services; utility systems; transportation; materials and waste management; human health, safety, and accidents; and noise and vibration. The draft EIS also provides an analysis of the No Action Alternative, under which DOE would not provide financial assistance to the TCEP, with the assumption that without federal financial assistance, the project would not be constructed.

Comment Period

DOE will consider all comments received or postmarked by close of business May 2, 2011 in preparing the final EIS and will consider late comments to the extent practical.

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ABBREVIATIONS

$\mu g/m^3$ - microgram per cubic meter
AADT - annual average daily traffic
ac - acre
ac-ft - acre-feet
A.D. - Anno Domini
AERMOD - EPA regulatory model
AR - access road option (e.g., AR1)
ARRA - American Recovery and Reinvestment Act
A.F. - associates' degree (forestry)
A.S. - associates' degree (science)
B.A. - bachelor of arts
B.C. - Before Christ
BLS - Bureau of Labor Statistics
B.S. - bachelor of science
Btu - British thermal unit
BLM - Bureau of Land Management
C.F.R. - Code of Federal Regulations
CCPI - Clean Coal Power Initiative
CO - carbon monoxide
CO_2 - carbon dioxide
COS - carbonyl sulfide
CR - County Road (e.g., CR 1216)
dB - decibels
dBA - A-weighted dB scale
DOE - U.S. Department of Energy
EIS - environmental impact statement
EOR - enhanced oil recovery
EPA - U.S. Environmental Protection Agency
EPACT - Energy Policy Act
ERCOT - Electric Reliability Council of Texas
ESL - effects screening limits
FAA - Federal Aviation Administration
FG Alliance - FutureGen Alliance
FM - Farm-to-Market Road (e.g., FM 1601)
FOA - Funding Opportunity Announcement
FSH - Fort Stockton Holdings
ft - foot
ft^3 - cubic foot
FTA - Federal Transit Administration
gal - gallon
GCA - Gulf Coast Waste Disposal Authority
GDP - gross domestic product
GHG - greenhouse gas
GIS - geographic information systems
H_2 - hydrogen gas
H_2S - hydrogen sulfide
H_2SO_4 - sulfuric acid
ha - hectare
HAP - hazardous air pollutant
Hg - mercury
HRSG - heat recovery steam generator
I - Interstate Highway (e.g., I-20)
IGCC - integrated gasification combined-cycle
IMPLAN - impact analysis for planning
in - inch
in^2 - square inch
IPCC - Intergovernmental Panel on Climate Change
ISD - Independent School District
km - kilometer
km^2 - square kilometer
KOP - key observation point
kV - kilovolt
L - liter
lbs - pounds
Ldn - day-night level
LEAP - La Entrada al Pacifico
Leq - equivalent sound level
LOS - level of service
m - meter
m^3 - cubic meter
M.A. - master's degree (arts)
mi - miles
M.E.M. - master's of environmental management
M.P.P. - master's of public policy
M.S. - master's degree (science)
M.U.E.P. - masters of urban and environmental planning
MVA - monitoring, verification, and accounting
MW - megawatt

n/a - not available
N_2 - nitrogen gas
NAAQS - National Ambient Air Quality Standards
NEPA - National Environmental Policy Act
NETL - National Energy Technology Laboratory
NG - natural gas pipeline option (i.e., NG1)
NH_3 - ammonia
NHD - National Hydrography Dataset
NO_2 - nitrogen dioxide
NO_x - nitrogen oxides
NOI - Notice of Intent
NRHP - National Register of Historic Places
O_2 - oxygen
O_3 - ozone
OSHA - Occupational Safety and Health Administration
Oxy Permian - Oxy USA-W Texas Water Supply
PCE - passenger car equivalent
PEM1Cxs - palustrine emergent, persistent, seasonally flooded, excavated, spoil
PEM2C - palustrine emergent, nonpersistent, seasonally flooded
PM - particulate matter
PM_{10} - particulate matter with aerodynamic diameter equal to or less than 0.00039 inch (10 micrometers)
$PM_{2.5}$ - particulate matter with aerodynamic diameter equal to or less than 0.000098 inch (2.5 micrometers)
polygen - polygeneration
ppm - parts per million
ppmv - parts per million by volume
PSD - Prevention of Significant Deterioration
PSS1K - palustrine scrub-shrub, persistent, artificially flooded
QRA - quantitative risk analysis
R5AB3K - riverine, unknown perennial, aquatic bed, rooted vascular, artificially flooded
ROI - region of influence
ROW - right-of-way
RPS - Renewable Portfolio Standard
RRC - Railroad Commission of Texas
SHPO - State Historic Preservation Officer
SIL - significant impact level
SL - sensitive receptor locations (e.g., SL-1)
SO_2 - sulfur dioxide
SPCC - spill prevention, control, and countermeasures
SPP - Southwest Power Pool
SWCA - SWCA Environmental Consultants
SWPPP - Storm Water Pollution Prevention Plan
t - metric tonne
TBD - to be determined
TCEP - Texas Clean Energy Project
TCEQ - Texas Commission on Environmental Quality
TEX. ADMIN. CODE - Texas Administrative Code
TL - transmission line option (e.g., TL1)
tn - ton
TPDES - Texas Pollutant Discharge Elimination System
TPWD - Texas Parks and Wildlife Department
TWDB - Texas Water Development Board
TxDOT - Texas Department of Transportation
U.S. - United States
U.S.C. - United States Code
UPRR - Union Pacific Railroad
USFWS - U.S. Fish and Wildlife Service
vpd - vehicles per day
WL - waterline option (e.g., WL1)
ZLD - zero liquid discharge

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Chapter 1. Purpose and Need

1 PURPOSE AND NEED

This chapter introduces the Proposed Action, describes the purpose and need for agency action, and outlines the scope of the environmental impact statement (EIS). This chapter also summarizes the National Environmental Policy Act (NEPA) of 1969 (Public Law 91-190) process, project objectives, and the public scoping process undertaken for this EIS.

1.1 Introduction

The United States (U.S.) Department of Energy (DOE) proposes to provide federal financial assistance to Summit Texas Clean Energy, LLC (Summit or Proponent) for its proposed Texas Clean Energy Project (TCEP) near Odessa, Texas (Figure 1.1). DOE has prepared this EIS in accordance with NEPA (42 United States Code [U.S.C.] §§ 4321 et seq.), NEPA-implementing regulations promulgated by the Council on Environmental Quality (Title 40, Code of Federal Regulations [C.F.R.] Parts 1500–1508), and DOE's NEPA procedures (10 C.F.R. Part 1021). This EIS describes the potential environmental impacts associated with the TCEP, as well as alternatives to and options for the TCEP, including the No Action Alternative. DOE will use this EIS to inform its decision on whether to provide financial assistance for the TCEP and, if so, whether environmental mitigation measures should be imposed.

The TCEP would comprise planning, design, construction, and operation by Summit of a coal-based electric power generation and chemicals production plant integrated with carbon dioxide (CO_2) capture and geologic sequestration through enhanced oil recovery (EOR). Summit is owned jointly by the Summit Power Group, Inc. and CW NextGen, Inc., a Clayton Williams company. The project team includes Summit; Summit Power Group, Inc.; Siemens Energy, Inc.; Linde, AG; Fluor Corporation; and Blue Source, LLC, among others.

> The TCEP would produce electricity and CO_2 for use in EOR. It would also produce urea, which is used as a fertilizer. These products of the plant would be made available for commercial use. Because the plant would produce several commodities, it is referred to as a **polygeneration** (or polygen) plant in this EIS.

DOE selected this project for an award of financial assistance through a competitive process under the Clean Coal Power Initiative (CCPI) Round 3 program, as announced under Funding Opportunity Announcement (FOA) DE-FOA-0000042. DOE's financial assistance would occur through cost sharing, by applying money from the American Recovery and Reinvestment Act of 2009 (ARRA) (Public Law 111-5), as specified under the terms and conditions of a financial assistance agreement between DOE and Summit.

DOE proposes to provide Summit with approximately $450 million in financial assistance for this project on a cost-shared basis. The TCEP would demonstrate the full integration of CO_2 capture and geologic sequestration with a commercial, coal-based polygeneration plant (or polygen plant). DOE's contribution of $450 million would constitute approximately 26 percent of the estimated total development and capital costs of the project, which is estimated to be $1.73 billion (2009 dollars).

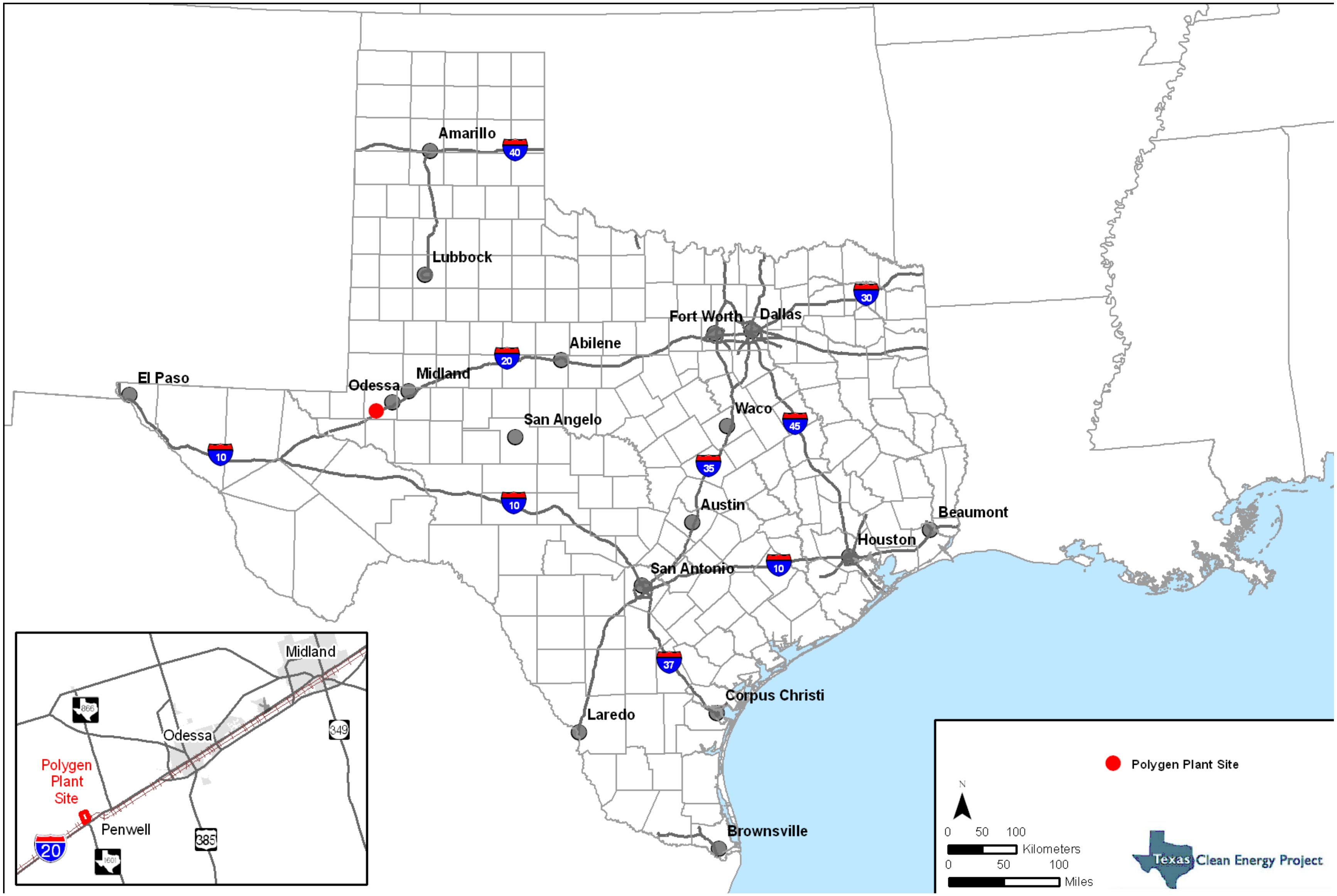

Figure 1.1. General location map.

1.2 Project Background

This section describes DOE's CCPI program and provides a brief overview of Summit's proposed project.

1.2.1 Clean Coal Power Initiative

The CCPI is a cost-shared collaboration between the federal government and industry to increase investment in advanced, low-emissions coal technologies, consistent with the Energy Policy Act (EPACT) of 2005 (Public Law 109-58).

The CCPI's goal is to accelerate the readiness of new coal-based technologies for commercial deployment, thus enabling future access to clean, reliable, and affordable power for the U.S. By commercially demonstrating selected advanced technologies, the CCPI encourages the emergence of new electricity and hydrogen gas (H_2) production technologies from the core research and development activities, contributes to proving the feasibility of integrating CO_2 management with power production, and facilitates widespread commercial deployment of coal technologies that can benefit our society. CCPI directly supports the Climate Change Technology Program to reduce emissions of CO_2, a greenhouse gas (GHG).

The CCPI is closely linked with research and development activities driving toward ultra-clean, fossil fuel–based energy complexes in the twenty-first century. When integrated with other DOE initiatives, the CCPI will help the nation successfully commercialize advanced power systems that will produce electricity at greater efficiencies and attain near-zero emissions, including management of CO_2 emissions. CCPI technologies offering CO_2 capture and storage, or beneficial reuse, will significantly reduce the emissions of CO_2 from fossil-based power generation. This commitment to low-CO_2 emissions, coal-based electric power will effectively respond to the national challenge of meeting the dynamic national electricity supply requirements while simultaneously decreasing emissions of CO_2 from coal-based electric power generation. More specifically, the CCPI addresses this challenge through a focus on demonstrations, at commercial scale and in commercial settings, of advanced and innovative low-CO_2 emissions coal-based technologies and on opportunities for timely deployment of those technologies by the power industry.

Public Law 107-63, enacted in November 2001, initiated and funded the initial phases of the CCPI. Later, with Title IV of EPACT 2005, the U.S. Congress established additional criteria for projects receiving financial assistance under this program. Under these criteria, CCPI projects must "advance efficiency, environmental performance, and cost competitiveness well beyond the level of technologies that are in commercial service" (EPACT 2005, § 402(a)). In February 2009, the ARRA appropriated $3.4 billion to DOE for "fossil energy research and development." DOE intends to use a significant portion of these funds to provide financial assistance to CCPI projects.

DOE conducts its CCPI financial assistance through a series of FOAs or "rounds," which industry can respond to by preparing and submitting applications requesting federal financial assistance for proposed demonstrations. DOE issued the first CCPI FOA (Round 1) in March 2002. A second FOA (Round 2) was issued in February 2004. A third FOA (Round 3) was issued in August 2008 with a new requirement for technologies that capture and sequester, or put to beneficial reuse, CO_2 emissions. As part of DOE's ARRA implementation, CCPI Round 3 was reopened in June 2009.

CCPI Round 3 allowed DOE financial assistance for coal-based power technologies that would produce heat, fuels, chemicals, H_2, or other useful products in any combination with production of electricity. Applications for demonstrations under the CCPI Round 3 were evaluated against specific programmatic criteria, summarized as follows:

- Technical Merit, Technical Plan, and Site Suitability:
  - Ability of the technology and technical plan to achieve project goals
  - Identification of potential risk elements, quality and adequacy of the approach to assessing and managing risk, conformance of risk management approach with industry standards
  - Ability of the proposed technology to meet the priority objectives of the FOA and to achieve progress toward the performance targets of EPACT—specifically, to support the ability of the project to achieve the minimum CO_2 capture efficiency of 50 percent and make progress toward the target of 90 percent CO_2 capture efficiency—and specifically to support the ability of the project to capture and sequester, or put to beneficial use, a minimum of 300,000 tons (tn) (272,155 metric tonnes [t]) per year of CO_2
  - Adequacy of economic metrics including tons of CO_2 sequestered per dollar of carbon capture and sequestration capital cost and per dollar of carbon capture and sequestration operating cost; adequacy of the proposed approach to sequestration or beneficial use
  - Quality and adequacy of the proposed site for supporting the proposed project
  - Strength of the commitment(s) for use and availability of the host site
  - Adequacy of the integration of the key physical or logistical (external) elements with the project necessary for a successful demonstration
  - Reasonableness and appropriateness of the proposed schedule
- Project Organization and Project Management Plan:
  - Completeness of the proposed project team and ability of the proposed team to successfully provide the skills and resources needed to implement the project as proposed
  - Adequacy of corporate background and experience to support successful performance
  - Clarity and logic of proposed organizational structure with respect to responsibilities and authorities
  - Soundness and completeness of the project management plan for establishing the baseline scope, schedule, and cost of the project, including the work breakdown structure and statement of project objectives, project schedule, baseline cost plan, project management controls, communication protocols, risk management, and environmental management
- Commercialization Potential:
  - Completeness of the commercialization plan
  - Economic viability

    - Potential for proposed technologies and sequestration approaches to meet DOE's priority objectives to achieve widespread commercial deployment
    - Potential for spin-off products
- Funding Plan and Financial Business Plan:
    - Financial condition and capacity of proposed funding sources to provide their portion of project costs, including development costs
    - Completeness and reasonableness of the financial business plan, including financial projections and models and degree of financial commitment to the project
- Adequacy of the Budget Information and Financial Management System
- Environmental:
    - Applicant's awareness of project-related requirements, including environmental risks and impacts
    - Ability to meet compliance requirements

The industry participants are responsible for project definition as well as design, construction, and operation of the facilities. DOE is responsible for 1) ensuring that the industry participants execute projects pursuant to the terms and conditions established in the cooperative agreements, 2) monitoring project activities relative to cooperative agreement requirements, 3) reviewing project performance and documentation, 4) providing technical advice to ensure that critical programmatic issues are addressed, and 5) ensuring that project costs shared by DOE are allowable and can be allocated.

Summit submitted its CCPI application on August 24, 2009, and was one of three projects initially selected for further consideration under the reopening of Round 3. As detailed in the application, the TCEP would be a first-of-its-kind polygen plant located in the West Texas Permian Basin, an area with substantial energy resource development and CO_2 beneficial reuse/storage activity. The TCEP would integrate, for the first time, proven gasification and CO_2 capture technologies in a commercial project to achieve an overall CO_2 capture rate of approximately 90 percent on a plant-wide basis. The TCEP would annually capture approximately 3 million tn (2.7 million t) of CO_2, which would be purchased by others for EOR operations that ultimately lead to geologic sequestration of the CO_2. In addition to electric power and captured CO_2 for EOR, the TCEP would produce urea, a fertilizer. Products of the gasification process such as argon and sulfuric acid (H_2SO_4) would be made available for commercial purchase. Slag, an inert product of the gasification process, would be sold for beneficial reuse such as in the manufacture of cement and roofing tiles or for use as a road base, asphalt filler, or sandblasting agent.

1.2.2 Summit's Proposed Project: TCEP Overview

As proposed by Summit, the TCEP would consist of a polygen plant and associated linear facilities that would be constructed and operated to serve the plant. The TCEP would employ integrated gasification combined-cycle (IGCC) technology. Gasification is the process of converting coal into a gaseous fuel called synthesis gas (syngas). A combined-cycle electric power plant is one that uses both a combustion turbine-generator and a steam turbine-generator (which uses steam produced by exhaust heat from the combustion turbine-generator) at one location to produce electricity. Combining (integrating) the gasification process with the combined-cycle power plant is known as IGCC.

The polygen plant would be located on approximately 600 acres [ac] (243 hectares [ha]) and would include CO_2 capture and compression to transport the CO_2 for off-site geologic sequestration through EOR. Specifically, the polygen plant would consist of an air separation unit, a coal gasification island (with two gasifiers), a syngas cleanup system, mercury (Hg) removal, acid gas removal (for sulfur species and CO_2), a CO_2 compressor system, a H_2SO_4 plant, a combustion turbine-generator, a heat recovery steam generator (HRSG), a steam turbine-generator, and a urea production plant. The proposed linear facilities would consist of an electric transmission line, one or more water pipelines, a natural gas pipeline, a CO_2 pipeline connector, two access roads that would connect the plant to existing roadways, and a rail line connector.

Summit's TCEP would generate approximately 400 megawatts (MW) (gross) (213 MW net) and be expected to generate approximately 1.7 billion net kilowatt-hours of electricity per year, which would be delivered to the electric grid system to help meet future demand. In addition, the plant would be designed to capture, as CO_2, 90 percent or more of the total carbon in the fossil fuel used as feedstocks and fuels for the plant under typical operating conditions. Summit proposes to capture approximately 3 million tn (2.7 million t) of CO_2 annually. The captured CO_2 would be sold under binding commercial contracts and subsequently injected into geologic formations for EOR. In addition, the plant would be designed to produce urea for sale as fertilizer. Products (argon, H_2SO_4, and inert slag) from the gasification process would also be sold on the commercial market.

Summit has applied for a grant under DOE's CCPI Round 3 program and an Internal Revenue Service Code Section 48A Qualifying Advanced Coal Project investment tax credit. However, most of the TCEP would be conventionally financed. Most of TCEP's funds would consist of owner-invested equity and debt obtained in private capital markets. No federal loan guarantee is currently envisioned, and no new CO_2 sequestration grants are assumed.

1.3 Purpose and Need for Action

This section describes DOE's purpose and need for agency action as well as Summit's reasons for pursuing the project.

1.3.1 DOE's Purpose and Need

DOE's purpose for its Proposed Action in the context of the CCPI Round 3 program is to advance the program by providing financial assistance to projects that have the best chance of achieving the program's objectives as established by the U.S. Congress. These objectives are the commercialization of clean coal technologies that advance efficiency, environmental performance, and cost competitiveness well beyond the level of technologies that are currently in service. Specifically, DOE's purpose and need for selecting TCEP for an award is to demonstrate the commercial-readiness of CO_2 capture and geologic sequestration (through EOR), fully integrated with a polygen plant. The technical, environmental, and financial data generated from the design, construction, and operation of the polygen plant would result in a commercial reference plant for the technology. Programmatically, the proposed project was selected under the CCPI program as one in a portfolio of projects that would represent the most appropriate mix to achieve programmatic objectives and meet legislative requirements.

1.3.2 Summit's Purpose and Need

Summit's primary business is the development of low- and zero-carbon power projects, including gasification/CO_2 capture and storage projects, wind projects, solar power projects, and combined-cycle gas-fueled power projects. In addition to continuing and expanding this business strategy, the purpose of the TCEP is to add low CO_2 emissions base-load power to the nation's electricity generation mix, to provide supply stability to offset the irregular nature of West Texas wind generation, and to store captured CO_2 geologically, in this case by using it to boost production of oil wells in the Permian Basin. The sale of granulated urea produced at the plant would support the farming industry and reduce annual imports of foreign-produced urea by approximately 10 percent. Product sales of argon and H_2SO_4 would support the chemical industry; and sales of inert, nonleachable slag would support general cement, concrete, and roofing tile manufacture, as well as road construction.

Summit is responding to a regional need for a firm (nonfluctuating) supply of electric power, including peaking capacity during summer months. The Electric Reliability Council of Texas (ERCOT) manages the flow of electric power to 22 million Texas customers, which represents 85 percent of the state's electric load and 75 percent of the Texas land area. A 2010 ERCOT capacity, demand, and reserve report estimates that peak demand (including a 13.5 percent reserve margin) in the ERCOT market area will increase from approximately 70,000 MW in 2010 to approximately 96,000 MW in 2030. To address this demand, ERCOT forecasts a need for new generation from approximately 6,400 and 33,000 MW in 2015 to approximately 50,000 and 70,000 MW in 2030 to account for retiring power plants more than 30 years old.

There are ERCOT interconnect studies currently underway for approximately 18,500 MW of new power resources, of which approximately 7,200 MW would be for wind-powered generation projects (ERCOT 2010a). However, less than 1,000 MW of new wind power projects went into service in 2009 and approximately 350 MW of new wind power projects were expected in 2010. Summit, as a wind power producer itself, believes that the wind power market in Texas will be weak for the foreseeable future for a variety of reasons, including the lack of national renewable portfolio standards (RPS), the dearth of available bilateral power sale contracts for wind power with Texas utilities (many of which are reaching their limits in terms of ability to integrate wind into their resource mix and still meet their firm loads), and the seasonally depressed power prices available for wind generation. In the current ERCOT market, it is almost impossible to finance a wind power project because it is very difficult to obtain a long-term power sales contract with a utility, given the nonfirm nature of wind power and financial and transmission constraints.

The amount of solar-generated capacity in the ERCOT market area is very small. Statewide, renewable energy projects including solar-generated capacity account for approximately 1 percent of total generating capacity. ERCOT studies are underway for approximately 90 MW of solar power. Summit is actively pursuing photovoltaic solar power projects in Texas (including West Texas). However, for a variety of cost and market reasons, commercial opportunities to develop new solar projects in Texas remain limited. It is currently very difficult to find utility buyers in Texas for any large amount of solar power, although Summit hopes that situation will improve in future years.

In 1999, Texas enacted an RPS to promote the use of renewable energy sources. The standard mandated that electricity providers (competitive retailers, municipal electric utilities, and electric cooperatives) collectively generate 2,000 MW of additional renewable energy by 2009. The 2005 Texas Legislature increased the state's total renewable-energy mandate to 5,880 MW by 2015 with a target of 10,000 MW in 2025.

Currently, wind power represents the bulk of renewable energy development occurring under the Texas RPS. In an effort to diversify the state's renewable generation portfolio, legislation passed in 2005 included a requirement that the state meet 500 MW of the 2025 target with nonwind renewable generation. The Public Utility Commission of Texas is also considering a rule to require retail electric providers to purchase at least 500 MW of nonwind renewable energy in the ERCOT market by 2015. Despite these requirements for renewable energy sources, such sources would not be sufficient to meet the projected deficit of between approximately 6,400 and 33,000 MW in 2015.

Further, unlike most renewable energy projects, the proposed TCEP would produce base-load electric power. Summit believes that the operation of the proposed TCEP would allow intermittent, renewable energy projects to be more viable by providing a firm, stabilizing power source to help anchor electrical power generation in West Texas.

1.4 Regulatory Framework

This section describes the NEPA requirements that DOE must meet to inform its decision on whether to partially fund the TCEP, and the state requirements that Summit must meet to construct and operate the polygen plant.

1.4.1 National Environmental Policy Act

For every recommendation or report on proposed major federal actions significantly affecting the quality of the human environment, NEPA requires all federal agencies to prepare an EIS that addresses 1) the environmental impact of the proposed action; 2) any adverse environmental effects that cannot be avoided should the proposed action be implemented; 3) alternatives to the proposed action; 4) the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity; and 5) any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented. NEPA also requires consultations with federal agencies that have jurisdiction by law or special expertise with respect to any environmental impact involved. The EIS, along with the comments and views of consulted governmental agencies, must be made available to the public.

DOE determined that providing financial assistance for the construction and operation of the TCEP would constitute a major federal action that could significantly affect the quality of the natural and human environment. Therefore, DOE has prepared this EIS in compliance with requirements for implementing NEPA as established by the Council on Environmental Quality regulations (40 C.F.R. Parts 1500–1508) and DOE procedures for implementing NEPA (10 C.F.R. Part 1021).

The NEPA process for the TCEP began in June 2010 with the publication of DOE's Notice of Intent (NOI) to prepare the EIS. Following the 45-day public comment period on this draft EIS, DOE will consider all substantive comments received within the comment period and issue a final EIS. The NEPA process will conclude with the publication of DOE's Record of Decision. DOE plans to complete its NEPA process in the summer of 2011.

1.4.2 State Requirements

1.4.2.1 TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

The U.S. Environmental Protection Agency (EPA) has delegated its authority to enforce various federal environmental laws to the Texas Commission on Environmental Quality (TCEQ). Thus, TCEQ would be responsible for the issuance of permits required under the Clean Water Act (40 C.F.R. Parts 104–140), the Clean Air Act (40 C.F.R. Parts 50–96), the Resource Conservation and Recovery Act (40 C.F.R. Parts 239–299), and the Oil Pollution Prevention Act (40 C.F.R. Part 112). TCEQ is also responsible for enforcement of Texas state environmental laws regarding air and water quality, treatment and storage of hazardous wastes, and on-site sewage facilities.

1.4.2.2 TEXAS PARKS AND WILDLIFE DEPARTMENT

Texas Parks and Wildlife Department (TPWD) regulations prohibit the taking, possession, transportation, or sale without a permit of any animal species designated by state law as endangered or threatened. State laws and regulations prohibit commerce in threatened and endangered plants as well as the collection of listed plants from public land without a permit issued by the department.

1.4.2.3 TEXAS DEPARTMENT OF TRANSPORTATION

A permit from the Texas Department of Transportation (TxDOT) would be required for the placement of utilities within a state road right-of-way (ROW).

1.4.2.4 PUBLIC UTILITY COMMISSION OF TEXAS

Power-generation plants operating in Texas must register with the Public Utility Commission of Texas pursuant to Public Utility Commission Substantive Rule Section 25.109. As an exempt wholesale generator, the TCEP would not be required to obtain a Certificate of Convenience and Necessity from the Public Utility Commission for the transmission line that would be constructed from the plant to an interconnection with an existing transmission grid.

1.5 DOE Scoping Process

This section describes the activities DOE has undertaken to determine the actions, alternatives, and impacts to be addressed in this EIS and reports on the public and agency involvement process used to solicit comments on the scope of the document. The scoping report includes a copy of the NOI, the informational display boards used at the public scoping meeting, the presentations given by DOE and Summit at the scoping meeting, and a list of the meeting attendees (National Energy Technology Laboratory [NETL] 2010).

1.5.1 Notice of Intent

DOE published an NOI to prepare the EIS in the *Federal Register* on June 2, 2010 (75 *Federal Register* 30800). Publication of the NOI initiated a 30-day formal public and agency scoping period, during which DOE solicited comments regarding the proposed project, its potential impacts, and possible project alternatives.

1.5.2 Public Scoping Meeting

A scoping meeting was held on June 17, 2010, to provide information on project planning activities to date and to give federal, state, and local government agencies and members of the public the opportunity to ask questions of DOE and Summit. Meeting attendees were also invited to provide comments on the issues and alternatives that should be included in the draft EIS.

An open house was held from 4:00 to 7:00 p.m., during which informational display boards were arranged in stations around the meeting rooms for review. The formal component of the scoping meeting began at 7:00 p.m., with DOE representatives providing information on DOE's NEPA process and DOE's CCPI program. A Summit representative provided an overview of the TCEP.

Following these presentations, elected officials and members of the public were provided an opportunity to make oral comments regarding the scope of the EIS. A court reporter was present to record and provide a transcript of all spoken comments (NETL 2011). Approximately 75 persons attended the public scoping meeting.

1.5.3 Issues Identified during Scoping

In total, 218 comments were received from 23 commenters during the public scoping comment period from June 3, 2010 through July 2, 2010. Of the 23 commenters, 10 represented local, state, and federal government agencies and municipalities; two represented organizations; two represented businesses; and nine individuals represented themselves. A number of commenters stated their general support for or opposition to the proposed project, made rhetorical statements, asked questions, or provided statements of opinion. All comment submissions were reviewed to determine specific issues, concerns, and questions to ensure the consideration of all substantive concerns.

The following sections summarize the relevant issues and concerns related to the TCEP that were identified through the public scoping process and that are addressed in this EIS.

1.5.3.1 PROCESS ISSUES

Comments related to the NEPA process included requests for copies of the draft EIS and scoping meeting information, questions about the comment submittal process, and requests to be added to the distribution list. Commenters also inquired about the length of the NEPA process and recommended contacting specific federal agencies for information.

1.5.3.2 PURPOSE AND NEED

Commenters recommended examining the need for the TCEP considering current and future energy demands, regulations, and the availability of alternative energy generation sources such as solar, wind, nuclear, and conventional coal-based power plants.

1.5.3.3 PROPOSED ACTION

Commenters recommended incorporating project details such as process information, CO_2 monitoring systems for EOR, labor uses, and utility and resource requirements into the EIS. Other comments addressed rail and access road alignments, transmission corridors, contaminants, and various other site features.

1.5.3.4 ALTERNATIVE TECHNOLOGIES ISSUES

Commenters requested examination of alternative technologies to various chemical processes, including ammonia (NH_3) production and Hg removal as well as technologies that reduce particulate matter (PM) emissions.

1.5.3.5 RESOURCE AND ANALYSIS ISSUES

Numerous comments were received regarding potential impacts to natural and human environmental resources. In general, commenters requested a comprehensive evaluation of the direct, indirect, and cumulative effects of process inputs, oil and gas operations, and by-products. Most comments focused on air quality, climate change, water resources, and petroleum issues. A brief summary of comments received on particular resource issues is provided below.

- Air quality comments called for air emissions modeling to determine impacts on air quality, nearby national parks, and neighboring states that fail to meet federal air quality standards. Climate change comments questioned whether the net benefits of CO_2 sequestration through EOR efforts would be offset by full life-cycle CO_2 impacts associated with the recovered oil.
- Commenters requested information on petroleum issues including the EOR process and CO_2 monitoring methods as well as clarification on the liability and guarantees associated with the CO_2 monitoring system.
- Commenters raised concerns about potential impacts to water quality, surface water (including Monahans Draw), and ground water resources, and they recommended alternative water sources (i.e., brackish water) instead of fresh water to meet TCEP's needs for process water.
- Biological resources comments were focused on potential impacts to ecological resources; wildlife habitat; migratory birds; game species; and rare, threatened, and endangered species.
- The public raised issues regarding the effects of the project on the local community, including land use impacts to the rural character of the area, cultural impacts to historic structures and prehistoric resources, and impacts to recreational hunting and mineral rights ownership. Potential noise and visual impacts to Monahans Sandhills State Park and other sensitive receptors were also noted.
- Commenters inquired about the socioeconomic and environmental justice impacts resulting from the project, and they questioned whether associated by-products would overwhelm various economic markets.
- Utility systems inquiries focused on whether the project would affect transmission lines intended for wind and solar projects, and commenters requested analysis of available electric transmission capacity. In addition, commenters expressed concerns about the increase in rail traffic affecting vehicular traffic and the rate of traffic accidents.
- The public raised issues regarding materials and waste management, including whether facilities regulated by EPA are located near the project area and whether activities would affect homes with lead-based paint.
- Human health issues were directed toward safety and the potential for accidents at the plant site and during the CO_2 injection process for EOR purposes.

1.5.3.6 OUT-OF-SCOPE COMMENTS

DOE has addressed all substantive scoping comments in this draft EIS. However, there were several issues raised by the public that are beyond the scope of the EIS or were not substantive. This section provides a brief summary of comments that were determined to be out-of-scope or nonsubstantive.

Commenters recommended that DOE consider alternative energy sources such as solar, wind, nuclear, and conventional coal-fired power plants. However, DOE's purpose and need is to demonstrate an advanced power plant based on fossil fuels in general and coal in particular. These suggested alternatives would not fulfill DOE's purpose and need, and for that reason, are not reasonable alternatives and were not analyzed in this EIS.

Commenters requested that DOE analyze the full life-cycle impacts of mining and transporting coal to West Texas. Although the EIS does address the transportation of coal to the TCEP, the effects of commercial coal mining are generally well known and well described and are not within the scope of this EIS. The operation of the TCEP would not change mining techniques and, for the proposed project, DOE has no decisions that would affect coal mining techniques or the choice of coal mines. It is assumed that the coal intended for the TCEP would be used as a feedstock or fuel in another facility in the event that the TCEP is not constructed.

Commenters requested that DOE analyze potential impacts to federally listed species whose critical habitat would be traversed by the proposed Fort Stockton Holdings, LLC (FSH) waterline. Although DOE has evaluated all federally listed and state-protected species that could be affected by the TCEP, the FSH waterline is a separate action that is not dependent on whether the TCEP is constructed and operated. Because this action is independent of the TCEP, the evaluation of impacts to federally listed and state-protected species that could be affected by the FSH waterline is outside the scope of this EIS. However, the proposed connecting pipeline between the proposed FSH main pipeline and the polygen plant site is evaluated in this EIS.

Commenters questioned whether the TCEP EIS would be similar to the *FutureGen Project Final Environmental Impact Statement* (FutureGen EIS) (DOE 2007), which was prepared for DOE's proposal to provide financial assistance to the FutureGen Alliance (FG Alliance) for the FutureGen project, a coal-based electric power and H_2 production plant integrated with CO_2 capture and geologic sequestration. Although the FutureGen EIS considered the site that is now proposed for the TCEP, the FG Alliance and DOE eventually decided to construct the proposed FutureGen plant in Illinois (that project has since been modified). Thus, the TCEP is not the same as the FutureGen project; it is a different project and DOE is evaluating it as such. Because the location is the same, however, relevant information from the FutureGen EIS has been used to the extent appropriate in this TCEP EIS.

1.5.4 Additional Public Comment Opportunities

This draft EIS will be circulated for public review and comment during a 45-day comment period to begin on the day EPA publishes a notice of availability for the document in the *Federal Register*. Copies of the draft EIS will be sent to individuals and organizations on the mailing list prior to that date.

DOE will hold a public hearing on the draft EIS during the comment period. At the hearing, DOE will take oral comments on the content of the document. The date, time, and location of the public hearing will be widely publicized in local media.

Written comments on the draft EIS can be provided as follows:

- By letter addressed to Mr. Mark L. McKoy, DOE, NETL, 3610 Collins Ferry Road, P.O. Box 880, Morgantown, West Virginia 26507-0880
- By letter faxed to Mr. McKoy at (304) 285-4403
- By e-mail to summit.EIS@netl.doe.gov

DOE will consider all comments received or postmarked during the 45-day public comment period in its preparation of a final EIS. DOE will consider late comments to the extent practicable.

1.5.5 Consultation and Coordination

1.5.5.1 COORDINATION WITH FEDERAL AND STATE AGENCIES

DOE contacted several federal and state agencies by letter to initiate consultation regarding particular environmental resources in their jurisdictions or areas of special expertise, or to invite them to become cooperating agencies under NEPA. The agencies contacted were:

- U.S. Department of the Interior, Regional Environmental Office
- EPA, Region 6, Regional Environmental Review Coordinator, Office of Planning and Coordination
- TCEQ, Region 7, Midland
- U.S. Army Corps of Engineers, Fort Worth District
- U.S. Fish and Wildlife Service (USFWS), Austin Ecological Services Field Office
- U.S. Department of Transportation, Federal Highway Administration
- TxDOT, Office of Planning and Development
- Texas State Historic Preservation Officer (SHPO), Texas Historical Commission
- TPWD, Wildlife Habitat Assessment Program

The consultation letters are contained in Appendix A to this EIS, and the agency contacts are included in the distribution list for the draft EIS. No agency requested to participate as a cooperating agency for the EIS.

1.5.5.2 CONSULTATION WITH NATIVE AMERICAN TRIBES

DOE also sent letters to several tribes inviting them to attend and participate in the scoping meeting, and sent follow-up letters to provide information on how they could contact DOE if they had questions or concerns (see Appendix A). The tribes contacted were as follows:

- The Apache Tribe of Oklahoma
- The Comanche Tribe of Oklahoma

- The Kiowa Tribe of Oklahoma
- The Lipan Apache Tribe of Texas
- The Fort Sill Apache Tribe of Oklahoma
- The Wichita Tribe of Oklahoma
- The Ysleta Del Sur Pueblo of Texas
- The Mescalero Apache Reservation of New Mexico

The Ysleta Del Sur Pueblo of Texas requested consultation in compliance with the Native American Graves Protection and Repatriation Act (Public Law 101-601) only if human remains or artifacts were unearthed during the construction of the TCEP. No other responses were received.

1.5.5.3 SCOPE OF DOE'S ALTERNATIVES CONSIDERED

NEPA requires that agencies evaluate all reasonable alternatives to the proposed action. The purpose and need for agency action determines the range of reasonable alternatives. In this case, the purpose and need for DOE's proposed action is to advance the CCPI program by providing financial assistance to projects that have the best chance of achieving the program's objectives as established by U.S. Congress.

DOE's NEPA regulations include a process for identifying and analyzing reasonable alternatives in the context of providing financial assistance through a competitive selection of projects proposed by entities outside the federal government (10 C.F.R. § 1021.216). The range of reasonable alternatives in competitions for grants, loans, loan guarantees, and other financial support is defined initially by the range of responsive proposals received by DOE. Unlike projects undertaken by DOE itself, the department cannot mandate which entities submit proposals, where they propose to locate their projects, or how they propose to implement their projects, beyond expressing basic requirements in the FOA; these express requirements are limited to those that further the program's objectives. DOE's decision is then limited to selecting among the applications that meet the program's goals.

Recognizing that the range of reasonable alternatives in the context of financial assistance and competitive solicitations is determined by the number and nature of the proposals received, 10 C.F.R. § 1021.216 requires that DOE prepare an "environmental critique" that assesses the environmental impacts and issues relating to each of the proposals that the DOE-selecting official considers for an award. The DOE-selecting official considers these impacts and issues, along with other aspects of the proposals (such as technical merit and evidence of financial ability) and the program's objectives, in making awards. DOE prepared a critique of the proposals that were deemed suitable for selection in this round of awards for the CCPI program. Based on the critique, DOE prepared a publicly available environmental synopsis to document consideration given to environmental factors. The environmental synopsis is provided in Appendix B.

After DOE selects a project for an award, the range of reasonable alternatives becomes the project as proposed by the applicant, any alternatives still under consideration by the applicant or that are reasonable within the confines of the project as proposed (e.g., the particular location of the plant on the parcel of land proposed for the project), and a no action alternative.

In this EIS, DOE evaluates the project as proposed by Summit (with and without any mitigating conditions that DOE may identify as reasonable and appropriate), operational options that Summit is considering (e.g., water sources and transmission line interconnections), and the No Action Alternative.

As discussed in Section 1.2.1, DOE issued CCPI Round 3 in August 2008, and reopened it in June 2009 in response to the ARRA. Private sector participants submitted 38 proposals in response to the reopened solicitation. After an initial screening removed from further consideration those proposals that failed to meet all the published mandatory eligibility requirements, there were 25 responsive proposals that were subjected to environmental review and consideration (during the selection process) in accordance with 10 C.F.R. § 1021.216. Accordingly, DOE met its obligations under NEPA to consider the alternatives available to the agency when DOE completed this process. As the final step, DOE chose a group of proposals, representing diverse technologies and using a variety of coals, to further the goals of the CCPI program. The TCEP was selected under the reopening of Round 3 because of the opportunity to demonstrate the specific technology proposed: an IGCC power generation and chemicals production plant and CO_2 capture technologies in a commercial project to achieve an overall CO_2 capture rate of 90 percent. Other projects that propose to demonstrate other technologies are not alternatives to the proposed project for the purposes of this EIS, which was prepared to support a DOE decision on whether to provide partial funding for the TCEP and to inform other governmental agencies and the public about the proposed project and the potential environmental impacts.

1.5.5.4 REGION OF INFLUENCE AND AREA OF REVIEW

The scope of this TCEP EIS includes potential impacts that Summit's proposed project may have on the natural and human environment in the region of influence (ROI). In this document, the ROI establishes the area of review for potential impacts. The ROI for the proposed project varies depending on the environmental resource affected. The site for Summit's proposed project (polygen plant site) and the ROWs for the linear facilities represent the narrowest ROI in which environmental resources may be affected. For some resources, such as biological and cultural resources, the ROI may extend beyond these sites into lands adjacent to the property boundaries. For other resources, such as socioeconomics and transportation, the ROI may encompass the surrounding local communities. Other resources, such as air quality and water resources, may have regions of influence that extend beyond municipal and county boundaries.

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Chapter 2. Proposed Action and Alternatives

2 PROPOSED ACTION AND ALTERNATIVES

This chapter describes DOE's Proposed Action and No Action Alternative, and it describes Summit's proposed TCEP and alternatives considered by Summit but eliminated from further consideration. Along with an overview of the TCEP, this chapter provides detailed technical information on the proposed project that forms the basis for the analyses in this EIS. This information includes detailed descriptions of the polygen plant, linear facility options, CO_2 capture and sequestration methods, resources required for the proposed project, by-products and wastes, construction and operation plans, measures to reduce potential impacts, and post-operation activities. The chapter also describes the operational options considered by the project.

2.1 Introduction

The TCEP would be located approximately 15 miles (mi) (24 kilometer [km]) southwest of the city of Odessa in Ector County, Texas. The proposed 600-ac (243-ha) polygen plant site is located in the community of Penwell, just north of Interstate (I)-20 and a Union Pacific Railroad (UPRR) line. The land has historically been used for ranching and limited oil and gas activities.

As proposed by Summit, the TCEP would consist of the polygen plant and the linear facilities that would be constructed and operated to serve the plant. The polygen plant would use a commercial IGCC system and would be integrated with CO_2 capture and geologic sequestration through EOR. The proposed linear facilities would consist of an electric transmission line, one or more process waterlines, a natural gas pipeline, a CO_2 pipeline connector, a rail line connector, and two access roads that would connect the plant to existing roads.

Figure 2.1 shows the plant site and associated linear facilities, which consist of the four waterline options (WL1–WL4), six transmission line options (TL1–TL6), the CO_2 pipeline connector (CO_2), natural gas pipeline (NG1), two access roads (AR1–AR2), and one rail spur (RR1).

EOR refers to techniques that allow increased recovery of oil in partially depleted or high viscosity oil fields. CO_2 flooding (CO_2 EOR) has the potential to not only increase the yield of residual or high viscosity oil, but also to sequester CO_2 that would normally be released to the atmosphere.

In general terms, CO_2 is injected into an oil field through injection wells drilled near producing wells. The CO_2 and oil mix together and form a mixture that more easily flows to the production well. To sweep out residual oil, CO_2 is cycled through the oil field one or more times, with each cycle resulting in a part of the CO_2 becoming trapped in the spaces that were previously occupied by oil. The CO_2 that comes up the well with the oil is recovered and re-injected into the field. Maturing oil fields and rising oil prices have made this method of resource recovery increasingly attractive to industry. Currently, CO_2 EOR comprises approximately 37 percent of all EOR being performed in the United States (water is also used). The United States has been a leader in developing and using technologies for CO_2 EOR by performing approximately 96 percent of worldwide CO_2 EOR.

CO_2 EOR has been used by the oil and gas industry for more than 40 years, but only recently has its potential as a CO_2 sequestration method been realized and investigated. The CO_2 used to increase oil production is an expensive commodity, and for this reason, oil companies are highly motivated to ensure that CO_2 does not escape to the atmosphere.

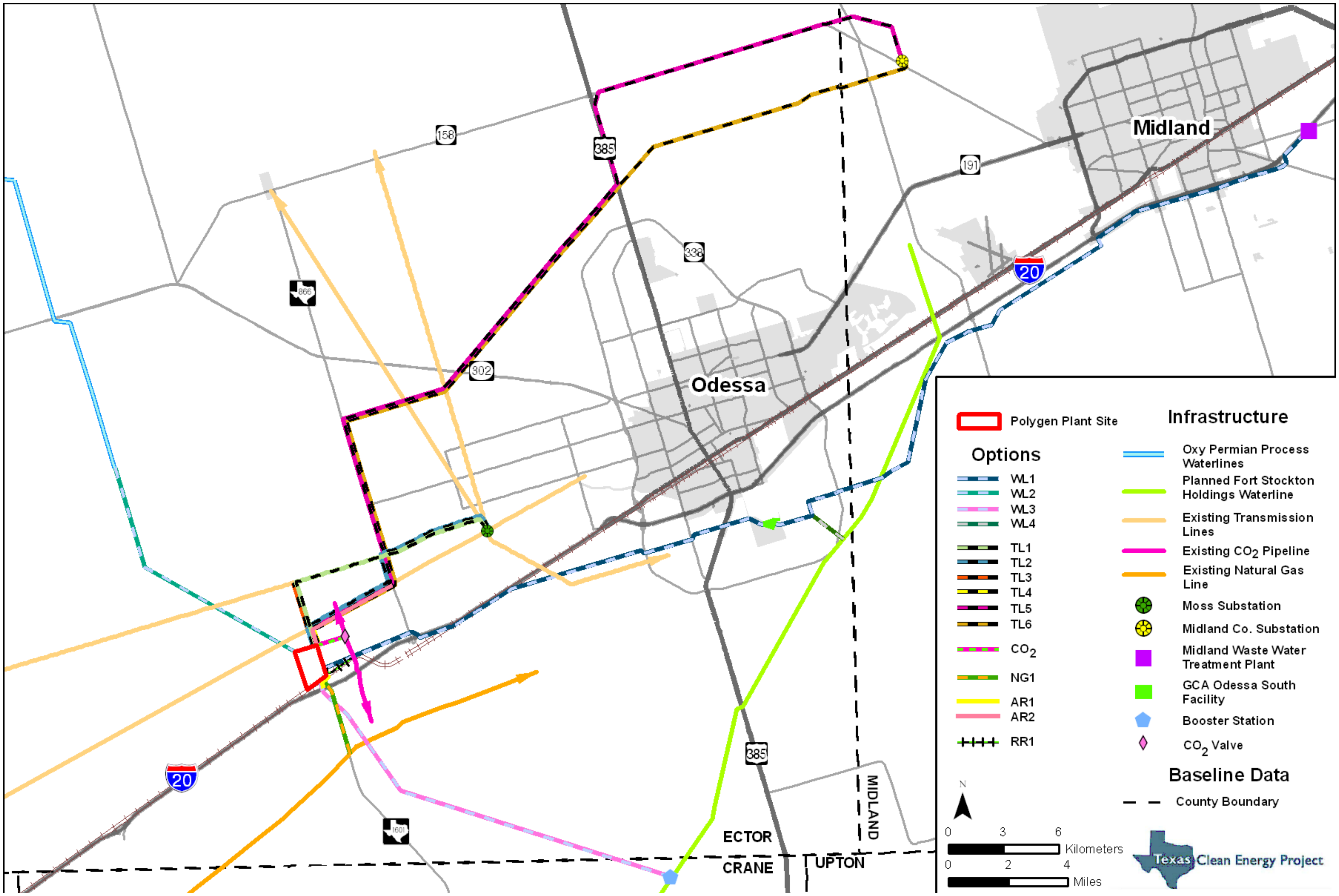

Figure 2.1. Polygen plant site and associated linear facilities.

The polygen plant is being designed to use low-sulfur, Powder River Basin sub-bituminous coal from Wyoming as the feedstock for the gasification island, which would use two Siemens gasifiers to convert that feedstock into syngas for downstream use. After further cleaning, chemical conversion and processing of the syngas, followed by capture and removal of CO_2, the H_2-rich syngas would be used in the power island to generate 400 MW (gross) of electrical power.

The TCEP would contribute approximately 213 MW net (1.7 billion net kilowatt-hours) of electricity per year to the electric grid system, which would help meet future demand. The remainder of the gross generation would be used to run the plant. In addition, the polygen plant would be designed to capture, as CO_2, 90 percent or more of the total carbon in the fossil fuel used in the plant under almost all operating conditions. The captured CO_2 would be sold under binding commercial contracts and subsequently injected deep underground for EOR. The plant would also produce urea for fertilizer. Argon and H_2SO_4 would be by-products of the gasification and syngas cleanup processes and would be made available for commercial sale. Slag (an inert by-product of the gasification process) could be sold as a raw material for manufacturing cement and other products.

Interconnections for supplies of natural gas and process water would all be required. Potable water would be trucked to the site. The TCEP generating facilities would connect with existing transmission lines. Captured CO_2 would be transported from the plant site by pipeline to an existing Kinder Morgan CO_2 pipeline. Coal would be delivered to the plant site by the UPRR line adjacent to the site. Chemical products produced by the plant would be transported off-site by rail or by truck.

Waste water would be managed through on-site processes to minimize overall water demand. Disposal of final brine water effluent would be through a zero liquid discharge (ZLD) system or by on-site deep well injection. Slag that could not be sold for commercial use would be sent by truck or rail to a licensed off-site landfill. Sanitary wastes would be collected and discharged directly to an on-site septic system.

The primary access to the plant would be from Farm-to-Market Road (FM) 866 at the northern border of the plant site, with emergency vehicle, plant administrative workforce, and visitor access from FM 1601 at the southeastern border of the plant site. Use of FM 1601 to access the plant site would require construction of an underpass, overpass, or at-grade intersection with the UPRR line.

2.2 DOE's Proposed Action

DOE's Proposed Action is to provide a total of approximately $450 million in financial assistance for Summit's proposed TCEP through a cooperative agreement. The money would be provided on a cost-share basis for the planning, design, construction, and demonstration-phase testing and operation of the project. Under the terms of the cooperative agreement, DOE has made available approximately $37 million on a cost-share basis for the project definition phase, which includes completion of the EIS. This is 80 percent of the estimated $46.3 million cost of the project-definition phase. The activities eligible for cost sharing during this phase include preliminary design and environmental studies that provide the basis for this EIS. Making these funds available does not prejudice DOE's ultimate decision on the Proposed Action and is consistent with DOE and Council on Environmental Quality regulations (10 C.F.R. § 1021.211 and 40 C.F.R. § 1506.1, respectively), which restrict DOE from taking action that would have an adverse environmental impact or limit the choice of reasonable alternatives until the Record of Decision has been issued.

Summit's application for DOE financial assistance indicated that the TCEP "is readily expandable with gasifiers and other components in modules" (Summit 2009). However, Summit has no plans for expansion at this time. Thus, such activities are speculative and not within the scope of this EIS. Any future expansion, were it to occur, would remain in the current 600-ac (243-ha) site, and no modifications to any linear facilities would be required. If a future expansion involved federal funds or federal lands or required a federal permit or approval, the potential impacts of such an expansion would be subject to the appropriate level of NEPA analysis and disclosure.

2.3 Development of Summit's Proposed Project

2.3.1 Technology Selection

Summit's primary business is the development of power projects having low- to zero-CO_2 emissions, including wind power projects, solar power projects, and combined-cycle gas-fueled power plant projects. Summit has more than $5 billion in commercially operating projects, most of them using Siemens power-generation equipment.

In the early 2000s, Summit began considering the development of an IGCC plant with the intention of providing CO_2 capture when the technology became available. In 2007, Siemens acquired and began testing a gasification technology. Subsequently, the TCEP began as a joint Summit and Siemens concept, building on the development of the proposed REC project in Butte, Montana. The REC project was conceived as a means of supplying electric power, H_2, argon, and other chemicals to REC Silicon, a large manufacturer of polysilicon for solar power and computer applications. Fluor was selected as the REC project's design engineer. Fluor began work under Summit's direction in the configuration and preliminary design engineering of the two-gasifier Siemens reference plant that is the model for the TCEP.

The TCEP's size was based on technology considerations and transmission limitations in West Texas. Summit and Siemens selected a two-gasifier configuration using Siemens SFG-500 gasifiers, with one combustion turbine and one steam turbine. Siemens has designed these gasifiers into a "twin pack" with all the surrounding feedstock, waste water, and product processing equipment to maximize efficiency. However, with two gasifiers and one combustion turbine, the polygen plant would produce excess syngas but not enough to support two combustion turbines (one gasifier would be insufficient for one combustion turbine). Although the excess syngas could be used to make several types of products, market research revealed that the production of urea for fertilizer would have the most financial benefit. A three-gasifier and two combustion turbine configuration was eliminated from consideration because the amount of electricity that would be generated as a result would likely exceed the transmission capacity available in the area.

While the basic configuration of the plant and its technology selections were specified in Summit's proposal submitted to DOE and accepted under the CCPI Round 3 program, two technology options remain under consideration by Summit. For the disposal of brine water from the reverse osmosis system, Summit is considering: 1) a brine concentrator and filter press system, 2) a solar evaporation pond system, or 3) a deep injection well located onsite. To meet the cooling needs for the chemical process portion of the plant, Summit is considering either wet or dry cooling towers, depending on the degree of cooling required and on system economics. These technology options are described in subsequent sections of Chapter 2, and their potential impacts are described where appropriate in Chapter 3.

2.3.2 Alternative Sites

Because of its desire to integrate IGCC technology with CO_2 capture, Summit focused its siting efforts in Texas, which has both a market for CO_2 for use in EOR and existing infrastructure for transporting CO_2 to oil fields. Oil producers in Texas have used CO_2 for many years, and the Texas Bureau of Economic Geology was willing to assist the project.

Summit considered several sites in Texas, including Oak Grove, Corpus Christi, Big Brown, and the two sites—Jewett and Odessa—that had been considered for DOE's FutureGen project, which also would have used IGCC with CO_2 capture. Summit ultimately selected the Odessa site primarily because of its proximity to an existing CO_2 pipeline and multiple EOR sites. The Odessa site also has close access to rail, natural gas, transmission lines, and available sources of water, which the other Texas sites lacked in varying degrees. Finally, the Odessa site enjoys significant community support for the TCEP.

2.3.3 Linear Facility Options

Summit selected options for its required linear facilities based on the most direct routes from the polygen plant site to the closest interconnection points, taking into account the need to minimize adverse impacts to residences and the environment and to minimize construction issues. The linear facilities selected would use existing linear facilities or ROWs to the fullest extent possible.

With respect to the process water needed for the plant, Summit sought to avoid water sources that would cause a conflict with municipal drinking water needs. Thus, Summit is considering the use of some of the city of Midland's waste water effluent blended with city of Odessa waste water with additional processing at the Gulf Coast Waste Disposal Authority (GCA) Odessa South Facility in Odessa. This may be supplemented by the use of brackish (highly saline and nonpotable) ground water from the Capitan Reef Complex Aquifer through an existing pipeline system owned by Oxy USA-W Texas Water Supply (Oxy Permian). In addition, FSH has proposed the development of a water pipeline to provide raw water for municipal use in Midland and Odessa. Should such a pipeline be constructed, Summit would also consider it as a potential process water source.

2.4 Summit's Proposed Project

2.4.1 Process Description

The TCEP would integrate coal gasification, combined-cycle power generation, CO_2 capture, and urea production. These four processes are described below, and a diagram of how these technologies are integrated is shown in Figure 2.2. Unless otherwise noted, the source for the process description is the *Texas Clean Energy Project Initial Conceptual Design Report* dated September 2010 (Summit 2010a).

2.4.1.1 COAL GASIFICATION, SYNGAS PROCESSING, AND CARBON DIOXIDE CAPTURE

Gasification is a thermo-chemical process that converts carbon-based materials, such as coal, into syngas, which is composed primarily of H_2 and carbon monoxide (CO). The conversion occurs in a reduced oxygen (O_2) atmosphere and at temperatures up to 3,000 degrees Fahrenheit (1,648 degrees Celsius). For the TCEP, coal feedstock would be pulverized and transferred to two Siemens gasifiers along with limited amounts of nearly pure O_2 gas. In the gasifiers, controlled reactions would take place, converting the coal into syngas. Along with the H_2 and CO, varying amounts of CO_2, nitrogen (N_2), sulfur species, methane, volatilized metals, and PM would also be in the raw syngas. The syngas would then be cooled and cleaned of PM.

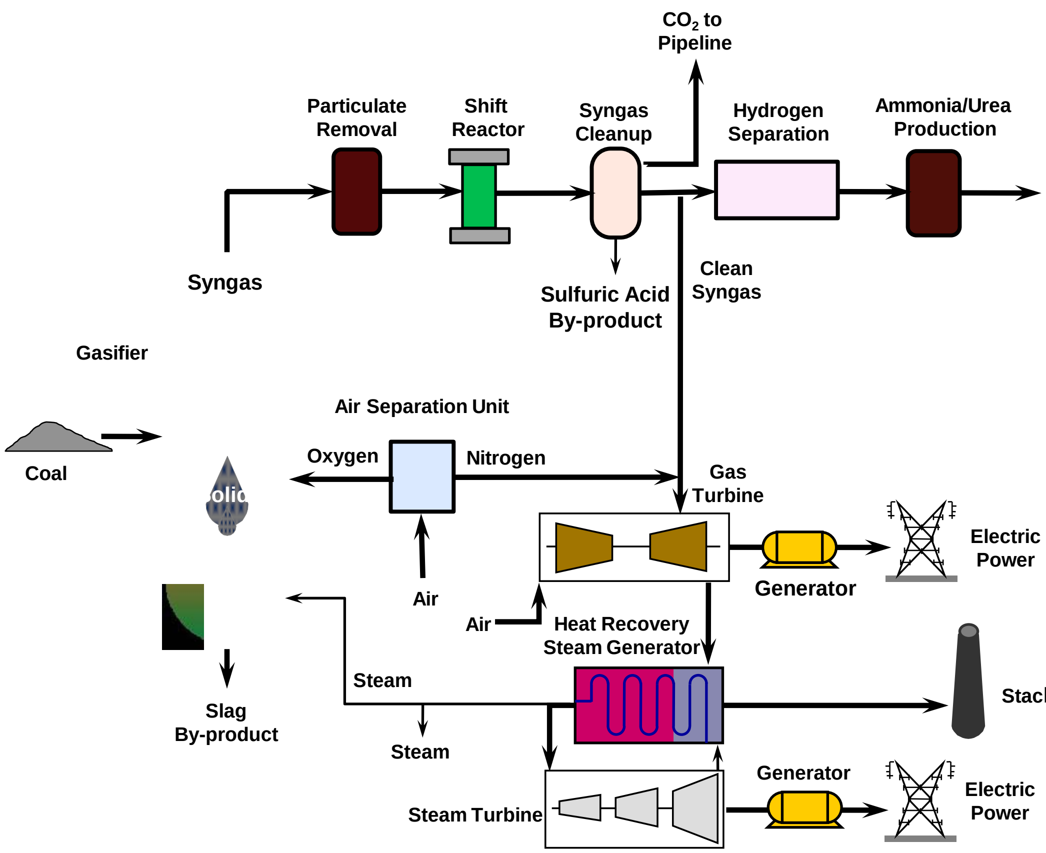

Figure 2.2. TCEP gasification, power generation, and urea production.

Next, the syngas would flow through a water-gas shift reactor. In that system, steam would be injected in the syngas over a catalyst bed, initiating a reaction where the CO in the syngas would be converted to CO_2 and the steam would be converted to additional H_2 in the syngas stream. This would provide a syngas stream that is concentrated in both CO_2 and H_2. Subsequently, the syngas would pass through a Hg removal system and then an acid gas removal system where first the sulfur species would be removed. Next, the CO_2 would be removed, creating a clean, H_2-rich concentration syngas upon exiting the acid gas removal unit. The captured CO_2 would be further cleaned and compressed, and then transported by a short pipeline to an existing regional CO_2 pipeline or, potentially, to a nearby EOR field. A portion of the captured CO_2 would also be used to produce urea. The H_2-rich syngas stream would be split, where part would be used to produce electricity and the other part would be used to produce urea for fertilizer.

Argon and H_2SO_4 are by-products of the gasification process and would be made available for commercial sale. Inert slag, another by-product of the gasification process, would be sold for manufacturing and construction uses or disposed of off-site.

2.4.1.2 POWER GENERATION

For the TCEP, the clean, H_2-rich, low-CO_2 syngas would be combusted in a combustion turbine-generator, generating electricity. Combustion of the H_2-rich fuel gas would produce water vapor and a low-CO_2 exhaust gas with significantly lower CO_2 emissions than would occur if the coal itself, or the raw syngas, had been combusted. The exhaust gas would be ducted through an HRSG, which would generate high-temperature, high-pressure steam. This steam would be piped into a steam turbine-generator, which would generate additional electricity. This integration of the combustion turbine-generator, HRSG, and steam turbine-generator is known as a combined-cycle power plant, and is presently one of the most efficient means for generating electricity because two opportunities are used to produce electricity from coal, instead of one steam turbine-generator alone.

The combined power generation from the combustion turbine-generator and the steam turbine-generator would be approximately 400 MW (gross) with 213 MW sent to the grid, on average, and the remainder being used to run the plant's equipment. The electricity sold would be transmitted to the regional electrical grid by a high voltage transmission line system. Natural gas would be used to start up the polygen plant and as a backup fuel (natural gas would also be used during operations to heat drying gases, supply an auxiliary boiler, and provide burner pilot flames such as for flares).

2.4.1.3 Fertilizer Production

With two Siemens gasifiers, the TCEP would produce more syngas than could be used for electricity production. The additional syngas produced would be converted to NH_3 using the Haber process. In that process, the H_2 in the syngas is reacted with N_2 from the air separation unit, forming NH_3. Downstream, the NH_3 is reacted with a portion of the CO_2 from a syngas cleanup system, thereby forming urea in a Bosch-Meiser process. The urea is produced as a granular product common in the fertilizer industry.

2.4.2 Process Components and Major Equipment

The site layout of the polygen plant is shown in Figure 2.3. A process flow diagram for the TCEP is shown in Figure 2.4. The process components and major equipment shown in the process flow diagram are described below.

2.4.2.1 COAL RECEIVING, STORAGE, AND HANDLING SYSTEM

At full load, the TCEP would consume approximately 5,800 tn per day (5,262 t per day) of Powder River Basin sub-bituminous coal, which would be delivered to the site by rail from Wyoming. A single system for receiving, storing, and handling coal would feed both gasifiers. The coal handling system would consist of a railcar unloading facility, a coal storage system, a reclaim system, a coal crushing system, and a silo fill system. The function of this system would be to unload coal from unit trains, convey it to the active storage pile, recover the coal from the storage pile, crush the coal, and convey it to the coal silos in the coal grinding and drying building.

The railcar unloading system would consist of rapid-discharge, bottom-dumping railcars with an automatic continuous dumping system. The rail unloading hopper would be capable of unloading coal from the railcars at a rate of 4,000 tn (3,628 t) per hour. Belt feeders would transfer coal from the unloading hoppers to a conveyor, which would transfer coal to the coal storage piles.

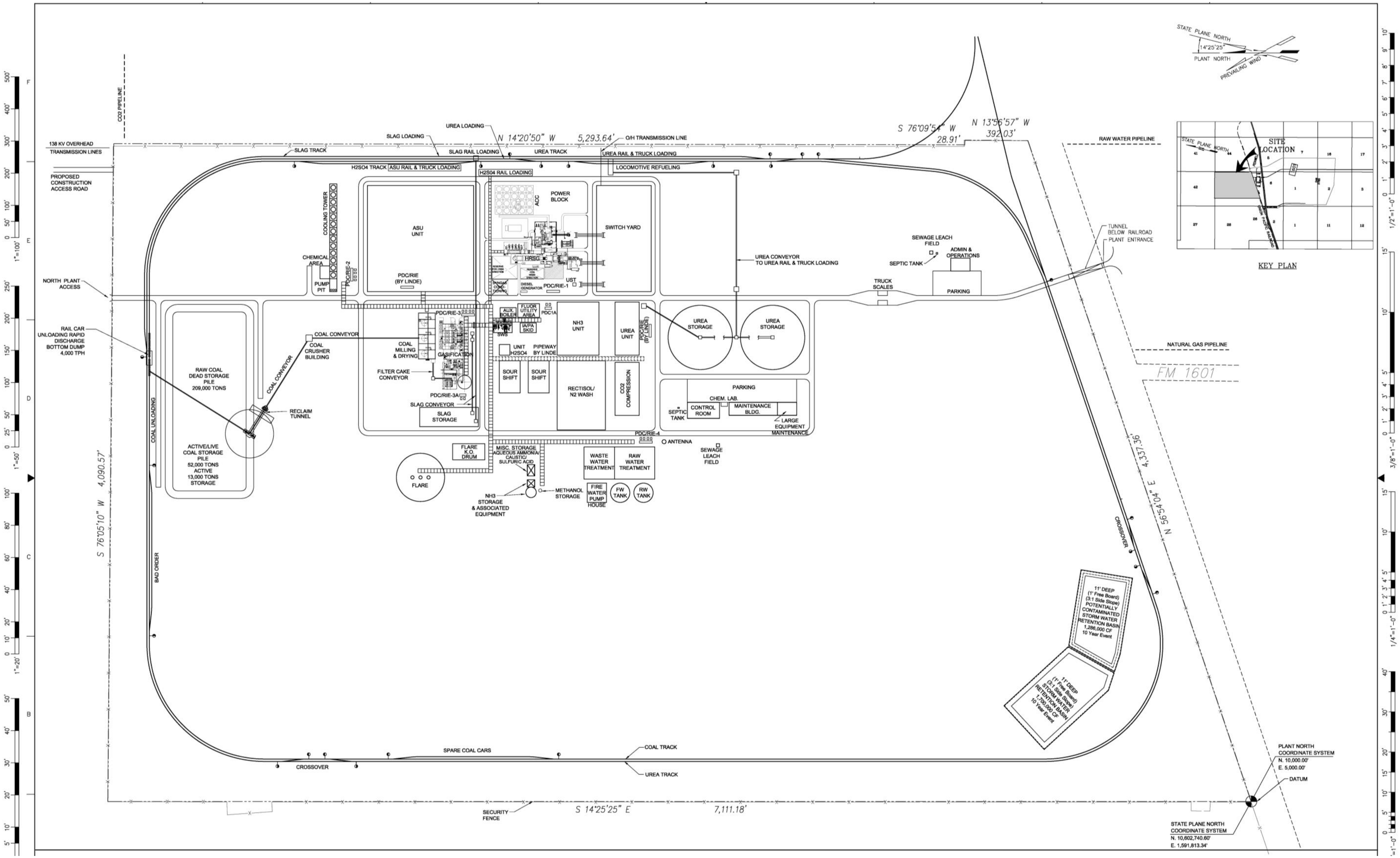

Figure 2.3. Polygen plant layout.

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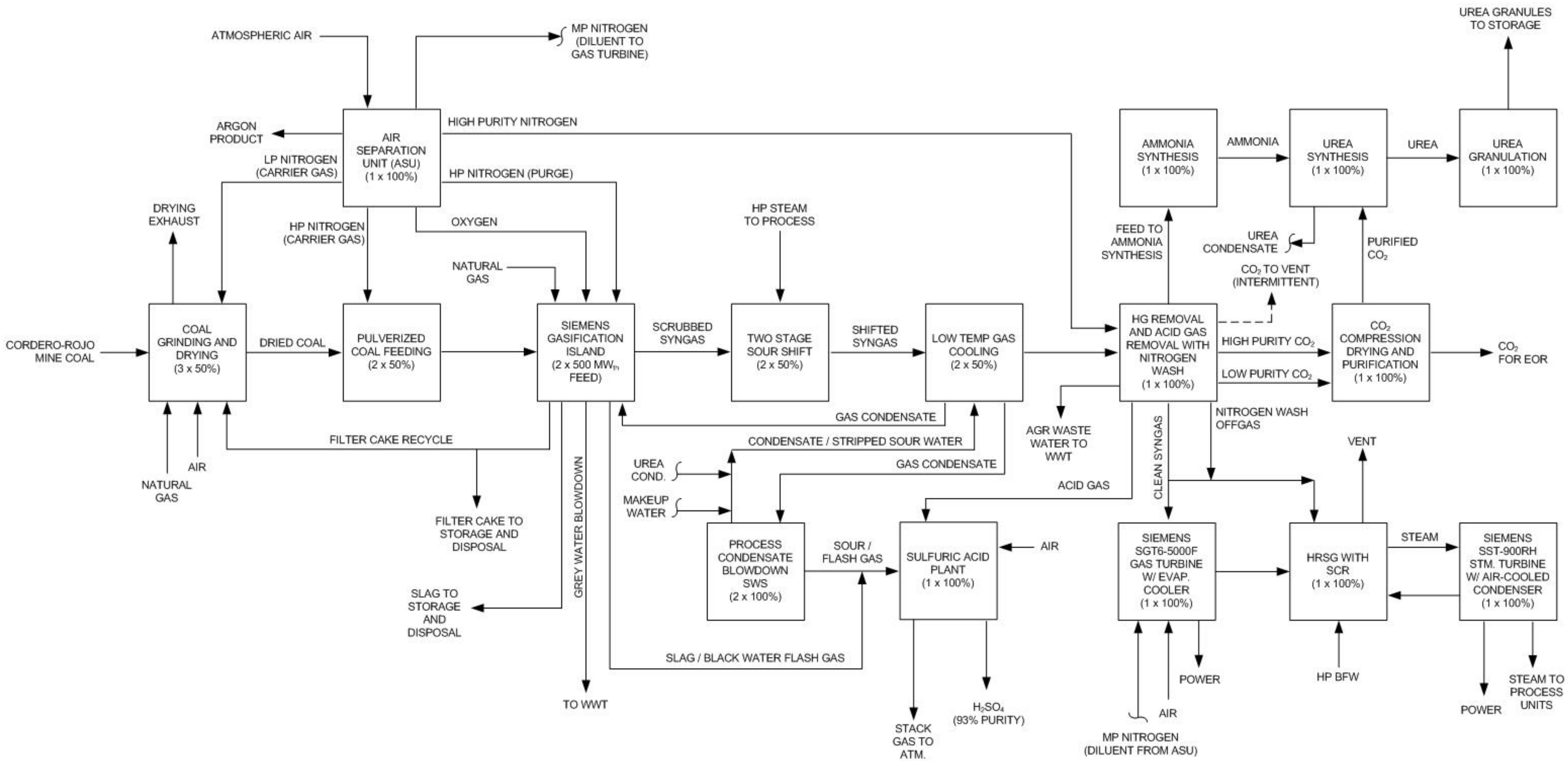

Figure 2.4. TCEP process flow diagram (Summit 2010a).

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From the coal pile, coal would be gravity-fed into the reclaim hoppers located below the pile. Reclaim belt feeders would transfer coal from the reclaim hoppers at a rate of 1,000 tn (907 t) per hour, to the crusher feed conveyors, which would transfer coal to the surge bin in the crushing system. From the surge bin, coal would be transferred to crushers by the crusher belt. Two crushers, each sized to process 1,000 tn (907 t) of coal per hour, would be used. A series of conveyors would transfer crushed coal from the crushers to the coal grinding and drying feed silos. All conveyors would be completely enclosed to reduce noise, and all coal handling buildings would be fully enclosed with dust suppression sprays and collection systems used to control dust and noise.

2.4.2.2 COAL DRYING AND GRINDING SYSTEM

The coal would be simultaneously dried to approximately 8 weight percent moisture and ground to less than 200 micrometers in diameter in two bowl mills. A traveling trip conveyor would feed each of the three grinding trains, distributing the coal into feed bins serving each train. Hot drying gases (heated by combusting natural gas) would also enter the mill from the bottom, and then carry the dried, crushed coal and gases out of the mill and to a cyclone classifier, which would return particles larger than the desired size to the mill. A portion of the spent hot drying gas would be purged through a dust collector (fabric filter) and vented to the atmosphere. Collected dust would be combined with the coal from the cyclone. The dry, ground coal would then be pneumatically conveyed (using N_2 gas) to the individual storage bins that serve each gasifier.

2.4.2.3 AIR SEPARATION UNIT

A single air separation unit would provide O_2 gas and N_2 gas for the entire TCEP plant. The air separation unit would produce 99.5 percent pure O_2 gas for use as an oxidant in the gasifiers, and 99 percent pure N_2 gas for use as a diluent in the combustion turbine and for producing urea fertilizer. In addition, N_2 gas at various pressure levels would also be used as a carrier gas for feeding the dried, pulverized coal to the gasifiers and for purging purposes in the gasification island. Producing high-purity O_2 gas in the air separation unit would also allow for a high-purity stream of argon gas to be recovered. This is a commercially marketable product.

For startup and shutdown purposes, and to enhance overall plant availability, liquid O_2 and liquid N_2 storage would be provided for 12 hours of plant operation.

2.4.2.4 GASIFICATION ISLAND

The gasification island would use two Siemens SFG-500 entrained flow, O_2-blown gasifiers to produce a raw syngas from the pulverized coal. The gasification island includes a pulverized coal feeding system, two gasifiers (including the quench sections), raw syngas scrubbers, black water treatment, and a slag discharge unit. The Siemens gasification island is shown in Figure 2.5.

<u>Gasifiers</u>

The coal feeding system would receive the pulverized and dried coal from the drying and grinding system described above, and feed it into the gasification reactors where the gasification reactions would take place. The coal would be almost totally gasified in this high-temperature environment to form raw syngas consisting principally of H_2, CO, CO_2, and water. The inorganic materials in the coal would be converted to a hot, molten slag. The hot raw syngas and the molten slag would leave the gasifier (shown as the reactor in Figure 2.5) and flow downward into the quench section. There, the raw syngas would be cooled by the injection of water, and the molten slag would solidify in the bottom of the quench section.

The mixture of granulated slag, quench water, and some unreacted char forms a mixture referred to as *black water*. The black water stream would be removed from the quench chamber and treated in the black water treatment plant. A portion of that stream would be recycled for use as quench water, with the remainder being cleaned further for use in other areas of the plant. The slag removed from the quench sump would be dewatered and conveyed to the slag handling, storage, and loadout system (see description below). Water carried out of the slag discharge system would be collected and pumped to the black water treatment plant. Water needed in the slag discharge system would be recycled from the black water treatment plant.

The raw syngas from the quench section would be sent to a Venturi scrubber system for removal of fine ash, chlorides, and char. A portion of the scrubber water would be directed to the black water treatment plant. To reduce fine particles in the raw syngas, a partial condenser would be installed downstream of the scrubber unit. A flash flare port with emergency depressurization would be located immediately downstream of the separator. During startup and in emergency situations, the raw syngas would be burned in a flare, with the exhaust gases vented to the atmosphere.

Black Water Treatment Plant

The black water treatment system would include one flash vessel for each of the two gasifiers, chemical dosing (for precipitation and flocculation to remove suspended solids), a settling basin, the waste water vessel, and a sludge filter press.

Liquid effluents from the quench chambers, the slag discharge units and overflow scrubbing water from the syngas scrubbers, as well as remaining syngas condensate, would contain fine PM, soot, salts, and condensed heavy metal sulfides removed from the syngas stream. The pressurized black water would be sent to the flash vessels to remove excess gases and to cool the black water.

The pretreated black water would then pass through the precipitation and flocculation steps, where flocculants would be added to stimulate coagulation and settlement of soot and fines. Fine slag and precipitate would be removed in a settlement basin, thickened and dewatered using a fabric filter to separate the precipitate (solids) from the black water stream. Most of the dried filter cake (containing a large fraction of carbon) would be mixed with coal and recycled in the gasifiers to produce more syngas, and the remainder would be containerized for appropriate off-site disposal. A portion of the clear effluent of the settlement basin (< 0.1 percent dry solids) and the filtrate of the filter unit would be collected and mixed with softened water for recycle to the gasification island for use in the quench and slag discharge systems. The remaining effluent, which would contain a high concentration of chloride salts, would be piped to the ZLD brine water treatment system for further treatment.

Slag Handling, Storage, and Loading

This system would remove and collect inert gasifier slag and convey it to storage for the loadout system. The inert slag would be collected in the slag trough and conveyed to a covered storage area. The storage area would be periodically emptied by front-end loaders moving the slag to chain reclaimers. The chain reclaimers would convey the slag onto belt conveyors that transfer the slag to a loadout for rail or truck.

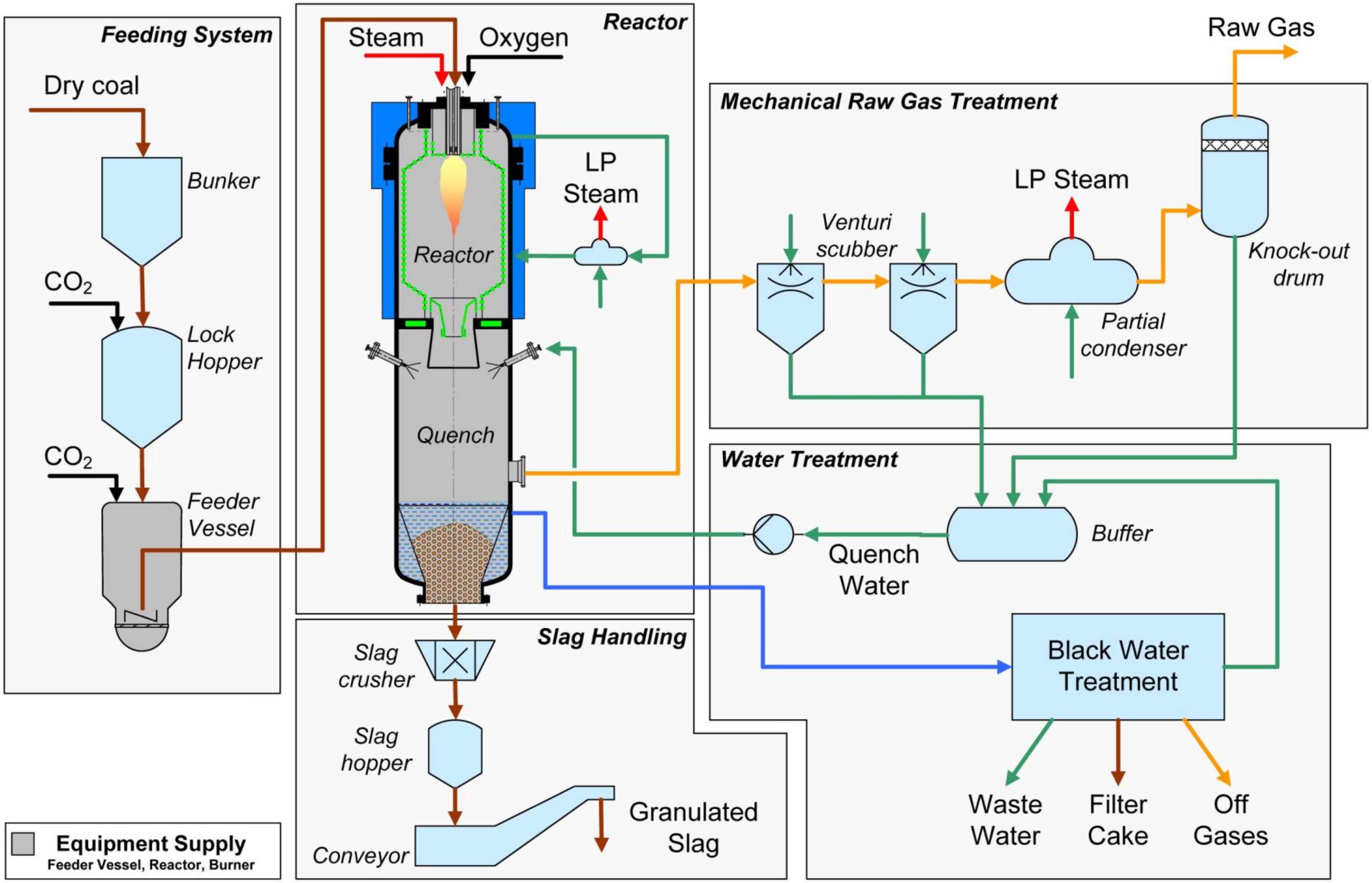

Figure 2.5. Siemens gasification island (Siemens 2010).

Slag from coal gasification and IGCC plants can be used in the manufacture of cement, as a road base, for manufacturing roofing tiles, as an asphalt filler, and as a sandblasting agent. The TCEP plans to sell the slag for such uses. Should the slag not be sold, it would be trucked or sent by rail to a permitted off-site solid waste landfill.

2.4.2.5 WATER-GAS SHIFT, LOW-TEMPERATURE GAS COOLING, AND MERCURY REMOVAL UNITS

The hot raw syngas would be further cooled and cleaned for use downstream for power generation and urea production. The main process units are described below.

Water-gas Shift Unit

To increase the H_2 content and decrease the CO content of the syngas for low-CO_2 power generation and for production of urea, the water-gas shift reaction would be used to shift the syngas composition. In the shift process, CO present in the raw syngas from the gasification island would react with steam over a catalyst bed to produce CO_2 and H_2. Once the syngas is shifted to a high concentration of CO_2, the CO_2 could be efficiently removed downstream, thereby removing most of the carbon from the syngas used in the combustion turbine.

The water-gas shift unit is also called a sour shift unit because the water-gas shift reactions would be accomplished prior to the acid gas removal, meaning that the syngas would still contain large amounts of hydrogen sulfide (H_2S) and carbonyl sulfide (COS). Because the shift reaction would release energy in the form of heat, the reaction equilibrium would favor high CO conversion at lower temperatures, and low CO conversion at higher temperatures. The heat from the shift reaction would be used to generate steam for use in other areas in the polygen plant.

In addition to converting CO, the shift catalyst would convert COS in the syngas to H_2S, which would be much easier to remove in the acid gas removal system than COS. After H_2S removal, there would be a low-sulfur syngas, which would minimize sulfur dioxide (SO_2) emissions in the combustion turbine exhaust and would reduce sulfur in the feed stream sent to the urea plant.

Low-temperature Gas Cooling Unit

Effluent from the water-gas shift unit would be cooled further in the low-temperature gas cooling unit. Water would condense from the syngas as it was cooled. This condensate would be collected, heated, and returned to the gasification island for use in the syngas scrubber. The cooled scrubber gases, which would contain sulfur gases, would be sent to the H_2SO_4 plant. The cooled syngas would be sent to the Hg removal unit.

Mercury Removal Unit

Hg removal would be accomplished by passing the syngas through sulfur-impregnated activated carbon beds, where the Hg compounds would be adsorbed and converted to stable mercuric sulfide. The system is expected to achieve greater than 95 percent Hg removal from the syngas, based on the performance of this technology in other coal gasification plants. At the end of their useful life, the carbon beds would be removed and transported off-site to appropriate facilities for disposal or recovery of the Hg compounds.

2.4.2.6 ACID GAS REMOVAL

The clean, shifted syngas stream would be sent to a Rectisol® acid gas removal system, which would use concentrated methanol (greater than 99 percent by weight) as a solvent in a recirculating wash column to physically dissolve and remove the acid gas components (H_2S, COS, and CO_2), produce two syngas streams of different qualities for downstream use, and produce concentrated streams of H_2S and CO_2 for downstream processing.

The H_2S and COS would be removed in the lower section of the Rectisol® wash column, with the CO_2 being removed in the upper section. Clean syngas streams would exit the Rectisol® system for downstream use. The first syngas stream would be rich in H_2 with a very low content of CO_2 and a total sulfur concentration of less than 0.1 parts per million by volume (ppmv). Approximately 75 percent of the syngas would be sent to the power block as a fuel for the combustion turbine. The remainder of the H_2-rich syngas would be sent to the N_2 wash unit for final purification before going to NH_3 synthesis and production of urea. The second syngas stream would contain a very low concentration of CO_2 in a range of 0.5 to 1 percent by volume, and would be used as a fuel gas in the duct burners in the power block. The sulfur-containing gases that are captured and removed would be sent to the H_2SO_4 plant.

The captured CO_2 would exit the acid gas removal system in low-purity and high-purity streams. The high-purity CO_2 stream would be sent to the urea synthesis plant. The low-purity stream and the remaining part of the high-purity CO_2 stream that could not be used in the urea production plant would be combined, dried, and compressed for off-site use in EOR.

The methanol storage tank for the Rectisol® system would be designed to store about 535,000 gallon (gal) (2,025,195 liters [L]), which is the total liquid methanol inventory of the Rectisol® unit plus the solvent make-up requirement for a minimum of three months. The methanol storage tank would be equipped with an appropriate fire protection system.

2.4.2.7 SOUR WATER TREATMENT

The coal gasification process would generate the following sour (sulfur-bearing) waste water streams:

- Gray water effluent from the black water clarifiers
- Black water clarifier sludge from the gasification block
- Syngas condensate from the raw syngas stream in the piping and in the syngas coolers upstream of the acid gas removal unit

The TCEP would incorporate a sour water stripper to treat sour waste water streams from the gasification process. The sour water stripper column would remove both H_2S and NH_3 from the sour water stream and return the treated water back to the gasification island for reuse.

The combined feed (from the sources listed above) would first enter a degassing drum, where dissolved gases would be released, and entrained oil and solids would be removed. The overhead from the degassing drum would be combined with the overhead from the downstream sour water stripper and sent to the H_2SO_4 plant. After degassing, the water temperature would be increased by heat exchange with the stripped sour water from the sour water stripper. The heated sour water would be fed to the steam reboiled sour water stripper. Most of the NH_3 in the sour water feed would be removed in this column. Sodium hydroxide would be injected as needed to facilitate the release of NH_3 from the condensate. Stripped sour water would then be sent to the ZLD system for cleaning.

2.4.2.8 SULFURIC ACID PLANT

Acid gas streams from the acid gas removal and sour water treatment units, along with flash gas from the gasification island, would be sent to the H_2SO_4 plant (a single 100-percent capacity unit). The H_2SO_4 plant would be recovered using a catalytic process to generate commercial-grade, concentrated H_2SO_4. The feed streams would be combusted with air to convert the sulfur compounds to SO_2. Natural gas would be used in normal operations for startup, support, and burner pilot flames.

Flue gas from the burner would be cooled by generating superheated steam in a waste heat boiler. The cooled process gas would be sent to a selective catalytic reduction system to reduce nitrogen oxides (NO_X) formed during combustion. After NO_X reduction, the gas would enter a catalytic SO_2 converter, where SO_2 would be oxidized to sulfur trioxide. Between each stage of the converter, the gas would be cooled through inter-bed coolers to maximize the conversion in each reactor. Heat from the gas exiting the SO_2 converter would be used to boil water, thereby cooling the effluent gas. During the cooling, most of the sulfur trioxide would react with water in the process gas to form gaseous H_2SO_4. Cooled process gas would condense in the form of concentrated H_2SO_4, and the remaining cleaned gas would exit as tail gas. Hot acid leaving the condenser would be cooled prior to being sent to storage. Concentrated H_2SO_4 product would be stored in a carbon steel tank coated with a fluorinated polymer. The on-site storage tank would hold approximately 36,000 gal (136,275 L) of H_2SO_4, or about four days of production. The product would be pumped from the storage tank to either rail tank cars or trucks for transportation off-site.

The tail gas from the condenser section would be routed to a tail gas scrubbing system consisting of a quench tower, scrubber column, mist filter, and clean gas blower. The gas would first enter a quench tower, where the temperature of the stream would be reduced by evaporating water into the gas. After being cooled, the gas would be routed to a packed scrubber tower to be treated with hydrogen peroxide to remove any residual SO_2. Finally, the overhead vapor would pass through an electrostatic mist filter to remove entrained acid mist. The cleaned gas would be sent to the H_2SO_4 plant stack.

2.4.2.9 CARBON DIOXIDE COMPRESSION AND DRYING

The CO_2 captured by the Rectisol® process would be dried, compressed, and split into two streams. The acid gas removal system would provide CO_2 at several pressure levels. CO_2 recovered at lower pressure would be routed to a low-pressure CO_2 compressor to be compressed in multiple stages with cooling between each stage. After exiting the low-pressure CO_2 compressor, the compressed gas would be mixed with the flash gas recovered from the high-pressure drum and sent to a drying package. Residual water would then be removed using molecular sieve technology. This CO_2 stream would be further compressed in the high-pressure CO_2 compressor. Some of the intermediate-pressure CO_2 would be passed through two catalytic reactors to remove residual H_2S and COS. After purification, this stream would be compressed and the majority of the CO_2 would be transported off-site for EOR, whereas the remainder would go to the urea facility.

2.4.2.10 LIQUID NITROGEN WASH

The H_2-rich syngas stream exiting the Rectisol® acid gas removal system, along with high-pressure N_2 from the air separation unit, would be fed to the liquid N_2 wash unit. Traces of water, CO_2, and acid gas removal solvent (methanol) would be removed in the adsorber unit. Both incoming streams of H_2-rich fuel gas and high-pressure N_2 would be cooled against product gas. The syngas stream would be fed to the bottom of the N_2 wash column, and high-pressure N_2 would be fed at the top of the column. Trace components (offgas) would be removed and separated at the bottom of the column as a fuel that would be used in the duct burners (direct fired gas burner located in the combustion turbine exhaust stream) in the combined-cycle power block (see Section 2.4.2.14). The pure H_2 product gas would exit at the top of the column, then through the heat exchanger (against the incoming H_2-rich fuel gas and high-pressure N_2).

2.4.2.11 AMMONIA SYNTHESIS UNIT

The hydrogen stream from the N_2 wash would be compressed and cooled, then mixed with N_2 from the air separation unit. This combined hydrogen and N_2 stream would be sent to a multi-bed catalytic reactor in which the NH_3 concentration would be increased using an iron-based catalyst. Liquid NH_3 from the bottom of the separator would be fed to another separator operating at a lower pressure. The liquid recovered from this vessel would be sent directly to a receiver in the refrigeration section of the NH_3 synthesis plant. Liquid NH_3 would enter the receiver, where it would be split into two streams. Multiple heat exchangers would be used to cool the liquid streams before routing them to one of two separators. Vapor from these separators would combine with the compressed NH_3 vapor from the storage tank and would be recycled back to the receiver at the front of the refrigeration section. Liquid NH_3 product from the bottom of the separators would be pumped to storage.

2.4.2.12 UREA SYNTHESIS UNIT

The urea synthesis unit would take the NH_3 product and convert it to urea. CO_2 from the acid gas removal unit would be compressed and sent to a urea reactor where it would combine with liquid NH_3 from the NH_3 synthesis unit. Ammonium carbamate would be formed and then would be allowed to decompose to urea.

The concentrated urea solution would be sprayed by a liquid jet into a granulator bed. The bed of particles would be fluidized with fluidization air. When the particles reached a desired size, they would fall through a bottom grid on the bed. The urea granules would be subsequently cooled. A fraction of the particles leaving the granulation bed would be sent to a crusher. The finer particles would act as seeds for growing urea granules in the granulation bed. The air exiting the granulator would be scrubbed with water to remove traces of urea before being directly vented to the atmosphere. The plant would include storage facilities for 40 days of urea production, not including railcars. The urea synthesis unit would produce 1,485 tn (1,347 t) per day of urea, requiring the input of 1,080 tn (980 t) per day of CO_2.

2.4.2.13 UREA HANDLING

The urea handling system would transfer urea from the urea synthesis unit to the rail loadout. A transfer conveyor would deliver urea from the plant to the tripper conveyor, which would transfer the urea to four storage domes at a rate of 150 tn (136 t) per hour. Another conveyor would pick up and transfer the urea from the storage domes to the urea loadout conveyor, which would then carry the urea to the loadout bin. Urea would be loaded into railcars for shipment to market at a rate of 400 tn (362 t) per hour, using a telescoping chute. The conveyors would be fully enclosed for weather protection and to control fugitive dust. All urea handling buildings would be fully enclosed or would have dust collection or control systems.

2.4.2.14 COMBINED-CYCLE POWER BLOCK

The IGCC power block would consist of a Siemens SGT6-5000F3 combustion turbine-generator configured to use either H_2-rich syngas or natural gas (as a startup and backup fuel), an HRSG, a duct burner using a mixture of syngas and liquid N_2 wash system offgas as a fuel, a reheat steam turbine-generator, an air-cooled condenser, flash drums, condensate pumps, and boiler feed water pumps.

The combustion turbine would be specially designed to combust a preheated H_2-rich syngas as the primary fuel with natural gas as the startup and backup fuel. The H_2-rich syngas would be diluted with high-pressure N_2 from the air separation unit. The addition of N_2 to the syngas, along with injection of additional N_2 at certain locations in the combustion zone inside the combustion turbine, would accomplish two key goals: 1) cooling the combustion flame which reduces the formation of thermal NO_X, and 2) increasing the mass flow through the combustion turbine, boosting the combustion turbine power output. The combustion turbine would have a nominal electric generating capacity of 230 MW.

The HRSG would convert the heat in the combustion turbine exhaust to steam, which would then be piped to the steam turbine, where it would be used to generate additional power. This configuration, which integrates the combustion turbine with the HRSG and a steam turbine-generator, is called a combined-cycle power plant and is one of the most efficient technologies for generating electricity. When conditions required additional power-generation capacity, duct burners fired with syngas and offgas would augment the energy contained in the combustion turbine exhaust, producing additional steam for the steam turbine.

The feed water system would move and control water flow through the HRSG to generate steam. The steam system would consist of three sections: high-pressure steam, reheat steam, and low-pressure steam. Some steam would be transferred to other locations in the plant to support functions other than driving the steam turbine. Superheated high-pressure steam would be supplied to the high-pressure section of the steam turbine by the HRSG. The exhaust from the high-pressure section of the steam turbine is called cold reheat steam because it is reduced in temperature and pressure. This steam would be returned to the HRSG, then reheated and combined with additional intermediate-pressure steam produced in the HRSG, and then sent to the intermediate-pressure section of the steam turbine as hot reheat steam. Exhaust from the intermediate-pressure section of the steam turbine (low-pressure steam) would be combined with low-pressure steam from the HRSG to supply the low-pressure portion of the steam turbine. Exhaust from the low-pressure portion of the steam turbine would be cooled in the air-cooled condenser.

2.4.3 Plant Utility Systems

The following plant facilities would also be components of the TCEP.

2.4.3.1 COOLING SYSTEM

Two types of cooling systems would be used at the polygen plant, wet and dry cooling. An air-cooled condenser would be used for the combined-cycle power block. For the chemical process portion of the polygen plant, units requiring cooling to temperatures less than 140 degrees Fahrenheit (60 degrees Celsius) may use wet cooling if other chilled process fluids are not available for heat transfer cooling. Air cooling (using the dry cooling tower) may be used for the chemical process portions of the polygen plant where less cooling is required. Makeup water for the wet cooling tower would be obtained from treated municipal waste water or, under some options, ground water. Cooling tower blowdown from the wet cooling tower would be directed to the ZLD system. The cooling tower would be equipped with a drift eliminator designed to limit drift losses to 0.001 percent of the circulation rate.

2.4.3.2 FLARE SYSTEMS

Flare systems would be provided to allow for the safe venting of gases produced during startup, shutdown, and upset conditions. Two flares, each approximately 200 feet (ft) (61 meters [m]) high, would be provided. The gasification island flare would be designed to burn 1) syngas associated with process operations and purges associated with normal gasifier operation, 2) nonspecification syngas generated during unit startup, 3) syngas generated during short-term combustion turbine outages, and 4) syngas released from pressure-relief valves used to protect against overpressure of individual pieces of process equipment.

Syngas sent to the flare during normal flaring events would be filtered, water-scrubbed, and further treated in the acid gas removal system to remove regulated contaminants prior to flaring. Flaring of untreated syngas or other streams would only occur as an emergency safety measure during unplanned plant upsets or equipment failures.

As part of the design of the flare systems, a natural gas–fueled pilot would remain lit on each flare during normal operation to ensure the flares are available if needed. During normal operation, heat input to each flare would include 300 standard cubic ft (ft^3) per hour (27.8 cubic m [m^3]) of natural gas used for pilot lights. The maximum estimated air pollutant emissions (in pounds per hour) are based on flaring the entire raw syngas flow from one gasifier operating at 60 percent capacity. This peak flaring rate would occur during planned gasifier startups. Annual emissions are based on the equivalent of 60 startups and shutdowns per gasifier each year, and three hours of flaring at the maximum hourly flow rate to the flare. The total raw syngas flow during a flaring event could either go to one flare or it could be split between the two flares.

The primary air contaminants in the raw syngas stream would be CO and H_2S, with trace amounts of COS and NH_3. Estimated CO emissions from the flares are based on 98 percent destruction of the CO (by combustion with air) in the flared stream. NO_X emissions are based on the TCEQ-approved factor for flares plus 50 percent conversion of the NH_3 to NO_X. H_2S and SO_2 emissions are based on 98 percent conversion of the H_2S and COS in the stream being converted (by combustion with air) to SO_2.

2.4.3.3 AUXILIARY BOILER

An auxiliary boiler using natural gas for fuel would be included. The boiler would have a maximum firing capacity of 250 trillion British thermal units (Btu) per hour (higher heating value). The boiler would be primarily used during startup and shutdown. The auxiliary boiler would be equipped with ultra-low NO_X burners and flue gas recirculation to control NO_X emissions.

2.4.3.4 BRINE WATER SYSTEMS

Brine water discharges would be handled by either the ZLD system or deep well injection, as follows.

Zero Liquid Discharge System

The primary brine water sources for the TCEP would be the oil water separator, urea condensate, gasification gray water purge, acid plant tail gas scrubber effluent, shift stripper purge, Rectisol® waste, cooling tower blowdown, contact and noncontact storm water and miscellaneous IGCC plant washdown wastes. The largest volume of brine water would be generated by the wet cooling tower blowdown, which would be treated using lime softening and reverse osmosis to recover most of the water for reuse at the plant site. All brine water would be treated on-site by the ZLD system with no liquid wastes being discharged. The polygen plant is being designed to optimize water reuse through recycling of process waste streams, thus minimizing the overall volume of process water required for the project and the volume of brine water to be treated by ZLD system. The primary ZLD system proposed for the project would consist of a brine concentrator and/or crystallizer, which would evaporate the reverse osmosis stream, thus forming a solid cake. A filter press or centrifuge may also be required to remove water from the ZLD unit. The solid filter cake would be transported to a licensed landfill for final disposal. The cake is expected to be nonhazardous but would be tested to confirm its characteristics.

An alternative option for the ZLD system is being considered for the TCEP. This option would use solar evaporation pond(s) in place of the brine concentrator and filter press system. The concentrated liquid wastes would be placed in the solar evaporation ponds that would be constructed with multiple individual cells that would facilitate the removal of the concentrated solids for disposal at an existing approved landfill. A minimum of two evaporation ponds would be constructed under this option. The size of the evaporation ponds would be dependent upon the final volume and source of the process water.

Deep Well Injection of Nonhazardous Brine Water

Another alternative option to the ZLD system described above would be the use of deep well injection of the reverse osmosis brine water. Under this option, the reverse osmosis brine water would be disposed of using up to three deep injection wells. The maximum instantaneous injection rate would be 126 gal (126 L) per minute, with an average rate of 85 gal (321 L) per minute over the 30-year design life of the polygen plant.

The injection wells would deliver the reverse osmosis brine water from the surface to the underground geologic Queen Formation through tubing, in conformance with requirements for Class I injection wells. The injection casing would be perforated in the Queen Formation at intervals selected using the results of geophysical logging.

Class I injection wells are used for deep injection and are regulated by the TCEQ.
Class II injection wells are related to energy by-products and are regulated by the Railroad Commission of Texas (RRC).
Class III injection wells are used to extract minerals other than oil and gas and are regulated by the TCEQ or the RRC, depending on the type of well.
Class IV injection wells are generally banned but may be authorized by the TCEQ or EPA in certain environmental cleanup operations.
Class V injection wells are used for many different activities and are regulated by either the TCEQ or the RRC, depending on the type of well.

The injection well pumping station would be capable of pumping the peak flow estimated to be 126 gal (126 L) per minute with one pump out of service. This would provide 100 percent pumping redundancy. In addition, the polygen plant would have a redundant power supply and automatic transfer switch along with redundant programmable logic controllers to help ensure the polygen plant was always available for service. The overall system design would provide flexibility to operate over a wide range of flows and pressures up to 950 pounds (lbs) (431 kilograms [kg]) per square inch (in^2). The piping configuration would allow both pumps to pump to the injection well header and into all of the injection wells. Typically only one pump would be operated at a time.

2.4.3.5 EMERGENCY DIESEL ENGINES

One 350-horsepower, diesel-fueled fire-water pump and two 2,205-horsepower, diesel-fueled emergency generators would be located at the TCEP. The pumps and generators would only operate during emergencies and on regularly scheduled intervals for testing. It is estimated that these engines would be operated a maximum of 52 nonemergency hours per year each for testing. The engines would not operate during normal polygen plant operations.

2.4.3.6 STORM WATER MANAGEMENT

Storm water runoff would be directed to on-site retention/settling ponds to control peak discharge. The ponds would be sized based on the area of impervious surface on the polygen site and the maximum design storm-flow volumes. There would be no discharge from the storm water runoff ponds.

Any storm water runoff that came into contact with an area that had the potential for the presence of oil (such as water runoff from parking lots) would be directed to a separate retention pond and then on to an oil/water separator.

2.4.3.7 CONTROL SYSTEMS

The TCEP control system would allow monitoring and control of the plant to be accomplished from a central control room. From work stations, operators would monitor the plant processes and manipulate controls as needed to maintain efficient and safe plant operations. Engineering work stations would give the plant engineering workforce the ability to monitor plant operations and update software and control schemes as needed.

2.4.4 Disposition of Carbon Dioxide

2.4.4.1 PIPELINE NETWORKS

The TCEP's captured CO_2 up to a maximum of approximately 3 million tn (2.7 million t) per year would be transported by a 12-inch (in) (30-centimeter [cm]) steel pipeline to an interconnection with the existing Kinder Morgan Central Basin pipeline, which is located approximately 1.0 mi (1.6 km) east of the proposed plant site. From there, the CO_2 would be comingled in the pipeline with CO_2 from other sources and then transported through the existing and extensive CO_2 pipeline system in the Permian Basin where it would be sold and used for EOR.

The TCEP interconnection to the Kinder Morgan pipeline would be buried approximately 4 ft (1.2 m) below the ground surface. The interconnection would deliver the CO_2 at a pressure of approximately 2,000 lbs (907 kg) per in^2. The CO_2 delivered to the Kinder Morgan pipeline would meet the following specifications:

- Contain at least 95 mole percent of CO_2
- Contain no free water and no more than 30 lbs (14 kg) of water per 1 million ft^3 in the vapor phase
- Contain no more than 20 ppmv of H_2S
- Contain no more than 35 ppmv of total sulfur
- Not exceed a temperature of 120 degrees Fahrenheit (49 degrees Celsius)
- Contain no more than 4 mole percent of N_2
- Contain no more than 5 mole percent of hydrocarbons and the dew point would not exceed −20 degrees Fahrenheit (−29 degrees Celsius)
- Contain no more than 10 parts per million (ppm) by weight of O_2
- Contain no more than 0.3 gal (1.1 L) of glycol per 1 million ft^3, (2.8 million m^3) and at no time would such glycol be present in a liquid state at the pressure and temperature conditions of the pipeline

All of the potential CO_2 purchasers under consideration at this time are or can be connected to the Kinder Morgan CO_2 pipeline system, and there is no requirement for any other CO_2 pipelines to be constructed other than the proposed connecting pipeline to the Kinder Morgan system. However, there may be commercial reasons to prefer a direct pipeline connection from the TCEP to a CO_2 offtaker in some circumstances, although no such direct pipelines are currently anticipated. Should a direct pipeline be proposed in the future, the possible pipeline route (or routes) could require new ROW(s) and additional environmental analysis. A direct pipeline would not be expected to exceed 10 mi (16 km) in length. Because no direct pipelines are proposed at this time, no further analysis of that option is included in this document.

2.4.4.2 CARBON DIOXIDE MARKETS

Summit plans to sell most of the CO_2 captured by the TCEP for EOR in the Permian Basin of West Texas, with the remainder used to produce urea as discussed in Section 2.4.2.12. This commercially proven and long-established use of CO_2 is for tertiary production of oil (i.e., the third stage of production) at existing oil-producing fields. Primary production follows initial drilling and results from natural pressure in the oil reservoir or pumping of wells and gravity-induced flow in the reservoir toward producing wells. Secondary production comes from injection of water, which sweeps residual oil toward producing wells and helps bring additional oil to the surface. Injection of CO_2 is typically used to enhance production when production by water injection declines below economical levels. The use of CO_2 as a tertiary method of recovery usually produces an incremental 10 to 20 percent of the original oil in place, depending on the rock qualities.

The most likely potential buyers would be producers who already use CO_2 for EOR. Such producers may want more CO_2 than they are currently able to obtain (e.g., to expand their current CO_2 EOR), or they may want to buy Texas-generated CO_2 to obtain state tax benefits. It is likely that the TCEP's captured CO_2 would be sold to buyers that already use CO_2 for EOR, although other buyers could be oil producers that wish to commence using CO_2 to continue production at existing fields.

2.4.4.3 MONITORING, VERIFICATION, AND ACCOUNTING

Monitoring, verification, and accounting (MVA) measures provide an accurate accounting of stored CO_2 and a high level of confidence that the CO_2 is not being released or leaked to the surface. Such measures include EOR system material balance accounting, modeling, plume tracking, and leak detection.

Material balance accounting compares total injected CO_2 and CO_2 being recovered from oil production. Modeling involves putting field data into a representation of the CO_2 storage system. Usually computer models are used, and these provide helpful mathematical-numerical analysis and visualization of the system. The computer models provide a representation of the underground conditions that influence the behavior of CO_2 that has been injected into geologic formations and characterize the resulting pressure changes and fluid flow throughout the system. They may also provide a representation of certain types of geomechanical changes to the reservoir. Underground plume tracking provides the ability to map the injected CO_2 and track its movement and fate through a reservoir. Usually this is done by mapping pressure data from various wells in the field, although it may also be accomplished with repeat seismic surveys. CO_2 leak-detection systems provide critical measures of whether CO_2 is escaping from the storage reservoir at points or areas of monitoring.

A monitoring program for CO_2 injected in a reservoir for EOR serves the following purposes:

- Supports management of the injection process
- Identifies leakage risk or actual leakage and offers another layer of protection for drinking water aquifers located above the zones of injection. It provides early warnings if the CO_2 is migrating out of the intended reservoir zone
- Provides regulatory assurance that the injected CO_2 ultimately remains confined in the reservoir
- Meets monitoring requirements that may be required by carbon registries to verify carbon credits
- Verifies and provides input into reservoir models

The TCEP monitoring program would be specifically designed for each oilfield using CO_2 from the TCEP and would include one or more of the following approaches:

- Measuring to determine the mass of CO_2 injected, principally derived from the fluid pressure, temperature, flow rate, and gas composition at the wellhead
- Monitoring of the storage reservoir's pressure during the injection process using well gauges
- Using well data and seismic survey results, monitoring of the migration and distribution of CO_2 in the subsurface formation, focusing on the intended storage reservoir but including any unintended migration out of the storage reservoir
- Monitoring of the shallow subsurface through shallow wells to detect and quantify any CO_2 migrating out of the storage reservoir toward the ground surface
- Monitoring of the ground surface and atmosphere to detect and quantify CO_2 leaking into the biosphere

- Measuring and monitoring of the CO_2 that is produced with the oil, separated in the surface facilities, and reinjected into the storage reservoir

An operator implementing an EOR project with CO_2 is highly motivated to track and contain all the CO_2 purchased because it is expensive. If the CO_2 is lost out of the producing zone or vented into the atmosphere, the operator must purchase additional CO_2. This means that the operator is motivated to design the EOR project to minimize the loss of CO_2, either in the oil reservoir or in the surface facilities.

As part of the TCEP, Summit would work with EOR operators in the target field (or fields) to develop appropriate MVA measures, even though the CO_2 captured from the TCEP would be co-mingled with CO_2 from other sources. This effort would include coordination with the EOR field operators and the Texas Bureau of Economic Geology, which also functions as the State Geological Survey. Furthermore, all CO_2 injected for EOR in Texas is regulated by the RRC, which has been delegated Clean Water Act enforcement authority by EPA.

Summit has prepared a generic monitoring plan for the EOR sequestration of CO_2 that would be captured from the TCEP, and presented this plan for review to the Texas Bureau of Economic Geology (Summit 2010b). In the plan, Summit provided a suite of proposed monitoring technologies and noted that the final choice of specific monitoring technologies would be based on site-specific conditions taking into account the EOR site's geologic characterization and risk assessment. Table 2.1 describes these proposed MVA requirements.

Table 2.1. Summit's Proposed Monitoring, Verification, and Accounting for Carbon Dioxide Enhanced Oil Recovery Sequestration

Technology	Potential for Use
Baseline Monitoring	
Geochemical sampling*	Sampling of nearest aquifers and underground sources of drinking water zones would be conducted at least monthly for a year prior to CO_2 injection and more frequently if required by future regulations. Sensitivity analysis will determine which constituents will be sampled, sampling method, and frequency.
Mechanical integrity testing†	Mechanical integrity testing would be conducted by the operator in compliance with RRC regulations prior to initial injection of CO_2,
Pressure monitoring*	Pressure histories above the confining system will be monitored for one year prior to injection to determine trends from production and water disposal pre-injection.
Pressure testing†	Testing as required per RRC regulations prior to initial injection.
Operational Monitoring	
Geochemical sampling*	Sampling of nearest aquifers and underground sources of drinking waterzones would be conducted semiannually and more frequently if required by future regulations.
Mechanical integrity testing†	Mechanical integrity testing would be conducted by the operator prior to the initial injection of CO_2, and once every five years as required by the RRC. This frequency of testing may be increased if required by future regulations (EPA has proposed annual testing).
Pressure monitoring†	Pressure inside the injection tubing string and inside the annulus of the well would be measured continuously. Monitoring would also be performed periodically in the nearest underground sources of drinking water zones.

Table 2.1. Summit's Proposed Monitoring, Verification, and Accounting for Carbon Dioxide Enhanced Oil Recovery Sequestration

Technology	Potential for Use
Injection rate[†]	Injection rates would be measured continuously and reported monthly.
Pressure testing[†]	Testing is required prior to initial injection and once every five years thereafter. The frequency would conform to any change in regulations.
Material balance[†, *]	Material balances would be performed on a monthly basis on each injection pattern, comparing total injected CO_2 and CO_2 being recovered from oil production. The results would be compared to reservoir models for the injection pattern under review.

* Additional monitoring that EPA may require.

[†] Monitoring considered "business as usual" by industry.

2.4.5 Resource Requirements

Resource requirements for the TCEP include coal, land area, water treatment chemicals, natural gas, potable water, process water, transmission facilities, and transportation. These requirements are summarized in Table 2.2 and are described more fully below.

Table 2.2. TCEP Resource Requirements

Resource	Description
Coal	TCEP would use 5,800 tn (5.262 t) per day or 2.1 million tn (1.9 million t) per year of sub-bituminous coal from the Powder River Basin in Wyoming. The coal pile would be sized for about 45 days of total storage capacity, with approximately nine days of active storage and 36 days of inactive storage.
Natural Gas	2 trillion Btu (average annual use for startup, pilot burners, heating drying gases and other uses)).
Process Water	Annual peak water usage: up to 5.5 million gal (20.8 million L) per day.
	Annual minimum water usage: 3.5 million gal (13.2 million L) per day.
Potable Water	Peak construction (1,500 workers): 45,000 gal (170,000 million L) per day.
	Operation (150 workers): 4,500 gal (17,000 L) per day.
Electric Power	Construction power would be provided by connecting to a distribution line owned by Oncor Energy near the site.
Transportation	
Rail	The TCEP would require rail delivery of coal and some construction materials and equipment. The project may require rail transport off-site of construction and operational wastes and commercial products including argon, H_2SO_4, urea, and slag.
	Coal: maximum of up to five 135-car unit trains per day; average of up to three 135-car unit trains per week.
	Argon: Argon gas would be transported in rail tank cars.
	H_2SO_4: Up to one-half railcar per day would be filled and sold.

Table 2.2. TCEP Resource Requirements

Resource	Description
	Slag: up to five railcars per day.
	Urea: up to 15 railcars per day or an average of twenty 25-tn (23-t) trucks per day.
Truck (other materials [in and out])	The TCEP would require truck delivery for potable water, operations chemicals, and some construction materials and equipment. The project may also require truck transport off-site of construction and operational wastes and commercial products including argon, H_2SO_4, urea, and slag.
	Potable water (construction): forty-two 25-tn (23-t) trucks per week.
	Potable water (operations): five 25-tn (23-t) trucks per week.
	Slag: average of twenty 25-tn (23-t) trucks per day.
Land Area	
Polygen Plant	The polygen plant site would be constructed on 600 ac (243 ha). It is assumed that 300 ac (121 ha) of the site would be permanently developed.
Linear Facilities	All linear facility options are estimated to have a 100-ft (30-m) construction ROW and 50-ft (15-m) operational ROW. Temporary impacts during construction could range from 249 to 1,119 ac (101–453 ha), whereas permanent impacts from operations could range from 134 to 576 ac (54–233 ha), based on the smallest combination (WL2, TL4, CO_2, NG1, AR1, AR2, RR1) and largest combination (WL1, TL5, CO_2, NG1, WL4, AR1, AR2, RR1) of the linear facility options. Impact area details can be found in each linear facility description below.
Natural Gas Pipeline	
NG1	2.7-mi (4.3 km), 12-in (30-cm) diameter interconnection pipeline along FM 1601 from an existing 20-in-diameter main line operated by ONEOK located south of the polygen plant site; 100-ft (30-m) construction ROW and 50-ft (15-m) operational ROW; 32.7 ac. (13.2 ha) temporary impact and 16.4 ac. (6.6 ha) permanent impact.
Process Waterlines	
WL1	A 41.2-mi (66.3-km), 20- to 24-in (51- to 61-cm) diameter pipeline would be constructed south of I-20 from the City of Midland Wastewater Treatment Plant to the GCA Odessa South Facility and from there to the polygen plant site. A maximum of 501.9 ac (203.1 ha) of temporary impacts and 252.4 ac (102.1 ha) of permanent impacts could occur.
WL2	A 9.3-mi (15.0-km), 16-in (41-cm) diameter pipeline would be constructed to connect to an existing Oxy Permian pipeline northwest of the polygen plant site. A maximum of 113.5 ac (45.9 ha) of temporary impacts and 56.3 ac (22.8 ha) of permanent impacts could occur.
WL3	A 14.2-mi (22.9-km), 16-in (41-cm) diameter pipeline would be constructed to connect to the proposed FSH main waterline project southeast of the polygen plant site. A maximum of 172.4 ac (69.8 ha) of temporary impacts and 86.6 ac (35.0 ha) of permanent impacts could occur.
WL4	A 2.7-mi (4.3-km), 16-in (41-cm) diameter pipeline would be constructed from the proposed FSH main waterline to the GCA Odessa South Facility. A maximum of 34.3 ac (13.9 ha) of temporary impacts and 18.1 ac (7.3 ha) of permanent impacts could occur.
Transmission Lines	
TL1	A 9.3-mi (15.0-km) transmission line would be constructed to connect to the ERCOT grid. 75 percent of the line would parallel a section line and existing 138-kilovolt (kV) line. A maximum of 116.6 ac (47.2 ha) of temporary impacts and 60.6 ac (24.5 ha) of permanent impacts could occur.

Table 2.2. TCEP Resource Requirements

Resource	Description
TL2	An 8.6-mi (13.8-km) transmission line would be constructed to connect to the ERCOT grid. 90 percent of the line would parallel a section line, FM 866, and existing 138-kV line. A maximum of 117.8 ac (47.7 ha) of temporary impact and 65.5 ac (26.5 ha) of permanent impacts could occur.
TL3	A 2.2-mi (3.5-km) transmission line would be constructed to connect to the ERCOT grid. The line would require new ROW. A maximum of 31.5 ac (12.7 ha) of temporary impacts and 18.0 ac (7.3 ha) of permanent impacts could occur.
TL4	A 0.6-mi (1.0-km) transmission line would be constructed to connect to the ERCOT grid. The line would require new ROW. A maximum of 11.7 ac (4.7 ha) of temporary impacts and 8.1 ac (3.3 ha) of permanent impacts could occur.
TL5	A 36.8-mi (59.2-km) transmission line would be constructed to connect to the Southwest Power Pool (SPP) grid. The line would parallel a section line, existing transmission lines, roads, and would partially require new ROW. A maximum of 459.2 ac (185.8 ha) of temporary impacts and 236.2 ac (95.6 ha) of permanent impacts could occur.
TL6	A 32.8-mi (52.8-km) transmission line would be constructed to connect to the SPP grid. The line would parallel a section line, existing transmission lines, roads, and would partially require new ROW. A maximum of 455.5 ac (184.3 ha) of temporary impacts and 212.0 ac (85.8 ha) of permanent impacts could occur.
Access Roads	
AR1	A 0.6-mi (1.0-km) access road would be constructed from the eastern corner of the polygen plant site to County Road (CR) 1216 (Avenue G) and would be improved from CR 1216 and FM 1601 to I-20). A maximum of 7.2 ac (2.9 ha) of temporary impacts and 4.0 ac (1.6 ha) of permanent impacts could occur.
AR2	A 3.7-mi (6.0-km) access road would be constructed from FM 866 along an existing 138-kV transmission line to the northeast corner of the polygen plant site. A maximum of 58.0 ac (23.5 ha) of temporary impacts and 35.5 ac (14.4 ha) of permanent impacts could occur.
Railroad Line	
RR1	A 1.1-mi (1.8-km) rail spur would be constructed to connect the existing UPRR line to the on-site rail loop. A maximum of 13.4 ac (5.4 ha) of temporary impacts and 6.7 ac (2.7 ha) of permanent impacts could occur. Attendant features would include a maintenance shop, refueling station, on-site engine yard.
CO_2 Pipeline	
CO_2	A 1.0-mi (1.6-km), 12-in (30-cm) CO_2 pipeline would be constructed to connect plant facilities to the existing Kinder Morgan Central Basin pipeline east of the polygen plant site; a maximum of 12.2 ac (4.9 ha) of temporary impacts and 6.1 ac (2.5 ha) of permanent impacts could occur.

2.4.5.1 COAL

The TCEP would use low-sulfur, sub-bituminous Powder River Basin coal. The plant would use approximately 2.1 million tn (1.9 million t) of coal annually, assuming operation at 100 percent capacity.

Coal would be received by rail in dedicated unit trains from a coal mine. Unit trains would contain up to 135 railcars, with the average unit train shipment containing 115 cars. Each railcar would carry up to 120 tn (109 t) of coal. A maximum of five unit trains per day could be received and unloaded at the plant site, based on an unloading rate of four hours per train. Coal would be stored on-site in coal piles, which would be sized for about 45 days of total storage capacity, with approximately nine days of active storage and 36 days of inactive storage.

The UPRR, which has a rail line at the southern border of the plant site, has agreed to provide coal transportation services to the TCEP. Rio Tinto, a coal producer, has provided a letter of support for the TCEP and is willing to provide sufficient quantities of coal from its Cordero Rojo Mine complex in Wyoming at standard market terms. Although Cordero Rojo coal is being used for purposes of preliminary design engineering, the TCEP would not be dependent on access to Cordero Rojo coal.

2.4.5.2 NATURAL GAS

Although the primary fuel source for electric power production would be coal-derived syngas, the TCEP would require up to 2 trillion Btu of natural gas annually for polygen plant startup and as a backup fuel for the power island. Natural gas would also be used during operations for heating drying gases, fueling an auxiliary boiler, and providing burner pilot flames (see Section 2.4.3.2 for pilot usage). Using the access to natural gas, Summit could decide to install the combined-cycle power island early in the construction process (that is, before the gasification island), which would allow for electricity production from natural gas until the gasification island could be installed and the TCEP began full operation. This would also result in permanent job creation earlier than expected. Use of natural gas for full electricity dispatch would require 17.5 trillion Btu annually.

The plant would tap an existing natural gas pipeline for access to natural gas. Natural gas would be obtained through a proposed 2.7-mi (4.3-km), 12-in-diameter (30-cm-diameter) pipeline that would connect with the ONEOK 20-in-diameter (50-cm-diameter) mainline south of the proposed plant site (NG1). The location of the NG1 is identified in Figure 2.6.

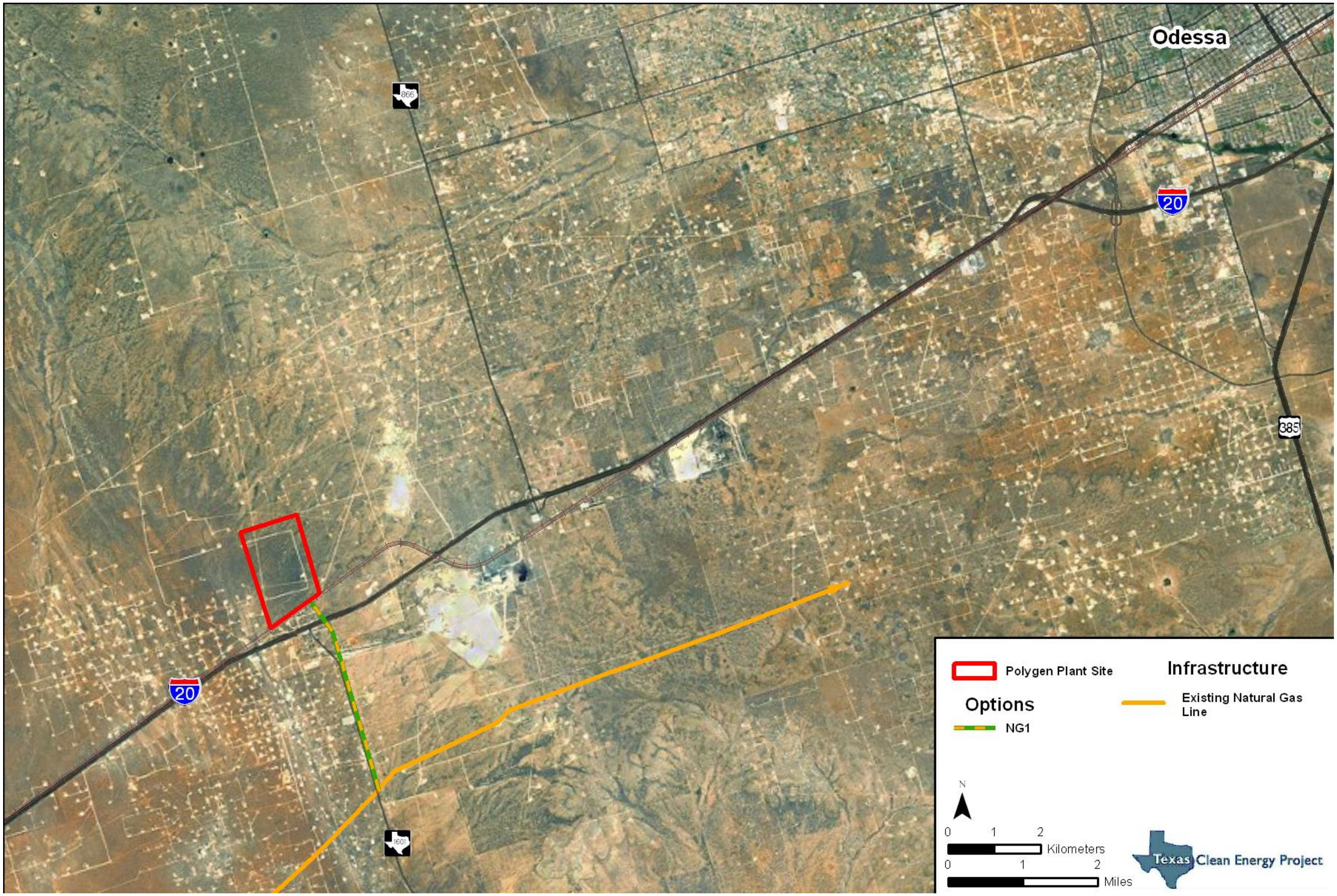

Figure 2.6. Proposed natural gas pipeline interconnection route (NG1).

2.4.5.3 PROCESS WATER

The TCEP would require a minimum of 3.5 million gal (13.2 million L) per day and a maximum of 5.5 million gal (20.8 million L) per day of water for all polygen plant uses. Water used for steam production in the HRSG must be of very high quality and, for economic reasons, would be condensed and reused rather than vented to the atmosphere as steam. Water for the plant would be supplied by a pipeline from one or more of the three sources as described below. WL1 is the preferred process water option. The locations of the four waterline options for providing water from the three sources are shown in Figure 2.7.

Gulf Coast Waste Disposal Authority

The GCA owns and operates the Odessa South Facility, an existing facility in Odessa that treats municipal sewage from the city of Odessa and industrial waste water from nearby industries. GCA's current capacity (as limited by their discharge permit) is 7.0 million gal (26.5 million L) per day; on average, the plant treats 2.0 million gal (7.5 million L) per day (Summit 2010c). GCA has a minimum required discharge rate of approximately 2.0 million gal (7.5 million L) per day into Monahans Draw. GCA currently has no water reuse customers.

For WL1, GCA would provide raw water to the TCEP from treated water from the Odessa South Facility. This facility would continue to receive waste water from the existing sources and would also receive waste water from the city of Midland. Untreated waste water from the city of Midland would be piped to the GCA Odessa South Facility for treatment. GCA would then pipe it to the TCEP as needed for use as raw water. WL1 would require the construction of a 20- to 24-in-diameter (51- to 61-cm-diameter) pipeline from the City of Midland Wastewater Treatment Plant to the GCA Odessa South Facility and from the GCA Odessa South Facility to the polygen plant site. The pipeline would be approximately 41.2 mi (66.3 km) long, of which approximately 20 mi (32 km) would require new ROW.

The specific quantity of waste water to be transferred from the city of Midland to the GCA Odessa South Facility is currently being negotiated by those two entities. The city of Midland has expressed an intention to supply, at a minimum, an amount that would allow GCA to supply the TCEP while not decreasing GCA's current discharge into Monahans Draw. The city of Midland is considering two approaches.

Under the first approach, the city of Midland would transfer its entire flow of untreated waste water to the GCA Odessa South Facility. The waste water is currently being treated (primary treatment only) and disposed of through agricultural irrigation. The city of Midland provides the waste water, fertilizer, and seed base to the selected bidders and collects a small percentage of the profit. This current practice of irrigation of hay or other crops as a means of disposal would be terminated.

The size of the pipeline between the City of Midland Wastewater Treatment Plant and the GCA Odessa South Facility might be larger than what is currently proposed by Summit. However, the width of the proposed ROW would not be increased. Treated water in excess of that used by TCEP would be either supplied for reuse by GCA or discharged into Monahans Draw. It is assumed that the quality of the treated waste water discharged into Monahans Draw would be at least the same as the currently discharged water; water quality details would be determined by a Texas Pollutant Discharge Elimination System (TPDES) permit. The sanitary sewer system for the city of Midland is separate from its storm water sewer system so no storm water from the city of Midland would be transferred to GCA. With this approach, GCA would need to construct additional handling and treatment capacity at its existing facility and existing, but currently unused, systems would be refurbished and put into service.

Under the second approach, the city of Midland would transfer less than all of its waste water to the GCA Odessa South Facility. The amount transferred would allow GCA to meet the TCEP needs and to maintain GCA's current discharge to Monahans Draw. Under this approach, the size of the pipeline between the City of Midland Wastewater Treatment Plant and the GCA Odessa South Facility would be 20–24 in (50–61 cm) in diameter. Waste water would continue to be sent from the City of Midland Wastewater Treatment Plant to irrigate croplands, although at a reduced level compared to current levels. GCA's current discharge rate of treated waste water into Monahans Draw would be maintained. It is assumed that the quality of the treated waste water discharged into Monahans Draw would be at least the same as the currently discharged water; water quality details would be determined by a TPDES permit. Under this approach, GCA would refurbish existing but unused systems at the GCA Odessa South Facility, but new construction at the GCA Odessa South Facility would be less than required for the first approach.

Oxy Permian

Oxy Permian operates a network of pipelines that provide brackish (highly saline and nonpotable) ground water from the Capitan Reef Complex Aquifer. The Oxy Permian Waterline option (WL2) would provide process water to the TCEP from the existing pipeline system through a new 9.3-mi (15.0-km), 16-in-diameter (41-cm-diameter) pipeline. Of the 9.3-mi (15.0-km) length, approximately 8.7 mi (14.0 km) of new ROW would be required. Process water from Oxy Permian would require treatment to meet gasifier manufacturer specifications.

Fort Stockton Holdings

Currently in the developmental stages, the FSH waterline project has been proposed to provide drinking water to the cities of Midland and Odessa. Under this option, FSH would provide water to the TCEP from one of two potential waterlines (WL3 and WL4). The viability of the main FSH waterline project would be independent of the TCEP. If it were built, the TCEP could use approximately 10 percent of the total water that would be available through the FSH waterline. The FSH water source would be ground water from the Edwards-Trinity (High Plains) Aquifer located near the city of Fort Stockton, which is approximately 66 mi (106 km) southwest of the proposed TCEP. Process water from the FSH option would require treatment to meet the gasifier manufacturer's specifications.

WL3 would require construction of a 14.2-mi (22.9-km) connector pipeline from the plant site to the FSH pipeline using 9.2 mi (14.8 km) of new ROW. As a backup to WL1, a 2.7-mi (4.3-km), 16-in-diameter (41-cm-diameter) pipeline (WL4) could be constructed from the main FSH waterline to the existing GCA Odessa South Facility where water would be treated and piped from the GCA Odessa South Facility to the polygen plant site using WL1. Approximately 1.3 mi (2.1 km) of WL4 would require new ROW.

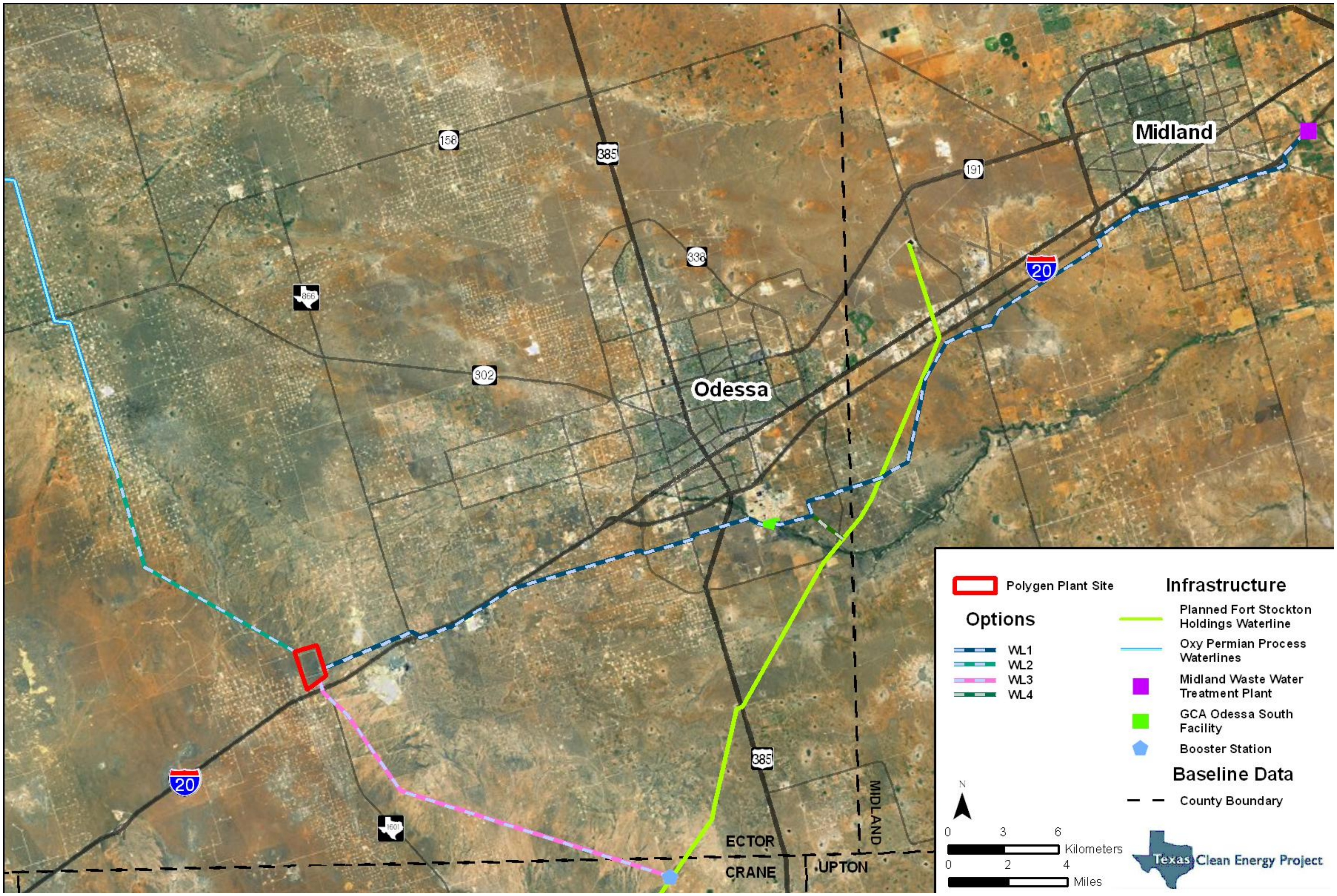

Figure 2.7. Proposed routes for the process water pipeline options (WL1–WL4).

2.4.5.4 POTABLE WATER

Potable water demand would be generated by construction and operations personnel. Approximately 30 gal (113 L) per day per person would be required. During construction peak employment, water demand would be approximately 45,000 gal (170,343 L) per day based on a peak construction workforce of approximately 1,500 workers. Once operational, water demand would decrease to 4,500 gal (17,034 L) per day based on approximately 150 workers on-site.

During construction, potable water would be delivered to the plant site by truck, requiring approximately six 25-tn (23-t) trucks per day (forty-two 25-tn [23-t] trucks per week). Potable water during TCEP operation would also be supplied by truck. Summit estimates that a seven-day operational workweek would require approximately five trucks per week.

2.4.5.5 ELECTRIC TRANSMISSION

Two large generator step-up transformers would be located next to the generators that they serve in the plant, and they would connect to a smaller transformer in an on-site switchyard. The switchyard would also include an 86-ft-tall (26-m-tall) dead-end structure, which would connect the transmission line to the off-site interconnection on a series of 86-ft-tall (26-m-tall) monopoles in 600-ft (183-m) spans. Transmission lines themselves would range from 20 to 80 ft (6–24 m) in height, depending upon the temperature (e.g., heat expansion) and mounting position on the monopoles. Interconnection studies may require upgrades to existing infrastructure. Potential infrastructure upgrades may include new and/or upgraded switch stations, upgraded substation at the point of interconnection, upgrading conductors and/or structures on existing transmission lines and other system infrastructure.

The TCEP would tie into the existing transmission grid at one of the six options described below. The proposed routes for the transmission line interconnection options are identified in Figure 2.8. TL4 is the preferred interconnection option. Maximizing the use of existing infrastructure facilities, Summit identified the following potential transmission line routes that would connect to the ERCOT market:

- TL1 would connect the TCEP with the existing Moss Substation. It would have a total length of 9.3 mi (15.0 km), with segments running parallel to a section line and an existing 138-kV transmission line. This route would require new ROW, although approximately 75 percent of the proposed transmission line would parallel existing linear facilities.
- TL2 would connect the TCEP with the existing Moss Substation. It would have a total length of 8.6 mi (13.8 km), with segments running parallel to a section line, FM 866, and an existing 138-kV transmission line. This route would require new ROW, although more than 90 percent of the proposed transmission line would parallel existing linear facilities.
- TL3 would have a total length of 2.2 mi (3.5 km) and would follow a section line north to a point where it would interconnect with the existing Oncor 138-kV transmission line. This route would require new ROW. This alternative may require the reconductoring of the existing 138-kV transmission line between the point of interconnection with the TCEP and the Moss Substation. The need for reconductoring would be determined by the ongoing interconnection studies currently being conducted by Oncor. Construction of a 5- to 10-ac (2- to 4-ha) switchyard would be required at the intersection point of the existing 138-kV transmission line and the new 2.2-mi (3.5-km) TL3. The switchyard would be used for the physical interconnection between the polygen plant site and the existing transmission

system and would include a ring bus, circuit breakers, lightning arrestors and a small single story building. The switchyard would be graded level and would be surrounded by a chain link fence, while the ground area around the equipment would be covered with gravel.

- TL4 would have a total length of 0.6 mi (1.0 km) and would follow a section line north to a point where it would interconnect with a second existing Oncor 138-kV transmission line. This route would require new ROW and may require the reconductoring of the existing 138 kV transmission line from the point of interconnection with the Moss Substation. The need for reconductoring would be determined by the ongoing interconnection studies currently being conducted by Oncor. Construction of a 5- to 10-ac (2- to 4-ha) switchyard would be also be required at the intersection point of the existing 138 kV transmission line and the new 0.6-mi (1.0-km) TL4.

Summit may determine that, from a power marketing standpoint, it is beneficial to connect to the SPP market instead of or in addition to the ERCOT market. The following two options would support the connection to the SPP:

- TL5 connect the TCEP with the existing Midland County Substation. It would have a total length of 36.8 mi (59.2 km), with segments running parallel to a section line, existing transmission lines and existing roads. This route would require new ROW.
- TL6 would connect the TCEP with the existing Midland County Substation. It would have a total length of 32.8 mi (52.8 km), with segments running parallel to a section line, existing transmission lines and existing roads. This route would require new ROW.

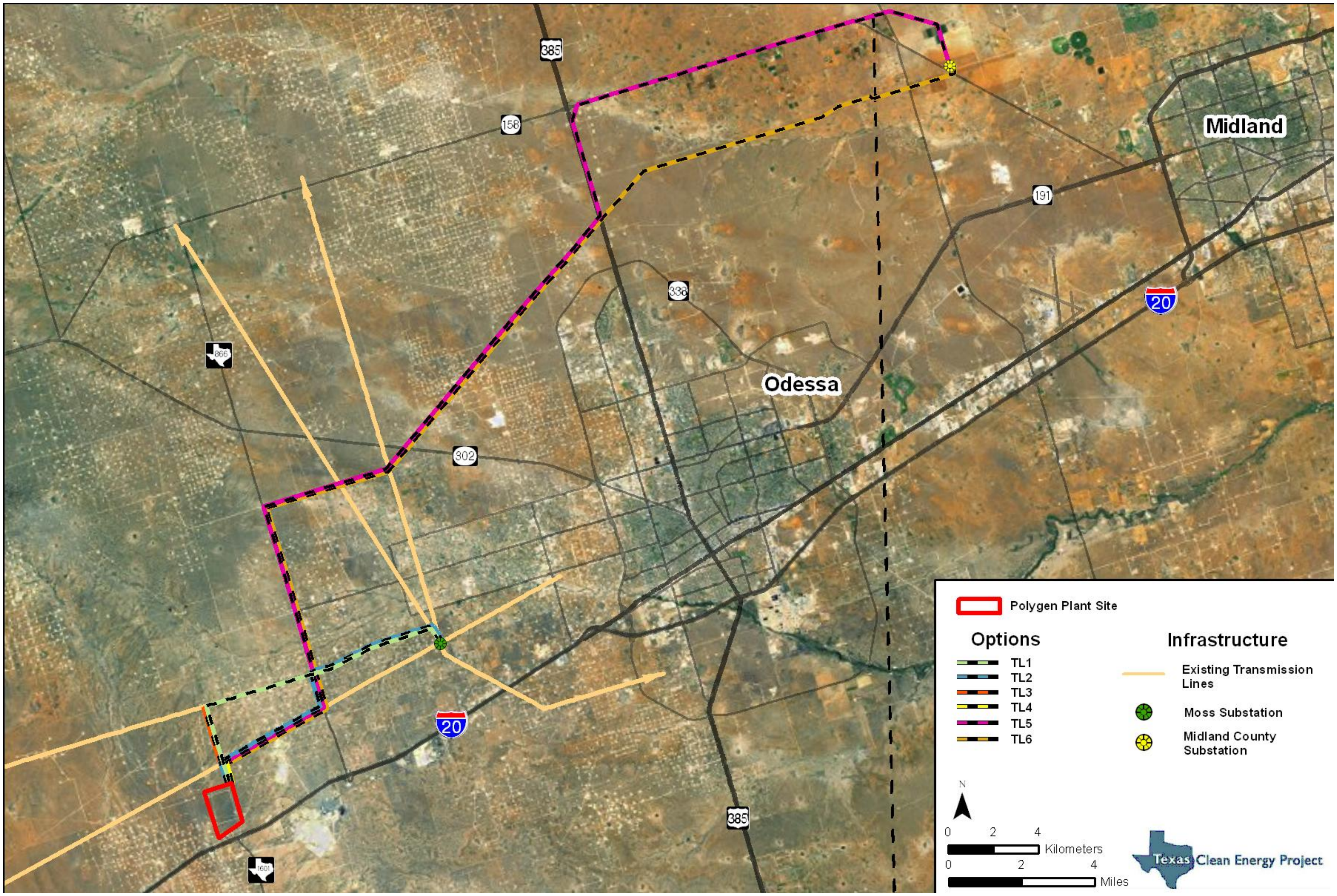

Figure 2.8. Proposed routes for the transmission line interconnection options (TL1–TL6).

2.4.5.6 CARBON DIOXIDE PIPELINE

As discussed in Section 2.4.4.1, captured CO_2 would be transported from the TCEP by pipeline to connect with an existing Kinder Morgan CO_2 pipeline located approximately 1.0 mi (1.6 km) east of the plant site. Figure 2.9 shows the proposed route for the CO_2 pipeline. All of the potential CO_2 purchasers under consideration at this time are or can be connected to the existing Kinder Morgan CO_2 pipeline system. However, there may be commercial reasons in the future to prefer a direct pipeline connection from TCEP to a local CO_2 offtaker. No such direct pipelines are currently under consideration.

2.4.5.7 TRANSPORTATION

Figure 2.10 identifies the two proposed access road and rail spur locations for the TCEP. Access to the polygen plant would be primarily by FM 866 (AR2) connecting to the northeast corner of the site. Approximately 95 percent of the construction and operations vehicle traffic would use AR2. This option would require the construction of approximately 3.7 mi (6.0 km) of a new county road, which Ector County has proposed to build. The new county road would intersect with existing FM 866 and would parallel an existing 138-kV transmission line for approximately 3.1 mi (5.0 km), then turn south for approximately 0.6 mi (1.0 km), where it would terminate at the northeast corner of the polygen plant site. Additional details regarding the access road off FM 866 are currently being developed by Ector County.

Access from FM 1601 (AR1) would be primarily for emergency vehicle access, plant administrative workforce, and visitors (anticipated 5 percent use). AR1 would require the construction of approximately 0.04-mi (0.06-km) underpass, overpass, or at-grade intersection with the UPRR line, which would connect the southeast corner of the plant site to CR 1216. Although details have not been finalized, for purposes of this analysis DOE assumed improvement of approximately 0.56 mi (0.9 km) may be required along CR 1216 and FM 1601 to I-20. Therefore, AR1 totals approximately 0.6 mi (1.0 km) for both construction and potential improvements. Figure 2.10 shows the proposed routes for the access road options.

A railroad line or *rail spur* (RR1) would be constructed from the UPRR line to the polygen plant site. This rail spur would connect to a rail loop within the site boundary that would facilitate the unloading of coal, the loading of H_2SO_4, urea, and slag, as well as the loading and unloading of construction and operations materials. Track layout design has not yet been finalized but would include the 1.1-mi (1.8-km) rail spur at the southeast corner of the plant site, on-site tracks to accommodate at least two coal train sets and two urea unit trains, a locomotive refueling location and road access for a tank truck, and an area for railcar maintenance (including a maintenance building) with access for a railcar repair contractor. Features associated with rail maintenance and refueling would include the plant's own small railcar pusher engine, aboveground fuel storage tanks and/or tanker trucks, lubricants, engine oils, hydraulic fluids, and other equipment necessary to ensure equipment remains in safe operating conditions. To minimize environmental risks, all attendant features will comply with applicable rules and regulations for their storage and handling, as well as implement spill and pollution controls.

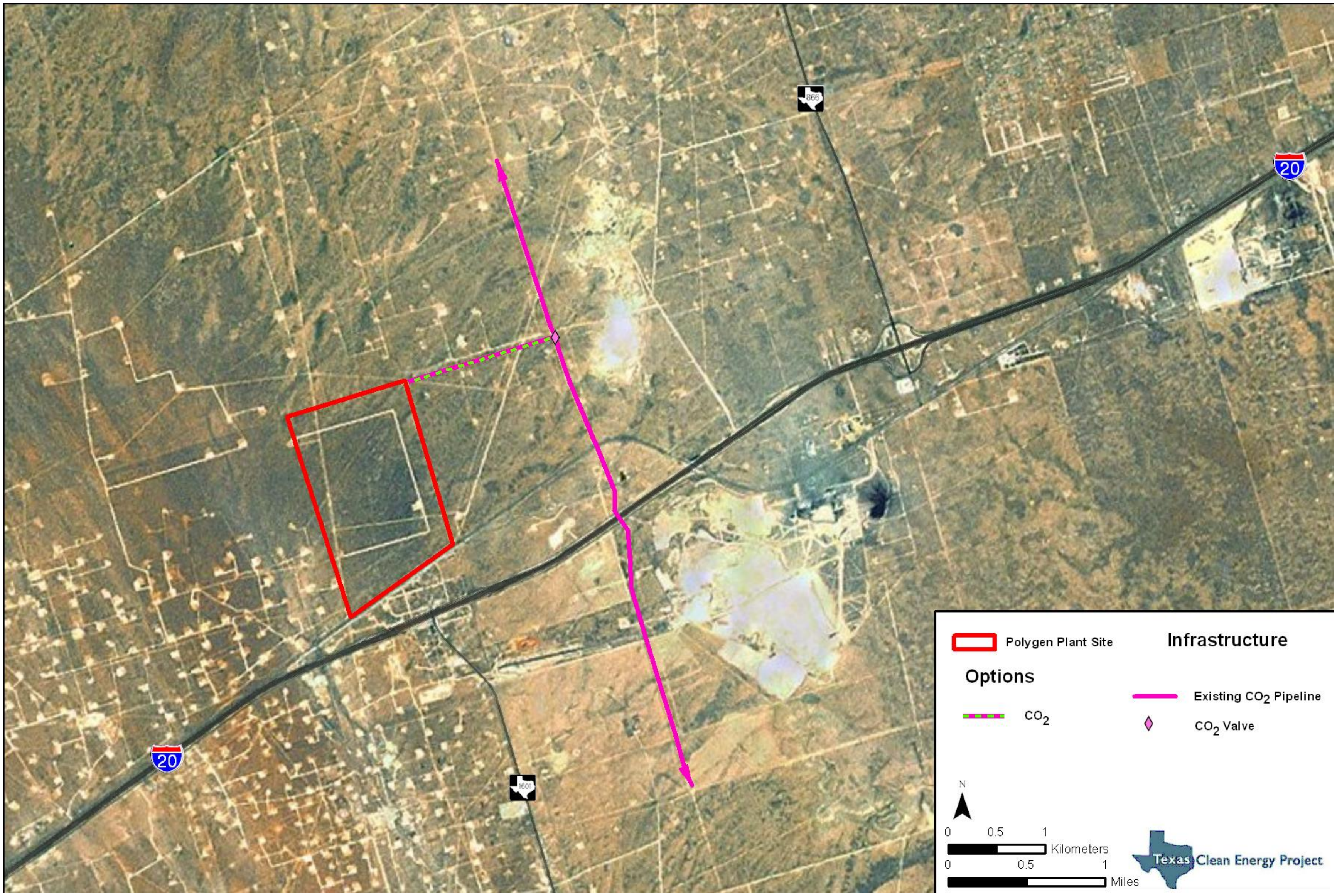

Figure 2.9. Proposed carbon dioxide pipeline route (CO_2).

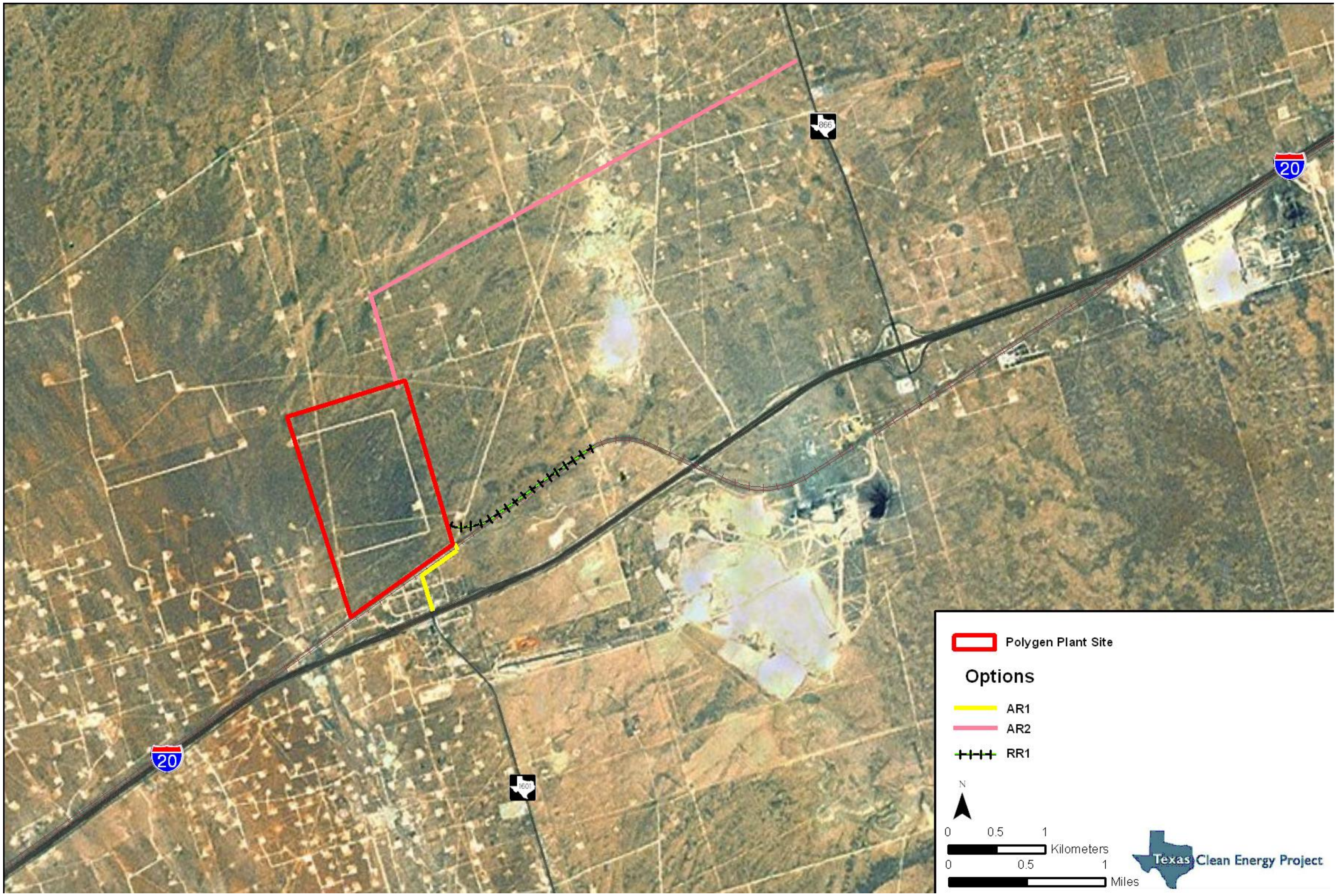

Figure 2.10. Proposed routes for TCEP access roads (AR1 and AR2) and the rail spur (RR1).

2.4.5.8 LAND AREA

The proposed plant site is approximately 600 ac (243 ha) in size, of which approximately 300 ac (121 ha) would be permanently affected by construction and operation of the proposed TCEP. Construction of the various off-site pipelines, transmission line, road access, and rail spur would also require commitments of land resources (see Table 2.2). All linear facility options would have an estimated 100-ft-wide (30-m-wide) construction ROW and a 50-ft-wide (15-m-wide) operational ROW. Temporary impacts during construction could range from 249 to 1,119 ac (101–453 ha), whereas permanent impacts from operations could range from 134 to 576 ac (54–233 ha) based on the smallest combination (WL2, TL4, CO_2, NG1, AR1, AR2, RR1) and largest combination (CO_2, NG1, WL1, WL4, TL5, AR1, AR2, RR1) of the linear facility options.

2.4.5.9 TOXIC AND HAZARDOUS MATERIALS

Hazardous materials that would be used or stored for TCEP operations include relatively small quantities of petroleum products, liquid O_2 and N_2, sulfur, catalysts, flammable and compressed gases, methanol, water treatment chemicals, and minor amounts of solvents and paints (see Table 2.2).

Natural gas and H_2-rich fuel gas (i.e., clean syngas), which are flammable fuels, would be used in the TCEP, specifically for the power block. Natural gas would be used as a startup and backup fuel and would also provide support during operations; it would be utilized directly from the on-site pipeline (connecting to the off-site main pipeline) and would not be stored on-site. H_2-rich fuel gas would be the primary fuel for the combustion turbine. It would be generated on site and not stored.

Bulk quantities of liquid O_2 and N_2 would be stored in tanks in the air separation unit to provide capacity for startups and continued plant operation during short-duration air separation unit system outages. Other gases stored and used at the polygen plant would include those typically used for maintenance activities such as shop welding, emissions monitoring, and laboratory instrument calibration. These gases would be stored in approved standard-sized portable cylinders kept at appropriate locations.

Water treatment chemicals would be required and stored on site. Bulk chemicals such as acids and bases for pH control would require storage in appropriately designed tanks, with secondary containment and monitoring. Hypochlorite bleach is expected to be used for biological control of the various circulating and cooling tower water streams. Other water treatment chemicals would be required as biocides and for pH control, dissolved O_2 removal, and corrosion control for boiler feed water, cooling tower treatment, and cooling water treatment.

For raw water treatment, coagulants and polymers could also be used. Chemicals used for these purposes are generally specified by the water treatment provider and are available under a number of trade names. Stored quantities of these materials would be small, ranging from 55-gal (208-L) drums to 500-gal (1,892-L) tanks.

Diesel fuel would be used for the emergency generator and for the fire-water pump. The expected stored quantity (2,000 gal [7,570 L]) was based on approximately eight hours of operation of the diesel generators at full output (approximately 3 MW). This limited storage would require the plant to have contracts with fuel providers specifying that deliveries of diesel fuel could be provided in fewer than eight hours in an emergency. Appropriate containment and monitoring for spillage control would be provided.

Other petroleum-containing hazardous materials include the combustion and steam turbine lube oils, steam turbine hydraulic fluid, transformer oils, and miscellaneous plant equipment lube oils. These materials would be delivered and stored in approved containers in areas with appropriate secondary containment and would be used in curbed areas that only drain to internal drains connected to an oil-water separator system. Oil reservoirs, containment areas, and the separators would be checked regularly to identify potential leaks and to initiate appropriate actions. The on-site switchyard, which would be the main connection between the polygen plant and the associated transmission line to the transmission grid, would include one small transformer that will require 250 gal (946 L) of mineral-based insulating oil. Two larger generator step-up transformers, which will also require about 18,000 to 20,000 gal (68,137–75,705 L) of mineral-based insulating oil, will be located next to the generators that they serve in the plant. Design of the switchyard and the area containing the larger transformers would include curbing to contain any potential spills, as well as a fire protection system.

Toxic and hazardous materials that would be used or stored for project operations include those used for general plant usage, gasification, raw water treatment, waste water treatment, cooling tower, urea synthesis, sour shift, power block, and fuel, as shown in Table 2.3.

Table 2.3. Toxic and Hazardous Materials and Estimated Storage at the Polygen Plant Site

Chemical	Estimated Storage on Polygen Plant Site	
	Volume (gal [L])	Mass (lbs [kg])
General Plant Usage		
Anhydrous NH_3	1,365,988 (5,170,827)	7,249,454 (3,288,297)
Aqueous NH_3	31,231 (188,222)	232,529 (105,473)
Caustic	29,802 (112,813)	301,153 (136,601)
H_2SO_4 (raw water treatment use)	54,062 (204,647)	815,176 (369,759)
H_2SO_4 Plant		
Hydrogen peroxide	9,725 (36,813)	89,700 (40,687)
H_2SO_4	36,408 (137,819)	558,817 (253,475)
Gasification		
Hydrochloric acid	13,981 (52,924)	131,637 (59,710)
Raw Water Treatment		
Anti-scalant	157 (594)	1,342 (609)
Calcium hydroxide (dry)	n/a	225,927 (102,479)
Ferric chloride	898 (3,399)	10,491 (4,759)
Hydrochloric acid	16,779 (63,515)	159,003 (72,123)
Nalco 7341 (sodium hypochlorite [bleach])	516 (1,953)	5,109 (2,317)
Sodium bisulfite	142 (538)	1,560 (708)
Sodium carbonate (dry)	n/a	409,968 (185,958)

Table 2.3. Toxic and Hazardous Materials and Estimated Storage at the Polygen Plant Site

Chemical	Estimated Storage on Polygen Plant Site	
	Volume (gal [L])	Mass (lbs [kg])
Waste Water Treatment		
Acetic acid	11,011 (41,681)	97,500 (44,225)
Ferric chloride	22 (83)	273 (124)
Hydrochloric acid	875 (3,312)	8,323 (3,775)
Nalco 7341 (sodium hypochlorite)	52 (197)	507 (230)
Organo sulfide	52 (197)	429 (195)
Phosphoric acid	90 (341)	1,248 (566)
Cooling Tower		
Nalco 3DT120	3,463 (13,109)	29,452 (13,359)
Nalco 3DT177	1,070 (4,050)	11,781 (5,344)
Nalco 7341 (sodium hypochlorite)	4,960 (18,776)	49,177 (22,306)
Nalco 90005	254 (961)	2,003 (909)
Nalco 71D5	524 (1,984)	3,640 (1,651)
Urea Synthesis		
UF85 (formaldehyde/urea/water)	23,863 (90,331)	260,000 (117,934)
Sour Shift		
Dimethyl Disulfide	591 (2,237)	5,200 (2,359)
Power Block*		
Hydrazine	875 (3,312)	7,377 (3,346)
Ammonium-Ethylenediaminetetraacetic acid disodium salt (dry)	n/a	18,200 (8,255)
Antifreeze (propylene glycol or ethylene glycol)	5,057 (19,143)	43,409 (19,690)
Ethylenediaminetetraacetic acid	778 (2,945)	6,500 (2,948)
Sodium borate (dry)	n/a	30 (14)
Trisodium phosphate	524 (1,984)	4,335 (1,966)
Fuel		
Coal dust suppression polymer	TBD	TBD
Diesel	1,997 (7,559)	16,000 (7,257)

Note: n/a = not available and TBD = to be determined.

*The power block consists of the electric generation unit, combustion turbines, HRSG, and associated equipment.

2.4.6 Emissions, Discharges, and Wastes

2.4.6.1 AIR EMISSIONS FROM PLANT OPERATIONS

The TCEP is being designed with state-of-the-art emissions-control systems that would allow for the conversion of coal to a H_2-rich syngas, which would burn with substantially less air pollution as compared to other fuels. H_2 would combust to produce water vapor. Because H_2 constitutes most of the fuel, much of the exhaust from the combustion-turbine would be water vapor.

> House Bill 469, passed by the Texas Legislature in 2009, requires the use of best available control technology by requiring that IGCC projects meet or improve upon the most stringent emissions limits that have been set for a U.S. coal-based plant. The emissions must be comparable to or better than those of a natural gas–fueled combined-cycle plant. The TCEP's air permit includes even lower emissions limits than those required by House Bill 469.

Summit's design team estimated the maximum and average emission quantities from each emission point using

- equipment supplier data;
- test results for similar equipment at other IGCC facilities;
- engineering calculations, experience, and professional judgment; and
- published and accepted average emission factors such as the EPA Compilation of Air Pollutant Emission Factors (AP-42).

The maximum air pollutant emissions from the polygen plant are shown in Table 2.4.

Table 2.4. TCEP Permitted Air Pollutant Emissions

Type	Emissions (tn [t] per year)
Criteria Air Pollutants	
NO_X	225.00 (204.10)
Volatile organic compounds	39.60 (35.90)
SO_2	251.10 (227.80)
CO	1,173.00 (1,064.10)
PM	416.10 (377.50)
PM_{10}	380.00 (344.30)
$PM_{2.5}$	367.00 (332.90)
Lead	0.02 (0.018)
Hazardous Air Pollutants (HAP)	
COS	2.61 (2.37)
Hg	0.01 (0.01)
Hydrochloric acid	1.39 (1.26)
Hydrofluoric acid	0.83 (0.75)
Formaldehyde	2.96 (2.69)

Table 2.4. TCEP Permitted Air Pollutant Emissions

Type	Emissions (tn [t] per year)
Other Air Pollutants	
H_2S	3.20 (2.90)
Total reduced sulfur	5.80 (5.26)
H_2SO_4	15.00 (13.60)
NH_3	363.00 (329.3)

Source: Summit (2010a).

Note: PM_{10} = PM with aerodynamic diameters equal to or less than 0.00039 in (10 micrometers); $PM_{2.5}$ = PM with aerodynamic diameters equal to or less than (0.000098 in (2.5 micrometer).

Table 2.5 compares the maximum emissions from TCEP to the emissions from conventional power plants in Texas ranging in size from 765 MW to 2,565 MW.

Table 2.5. Comparison of Power Plant Emissions Per Megawatt Hour

Power Plants	Air Emissions (lbs [kg]/MW-hours)				
	SO_2	NO_x	PM_{10}	Hg	CO_2
1970s pulverized coal plant	11.97 (5.43)	4.49 (2.04)	1.00 (0.45)	0.000214 (0.000097)	2,203 (999)
Recently permitted pulverized coal plant	2.01 (0.91)	0.84 (0.38)	0.42 (0.19)	0.000096 (0.000044)	2,203 (999)
Recently permitted coal plant using circulating fluidized bed technology	0.86 (0.39)	0.70 (0.32)	0.26 (0.12)	0.000008 (0.000004)	2,041 (926)
Recently permitted pulverized coal plant with carbon capture	0.65 (0.29)	0.55 (0.25)	0.29 (0.13)	0.000019 (0.000009)	331 (150)
TCEP	0.14 (0.064)	0.13 (0.596)	0.22 (0.10)	0.000007 (0.000003)	228 (103)

Source: Summit (2011).

2.4.6.2 WASTE WATER EFFLUENTS

Process Water Effluents

As described in Section 2.4.3.4, the TCEP would use a ZLD system to eliminate industrial brine water discharges. Cooling tower blowdown (water removed from the cooling system) and brine water generated from gasification and slag processing operations would be routed to the ZLD system. The ZLD process would remove suspended solids in a clarifier, concentrate the dissolved solids using a reverse osmosis system, and remove water from the dissolved solids through heating and vaporization. The system would recover distilled water for reuse in the TCEP, reducing fresh water consumption and concentrating contaminants into a solid waste stream. An optional ZLD system that would use solar evaporation ponds is also be considered.

The ZLD process would result in a solid filter cake material, which would be transported off-site to appropriate facilities for disposal. Based on preliminary design information, Summit estimates that up to 23,360 tn (21,191 t) of clarifier sludge and solids (filter cake) would be generated by the ZLD system annually. The filter cake is expected to be nonhazardous, but would be tested to confirm its characteristics.

Storm Water Management

Noncontact storm water runoff would be directed to an on-site retention pond designed to hold all runoff from the polygen site. Storm water would not be discharged from the retention pond. Any storm water runoff that had the potential to come in contact with oil (such as water runoff from parking lots) would be directed to a separate storm water pond that would direct collected storm water to an oil/water separator before entering the ZLD system pond.

Sanitary Waste Water

Approximately 150 portable toilets would be required during construction, which would be collected and removed by a licensed sanitary waste disposal. Sanitary wastes would be collected and discharged directly to an on-site underground septic disposal field. The septic field would be sized based on the number of workers, site-specific soil conditions and the specific areal requirements of the equipment to be used. It is estimated that sanitary waste would be approximately 55 gal (208 L) per person per day.

2.4.6.3 SOLID WASTES

In addition to the ZLD solid waste stream, other solid wastes such as spent catalyst materials, spent activated carbon beds associated with Hg removal processes, and spent activated carbon beds and char sludge associated with the sour water treatment system would also be generated, along with municipal-type wastes. Summit would manage operational wastes in accordance with applicable regulations, good industry practice, and internal company procedures. Hazardous and nonhazardous wastes would be properly collected, segregated, and recycled or disposed of at approved wastes management facilities. Volumes of these waste streams and their disposal methods are shown in Table 2.6.

Table 2.6. Solid Wastes from the Polygen Plant

Waste	Annual Quantity	Disposal Method
Black water system filter cake	86,870 tn (78,973 t) if filter cake recycle is not feasible 9,259 tn (8,400 t) if filter cake recycle is feasible	Industrial landfill
Clarifier sludge and solids (filter cake)	23,360 tn (21,191 t)	Industrial landfill
Sanitary waste	3,011,250 gal (11,398,820 L)	On-site leach field
Slag from gasifier	178,485 tn (162,060 t)	To be sold (landfill)
Solid waste (office and break room waste)*	252 tn (229 t)	Municipal/industrial landfill

*Quantity estimated for 200 workers using an industrial waste generation rate of 9.2 lbs (4.2 kg) per day per worker (California Integrated Waste Management Board 2006).

Removal of sulfur and downstream production of H_2SO_4 for commercial sale would eliminate sulfur as a significant solid waste. Slag production would be approximately 489 tn (444 t) per day. Slag is considered a potential revenue-producing stream that would be actively marketed by Summit; however, if no market is available slag would be disposed of in an off-site landfill.

2.4.6.4 Pollution Prevention, Recycling, and Reuse

The TCEP would be designed to minimize process-related discharges into the environment. A plan for pollution prevention and recycling would be developed during the detailed design and permitting steps, and the plan would be put into practice after the plant became operational. Table 2.7 lists some measures that may be employed as part of that plan.

Table 2.7. Possible Pollution Prevention, Recycling, and Reuse Features of the TCEP

Feature	Description
Spill prevention, control, and countermeasure (SPCC) plan	The SPCC plan would develop measures to take in the event of a spill, thereby insulating environmental media from the effects of accidental releases. The surfaces under and around aboveground chemical storage tanks would be lined or paved and curbed/diked, and would have sufficient volume to hold the contents of the tank. A site drainage plan would also be developed to prevent routine, process-related operations from affecting the surrounding environment.
Feedstock material handling	The coal storage area would be paved or lined so that runoff could be collected, tested, and treated as necessary. The coal storage area would be managed to control fugitive dust emissions. The coal conveyors would be covered.
Coal drying and grinding	The coal grinding equipment would be enclosed; a portion of the spent drying gas would be purged through a dust collector and vented into the atmosphere.
Gasification	The char produced in gasification would be removed in the black water treatment system as a dewatered filter cake and recycled for blending with the pulverized coal for feed to the gasifiers. This would improve the carbon conversion in the gasifier and reduce the amount of carbon contained in the gasifier slag.

Table 2.7. Possible Pollution Prevention, Recycling, and Reuse Features of the TCEP

Feature	Description
Slag handling	The slag dewatering system would generate some flash gas that contains H_2S. This flash gas would be sent to the H_2SO_4 plant. Water that is entrained with the slag would be collected and sent to the black water treatment system.
Sour water system	Sour water would be collected from the low-temperature syngas cooling system, and the NH_3 and H_2S would be stripped out and sent to the H_2SO_4 plant. The stripped condensate would be recycled to low-temperature syngas cooling.
ZLD unit	The ZLD unit would concentrate and evaporate the process condensate. The ZLD unit would produce high-purity water for reuse and a solid filter cake for disposal off-site. The ZLD would concentrate and dispose of heavy metals and other constituents in the process condensate. The ZLD would also be a recycle unit because the recovered water would be reused, reducing the total plant water consumption.
Hg removal features	The Hg removal unit would use specially formulated activated carbon to capture trace quantities of Hg in the syngas.
Acid gas removal	The acid gas removal system would remove H_2S and CO_2 from the raw syngas and produce a H_2-rich fuel gas for use in the combined-cycle power block and for urea production. The acid gas removal would produce concentrated H_2S feed for the H_2SO_4 plant and concentrated CO_2 for drying, compression, and transport for EOR.
H_2SO_4 plant	The H_2SO_4 plant would convert the H_2S to concentrated H_2SO_4, a commercial product.
Training and leadership	All corporate and plant personnel would be trained on continuous improvement in environmental performance, especially as such training and programs apply to setting, measuring, evaluating, and achieving waste reduction goals.

2.4.7 Marketable Products

2.4.7.1 ELECTRICITY

Approximately 400 MW (gross) of electric power would be generated by the TCEP, with approximately 213 MW (net) going to the power grid under maximum power output conditions. The balance of the gross power generated would be used to operate the plant and produce urea fertilizer.

2.4.7.2 CARBON DIOXIDE

The TCEP is expected to capture approximately 3 million tn (2.7 million t) of CO_2 per year. After compression, drying, and purification, part of the CO_2 would be sent to the urea synthesis plant, and the remainder would be put into the CO_2 pipeline for sale and transport to EOR. For the maximum urea production case, approximately 1,080 tn (980 t) per day of CO_2 would be sent to the urea synthesis plant, with approximately 9,050 tn (8,210 t) per day of CO_2 being compressed and sent to the CO_2 pipeline for use in EOR. In the maximum power case, 600 tn (544 t) per day of CO_2 would be sent to the urea synthesis plant, with approximately 9,100 tn (8,255 t) per day of CO_2 being compressed and sent to the CO_2 pipeline for use in EOR. There would be no storage of CO_2 on site.

2.4.7.3 UREA

Summit would expect to produce 1,485 tn (1,347 t) per day of granulated urea (542,025 tn [491,716 t]) annually at maximum capacity. This product would be transported off-site by rail, using an average of approximately 15 railcars per day. The plant would include storage facilities for seven days of urea production.

2.4.7.4 ARGON

Argon, an inert gas, would be produced as a by-product of the coal gasification process. Up to seven days of argon production may be stored on site; it would be transported off-site for sale in rail tank cars. Summit's market analysis confirms that there would be a viable market for the sale of the argon produced.

2.4.7.5 SULFURIC ACID

H_2SO_4, a hazardous material, would also be produced as a by-product of the coal gasification process. The TCEP would produce up to 56 tn (51 t) per day of H_2SO_4, which would be transported off-site by rail (up to four railcars per week) or truck. Prior to transport, H_2SO_4 would be stored in a small storage tank with a 36,400-gal (137,789-L) capacity and then pumped to the railcars on site. Summit's market analysis confirms that there would be a viable market for the sale of the H_2SO_4 produced.

2.4.7.6 SLAG

Slag production would be approximately 489 tn (444 t) per day. Slag is a potential revenue-producing stream that would be actively marketed by Summit. The slag would be temporarily stored on site prior to being loaded into railcars for sale and transportation off-site. If no market was available, it would be trucked to an off-site permitted solid waste landfill. Using 25-tn (23-t) trucks, off-site transportation of slag would require approximately 20 trucks per day.

2.4.8 Construction Plans

2.4.8.1 CONSTRUCTION STAGING AND SCHEDULE

The TCEP would be constructed over the course of up to 38 months, including the installation of linear facilities (process waterlines, CO_2 pipeline, high voltage transmission line, and road and rail access). Before construction, environmentally sensitive areas at the plant site and along the linear facility corridors would be identified so that impacts could be avoided or minimized. A storm water pollution prevention plan (SWPPP) would be developed for erosion prevention and sediment control during construction. The plan would include a description of construction activities, and address the following:

- The potential for discharge of sediment or pollutants from the site.
- The location and type of temporary and permanent erosion prevention and sediment control methods, along with procedures to be used to establish additional temporary controls as necessary for the site conditions during construction.
- The site map with existing and final grades, including dividing lines and direction of flow for all pre-construction and post-construction storm water runoff drainage areas located

within the project limits. The site map would also include impervious surfaces and soil types.

- The location of areas not to be disturbed.
- The location of areas where construction would be phased to minimize duration of exposed soil.
- The identification of surface waters and wetlands, either on site or within 0.5 mi (0.8 km) of the site boundaries, which could be affected by storm water runoff from the construction site during or after construction.
- Methods to be used for final stabilization of all exposed soil areas.

Initial site preparation activities would include building access roads, clearing brush and trees, leveling and grading the site, removing unnecessary existing pipelines and other oil field infrastructure and connecting to utilities. Construction would involve the use of large earthmoving machines to clear and prepare the site. Trucks would bring fill material for roadways and the plant site, remove plant-site material and debris, and temporarily stockpile materials. Construction crews would spread gravel and road base for the temporary roads, material storage areas, and parking areas.

Worker vehicles, heavy construction vehicles, diesel generators, and other machinery and tools would generate emissions. Fugitive dust would result from excavation, soil storage, and earthwork. Construction-related emissions and noise could be minimized by running electricity to the site from the local utility provider to reduce reliance on diesel generators, and by wetting soil to reduce dust during earthwork.

Summit's TCEP schedule provides the following key dates for the plant construction:

- December 2011–February 2012: Site mobilization and preparation
- February–July 2012: Construction of main foundations
- March–August 2012: Construction of steel
- November 2012–March 2013: Construction of transmission interconnection
- March 2013–April 2014: Construction of power island
- April 2013–September 2014: Construction of gasification island

Summit expects the TCEP to be operational in July 2015.

2.4.8.2 CONSTRUCTION MATERIALS

Construction materials would be delivered to the site by truck and rail. An access road to the plant site would be developed for construction traffic, and completion of the rail spur at the start of construction activities would allow some plant equipment to be delivered by rail. Approximately 20 trucks per day and approximately two trains per week would deliver material to the site.

During construction, temporary utilities would be extended to construction offices, worker trailers, laydown areas, and construction areas. The local electricity utility service would provide temporary construction power. Temporary generators could also be used until the temporary power system was completed. Construction crews would position temporary lighting for safety and security. Local telecommunication lines would be installed for telephone and electronic communications.

Water would be required during construction for various purposes, including personal consumption and sanitation, concrete formulation, preparation of other mixtures needed to construct the facilities, equipment washdown, general cleaning, dust suppression, and fire protection.

2.4.8.3 CONSTRUCTION WASTES

Construction of the TCEP would generate wastes that would be typical of the construction of any large industrial facility. Potential wastes would include soil and land clearing debris, metal scraps, electrical wiring and cable scraps, packaging materials, and office wastes.

Prior to conducting any land clearing or demolition, surveys for regulated substances (e.g., oil drums, asbestos-containing materials, and other regulated wastes) would be conducted. Any such materials found would be managed in accordance with applicable regulations.

Any potentially reusable materials would be retained for future use, and the recyclable materials would periodically be collected and transferred to local recycling facilities. If feasible, removed site vegetation would be salvaged or recycled for mulch. Other recyclable materials would include packaging material (e.g., wooden pallets and crates), support cradles used for shipping of large vessels and heavy components (gasifiers, combustion and steam turbine parts), and cardboard and plastic packaging. Metal scraps unsuitable for reuse would be sold to scrap dealers. Materials that could not be reused or recycled would be collected in dumpsters and periodically trucked off-site by a waste management contractor for disposal in a licensed landfill.

Construction water use would be greatest during the natural gas and CO_2 pipeline testing phase. Hydrotest water would be reused for subsequent pressure tests if practical. Spent hydrotest water would be tested to determine the presence of hazardous characteristics (e.g., traces of pipe oil or grease). If hazardous, the hydrotest water would be sent off-site for treatment; if nonhazardous, it would be routed to the ZLD system, disposed of through a licensed contractor, or discharged (with consideration for erosion protection). Scrap and surplus materials and used lubricant oils would be recycled or reused to the maximum extent practical.

Summit would ultimately be responsible for the proper handling and disposal of construction wastes. However, construction management, contractors, and their workers would be responsible for minimizing the wastes produced by construction activities. They would also be expected to adhere to all project procedures and regulatory requirements for waste minimization and proper handling, storage, and disposal of hazardous and nonhazardous wastes. Each construction contractor would be required to include wastes management in their overall project health, safety, and environmental site plans. Typical construction waste management activities may include the following:

- Creation of dedicated areas and a system for waste management and segregation of incompatible wastes. Wastes segregation would occur at time of generation.
- A waste control plan detailing wastes collection and removal from the site. The plan would identify where wastes of different categories would be collected in separate stockpiles, bins, etc., and clear, appropriate signage would be required to identify the category of each collection stockpile, bin, etc.

- Storage of hazardous wastes, as defined by the applicable regulations, separately from nonhazardous wastes (and other, noncompatible hazardous wastes) in accordance with applicable regulations, project-specific requirements, and good waste management practices.
- Periodic inspections to verify that wastes are properly stored and covered to prevent accidental spills and to prevent wastes from being blown away.
- Use of appropriately labeled wastes disposal containers.
- Implementation of good housekeeping procedures. Work areas would be left in a clean and orderly condition at the end of each workday, with surplus materials and wastes transferred to the wastes management area.

2.4.8.4 CONSTRUCTION LABOR

Based on other coal-fueled power plant construction projects, Summit estimates that an average of approximately 650 construction workers would be employed throughout the project. However, during peak construction, the projected number of on-site workers could be as many as 1,500. Summit expects that most labor would be supplied through the local building trades. It is estimated that construction workers would work a 50-hour workweek, and that construction activity would normally occur during daylight hours, but would not always be restricted to these hours.

2.4.8.5 CONSTRUCTION SAFETY POLICIES AND PROGRAMS

Construction of the entire TCEP would involve the operation of heavy equipment and other job site hazards typical of heavy construction projects. The TCEP would be subject to U.S. Occupational Safety and Health Administration (OSHA) standards during construction (e.g., OSHA General Industry Standards [29 C.F.R. Part 1910] and the OSHA Construction Industry Standards [29 C.F.R. Part 1926]). During construction, risks would be minimized by the TCEP's adherence to procedures and policies required by OSHA. These standards establish practices, chemical and physical exposure limits, and equipment specifications to preserve worker health and safety. Construction permits and safety inspections would be employed to minimize the frequency of accidents and further ensure worker safety. Construction equipment would be required to meet all applicable safety design and inspection requirements, and personal protective equipment would be used when needed to meet regulatory and consensus standards.

These laws and regulations would form the basis of TCEP construction safety policies and programs. In addition, Summit would develop overall site- and project-specific environmental health and safety policies and programs for the TCEP. These would be included in all construction contracts, and construction contractors would be required to adhere to them.

TCEP construction management would develop a manual to include detailed procedures for use in its Occupational Safety and Health Program; to assure compliance with OSHA and EPA regulations; and to serve as a guide for providing a safe and healthy environment for workers, contractors, visitors, and the community. These procedures would include job procedures describing proper and safe manners of working in the TCEP (e.g., handling and storage of NH_3 would comply with 29 C.F.R. § 1910.111), appropriate personal protective equipment (in compliance with 29 C.F.R. § 1910.132), and appropriate hearing-protection devices.

The manual would be used as a reference and training source and would include accident reporting and investigation procedures, emergency-response procedures, toxic gas rescue-plan procedures, hazard communication program provisions, material safety data sheet accessibility, medical program requirements, and initial and refresher training requirements. In addition, supplemental provisions would be added to the TCEP's emergency action, risk management, and process safety management plans.

Emergency services during construction would be coordinated with the local fire departments, police departments, paramedics, and hospitals. A first-aid office would be located on site for minor first-aid incidents. Trained and certified health, safety, and environmental personnel would be on site to coordinate emergency response. All temporary facilities would have fire extinguishers, and fire protection would be provided in work areas where welding would be performed.

The natural gas and CO_2 pipeline facilities would be designed, constructed, tested, and operated in accordance with applicable requirements included in the Department of Transportation regulations in 49 C.F.R. Part 192, Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards, and other applicable federal and state regulations, including OSHA requirements. These regulations provide for adequate protection of the public and workers and prevention of natural gas and other gas pipeline accidents and failures. Among other design standards, 49 C.F.R. Part 192 specifies minimum pipeline materials and qualifications, minimum design requirements, and requirements for protection from internal, external, and atmospheric corrosion.

2.4.9 Operation Plans

2.4.9.1 PLANT OPERATIONS

Following construction, Summit would begin initial startup, followed by demonstration testing and then operational testing. TCEP demonstration testing would include the following:

- Verification of coal feedstock amounts (per heat and material balances for specific cases)
- Verification of overall polygen plant 90 percent carbon capture
- Verification of CO_2 compression and meeting pipeline CO_2-quality specifications
- Plant performance and emissions testing (for compliance with permit limits and conditions)

Operational testing would occur in parallel with portions of the demonstration testing. Operational testing would focus on achieving reliable plant operation along with high thermal efficiency, low emissions, equipment performance improvement, and optimization of power generation and urea production. Operational testing would include the following:

- Plant reliability testing (to meet reliability goals and guarantees for individual gasification, urea production, and power generation systems as well as for the overall TCEP)
- Startup/shutdown testing (number and duration)
- Shakedown period (the shakedown period is expected to continue for three years, through late 2017)

The TCEP would operate for at least 30 years and possibly up to 50 years.

2.4.9.2 OPERATIONAL LABOR

The TCEP operational workforce would include a mix of plant operators, craft workers, managers, supervisors, engineers, and clerical workers. The TCEP would require skilled operations and maintenance personnel, with temporary construction or maintenance workers on site for periodic outages and additional work.

Workforce size would vary between the demonstration period and the period of commercial operation. Operations workforce would be assembled during the last 18 months of construction for training and to assist with startup of the facilities. The TCEP workforce would consist of approximately 150 full-time workers.

2.4.9.3 HEALTH AND SAFETY POLICIES AND PROGRAMS

TCEP design features and management programs would be established to address hazardous materials storage locations, emergency response procedures, worker training requirements, hazard recognition, fire control procedures, hazard communications training, personal protective equipment training, and reporting requirements. For accidental releases, significance criteria would be determined based on federal, state, and local guidelines, and on performance standards and thresholds adopted by responsible agencies.

Basic approaches to prevent spills to the environment would include comprehensive containment and worker safety programs. The comprehensive containment program would ensure the use of appropriate tanks and containers, as well as proper secondary containment using walls, dikes, berms, curbs, etc. Worker safety programs would ensure that workers are aware of, and trained in, spill containment procedures and related health, safety, and environmental protection policies.

2.4.9.4 CLOSURE AND DECOMMISSIONING

As noted above, the planned life of the TCEP would be 30 years. However, if the TCEP is still economically viable, it could be operated up to 50 years. A closure plan would be developed at the time that the plant was to be permanently closed. A closure plan would also be developed should unforeseen circumstances require the polygen plant to be closed earlier than the planned 30-year period. The removal of the TCEP from service, or decommissioning, may range from “mothballing” to the removal of all equipment and facilities, depending on conditions at the time. The closure plan would be provided to state and local authorities as required.

2.5 Avoidance and Mitigation Measures

For all environmental resources, the mitigation of potential adverse impacts from project activities would be achieved through the implementation of controls generally required by permitting processes and other federal, state, or municipal regulations and ordinances. Table 2.8 outlines specific mitigation measures, including those required under federal, state, or local regulations, and permitting requirements that Summit would implement to reduce adverse environmental impacts in specific resource areas.

Table 2.8. TCEP Incorporated Mitigation Measures

Resource	Mitigation Measure
Air Quality and GHG Emissions	<u>Construction</u> During construction, Summit would implement the following practices: • Using dust-abatement techniques such as wetting soils • Surfacing unpaved access roads with stone whenever reasonable • Covering construction materials and stockpiled soils to reduce fugitive dust • Minimizing disturbed areas • Watering land prior to disturbance (excavation, grading, backfilling, or compacting) • Revegetating disturbed areas as soon as possible after disturbance • Moistening soil before loading into dump trucks • Covering material in dump trucks before traveling on public roads • Minimizing the use of diesel or gasoline generators for operating construction equipment • Using modern, well-maintained diesel powered construction equipment <u>Operation</u> The following process enhancements and improved work practices would be implemented to mitigate emissions: • To reduce NO_x: Using diluent injection in the combustion turbine in addition to selective catalytic reduction; incorporating good flare design in accordance with 40 C.F.R. § 60.18; limiting the hours of operation of the fire pump and emergency generators • To reduce CO and volatile organic compounds: Implementing good combustion practices in the combustion turbine; incorporating good flare design; limiting the hours of operation of the fire pump and emergency generators • To reduce SO_2: Using clean syngas in the combustion turbine; incorporating good flare design; limiting the hours of operation of the fire pump and emergency generators; using low-sulfur diesel in the fire pump and emergency generators • To reduce H_2SO_4 mist: Using clean syngas in the combustion turbine • To reduce PM: Implementing good combustion practices in the combustion turbine; incorporating high-efficiency drift eliminators in the wet cooling tower; incorporating good flare design; limiting the hours of operation of the fire pump and emergency generators; using low-sulfur diesel in the fire pump and emergency generators • To reduce CO_2: Capturing as CO_2 90 percent of the carbon entering the plant with compression and pipeline transportation of the CO_2 for use in EOR; limiting use of the CO_2 bypass vent to 5 percent of the year • To reduce Hg: Using clean syngas in the combustion turbine

Table 2.8. TCEP Incorporated Mitigation Measures

Resource	Mitigation Measure
Geology and Soils	Construction Summit would develop and implement an approved SWPPP to reduce erosion, control sediment runoff, reduce storm water runoff, and promote ground water recharge. The SWPPP would be submitted to the TCEQ for approval prior to the initiation of any construction activities. Summit would stockpile and cover excavated topsoil until reuse, install wind and silt fences, and reseed disturbed areas. Operation Summit would continue to implement relevant parts of its approved SWPPP. Summit would develop and implement a SPCC plan covering TCEP operations, as required by TCEQ under the Clean Water Act (Public Law 92-500).
Ground and Surface Water Resources	Construction Summit would develop and implement an approved SWPPP for construction activities. The SWPPP would address the polygen plant site, laydown areas, and construction along linear facilities. Summit would implement dust suppression and sedimentation control measures. For construction of linear facilities, Summit would apply for appropriate permits for all stream and water crossings and would implement required mitigation measures. Operation Summit would continue to implement relevant parts of its approved SWPPP. Summit would develop and implement effective measures, in accordance with a SPCC plan, to mitigate potential impacts caused by the release of petroleum products. As needed, Summit would develop a water management plan to minimize potential impacts on water resources as a result of the TCEP's withdrawals of water for the plant.
Floodplains	Construction Summit would develop and implement an approved SWPPP to minimize sedimentation and the filling of any downstream floodplains. Operation Summit would develop and implement an approved SWPPP to minimize sedimentation and the filling of any downstream floodplains.

Table 2.8. TCEP Incorporated Mitigation Measures

Resource	Mitigation Measure
Wetlands	<u>Construction</u> Summit would develop and implement an approved SWPPP to minimize potential impacts on wetlands. Mitigation of wetland impacts would take place in the form of direct replacement or through the purchase of credits via an approved wetland bank under U.S. Army Corps of Engineers and TCEQ requirements and guidance. A Combined Wetland Permit Application, as applicable, would be submitted to applicable federal, state, and local regulatory entities and would include design details on any wetland replacement sites, wetland banks, and sources of wetland credits for the project. Mitigation requirements would be determined during the wetland-permitting phase of the project following the NEPA process and before construction activities begin. <u>Operation</u> Summit would continue to implement relevant parts of its approved SWPPP to minimize potential impacts on wetlands. Summit would develop and implement effective measures, in accordance with a SPCC plan, to reduce the risk of contamination of wetlands. Summit would use a ZLD system or wells for underground disposal of waste water, which would eliminate any discharges of process water and cooling tower blowdown into any water bodies and would, therefore, eliminate water quality impacts to wetlands.
Biological Resources	<u>Construction</u> Summit would develop and implement an approved SWPPP that would minimize potential impacts on wildlife using downstream water resources, wetlands, and floodplains. Summit would use dust suppression and sedimentation control measures. Summit would comply with the provisions of the federal Migratory Bird Treaty Act, which could include limiting land-clearing activities to periods outside of the nesting season. Summit would coordinate with the TPWD with regard to state-listed species and sensitive habitats listed in the TPWD Natural Diversity Database. Mitigation of impacts to state-listed species could incorporate a variety of options ranging from passive measures (e.g., construction timing outside critical breeding periods and permanent protection of known habitats elsewhere that contain the resource to be affected) or more aggressive measures (e.g., complete avoidance of impact). <u>Operation</u> Summit would continue to implement relevant parts of its approved SWPPP to help minimize impacts to certain biological resources. Summit would develop and implement effective measures, in accordance with an SPCC plan, to mitigate potential impacts caused by the release of petroleum products.
Aesthetics	<u>Construction</u> Summit would develop and implement a SWPPP to reduce erosion and minimize landscape scarring. Summit would employ dust-suppression techniques. <u>Operation</u> Summit would plan and install an outdoor lighting system that would minimize TCEP's nighttime, off-site illumination and glare.

Table 2.8. TCEP Incorporated Mitigation Measures

Resource	Mitigation Measure
Cultural Resources	Construction In accordance with Section 106 of the National Historic Preservation Act (Public Law 89-665), Summit has provided surveys and cultural resource assessments for the proposed polygen plant site and preliminary assessment recommendations for linear facilities to the Texas Historical Commission and other appropriate agencies for review and comment. With regard to the roads, rail lines, high-voltage transmission lines, and other linear facilities, archaeological surveys would only be conducted for corridors identified by state agencies as needing such surveys. Surveys would be completed if DOE issues a favorable Record of Decision.
Traffic and Transportation	Construction To prevent unnecessary traffic congestion and road hazards, Summit would coordinate with local authorities and employ safety measures, especially during the movement of oversized loads, construction equipment, and materials. Where traffic disruptions would be necessary, Summit would coordinate with local authorities and implement detour plans, warning signs, and traffic-diversion equipment to improve traffic flow and road safety. Operation Summit would make road improvements, where necessary, to minimize traffic congestion and road hazards. Improvements may include adding lanes for turning and acceleration.
Safety and Health	Construction and Operation Summit would comply with OSHA requirements as they apply to the project during construction and operation activities.
Noise	Construction Summit would equip steam piping with silencers to reduce noise levels during steam blows by up to 20–30 A-weighted decibels (dBa) at each receptor location. Operation Summit would equip silencers on the relief valves. Summit would perform a noise survey to ensure that operations are in compliance with applicable noise standards. Summit would locate and orient plant equipment to minimize sound emissions; provide buffer zones; enclose noise sources within buildings; install inlet air silencers for the combustion turbine; and include silencers on plant vents and relief valves.

2.6 DOE's No Action Alternative

Under the No Action Alternative, DOE would not share in the cost of the TCEP beyond the project definition phase; in other words, DOE would not share in the costs of detailed design, construction, or the three-year demonstration-phase testing and operations. In this case, some amount of the money withheld from partial funding for the TCEP may be applied to other current or future eligible projects that would meet the objectives of the CCPI program. In the absence of partial funding from DOE, Summit could still elect to construct and operate the TCEP if it could obtain private financing as well as the required permits from state and federal agencies; therefore, the DOE No Action Alternative could result in one of three potential scenarios:

- The TCEP would not be built.
- The TCEP would be built by Summit without benefit of partial DOE financial assistance.
- The TCEP would not be built by Summit and the 600-ac (243-ha) site could be sold for industrial, commercial, or residential development, the impacts of which would be dependent on the type of development pursued.

DOE assumes that if Summit were to proceed with development in the absence of partial funding, the project would include all the features, attributes, and impacts as described for the Proposed Action; however, without DOE participation, it is likely that the proposed project would be canceled. For the purposes of analysis in this EIS, the DOE No Action Alternative is assumed to be equivalent to a "no build" alternative, meaning that environmental conditions would remain in the status quo (no new construction, resource utilization, emissions, discharges, or wastes generated).

If the project were canceled, the proposed technologies of the TCEP (demonstration of commercial-scale IGCC integrated with carbon capture and geologic storage of CO_2 using EOR, and manufacture of urea from gasified coal) may not be implemented in the near term. Consequently, commercialization of the integrated technologies may be delayed or not occur because utilities and industries tend to use known and demonstrated technologies rather than new technologies. This "no build" scenario would not contribute to the CCPI program goals of accelerating the commercial readiness of advanced multi-pollutant emissions control; combustion, gasification, and efficiency-improvement technologies; and demonstrating advanced coal-based technologies that capture and sequester, or put to beneficial use, CO_2 emissions.

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Chapter 3. Affected Environment and Environmental Impacts

3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL IMPACTS

This chapter describes the existing human environment, including natural and man-made resources, of the project area, and characterizes its current condition as a baseline for environmental analysis. Potential environmental effects of Summit's proposed project and the No Action Alternative are then disclosed to inform the public and DOE's decision whether to provide financial assistance for the TCEP. This chapter includes the following sections:

- Introduction and Project Setting (Section 3.1)
- Impacts Assessment Background and Definitions (Section 3.2)
- Affected environment, environmental impacts, and mitigation (Sections 3.3 through 3.19)

3.1 Introduction and Project Setting

The proposed polygen plant site is located in Ector County approximately 15 mi (24 km) southwest of the city of Odessa (see Figure 2.1). Most of its associated linear facilities would extend outward from the plant site across parts of Ector County, mostly in the western part of the county. One waterline would extend into nearby Midland County (WL1) and another slightly into Crane County (WL3).

Ector County is located in the Llano Estacado and Arid Llano Estacado subecoregions, which are in the High Plains ecoregion of Texas (Figure 3.1). The Llano Estacado is one of the largest mesas or tablelands on the North American continent and straddles the Texas–New Mexico border between I-40 on the north and I-20 on the south, roughly between Amarillo and Midland-Odessa, Texas. The region is characterized by mostly treeless flat plateaus, few perennial streams, relatively low annual precipitation, and high wind velocities (Howard et al. 2003). The land is fertile when irrigated. Irrigation water is mined from the deeper parts of the Ogallala Aquifer by electric pumps because there is almost no usable surface water. The Llano Estacado has an extremely low population density, with most of the area residents located in the Texas cities of Amarillo, Lubbock, Midland, and Odessa (U.S. Census Bureau 2002).[1]

In the Llano Estacado lies much of the Permian Basin, a sedimentary basin extending from Lubbock to just south of Midland and Odessa, and extending westward into the southeastern part of the adjacent state of New Mexico (Figure 3.1; Dutton et al. 2004). The Permian Basin is one of the largest petroleum-producing basins in the U.S. It accounts for 19 percent of total U.S. oil production, and it contains approximately 22 percent of U.S. oil reserves (Dutton et al. 2004; Oxy Permian 2011). The Permian Basin encompasses all or parts of 49 counties in West Texas and all or parts of five counties in New Mexico (Figure 3.1).

[1] The results of the 2010 census were not available when the draft EIS was prepared; the 2010 results will be included in the final EIS.

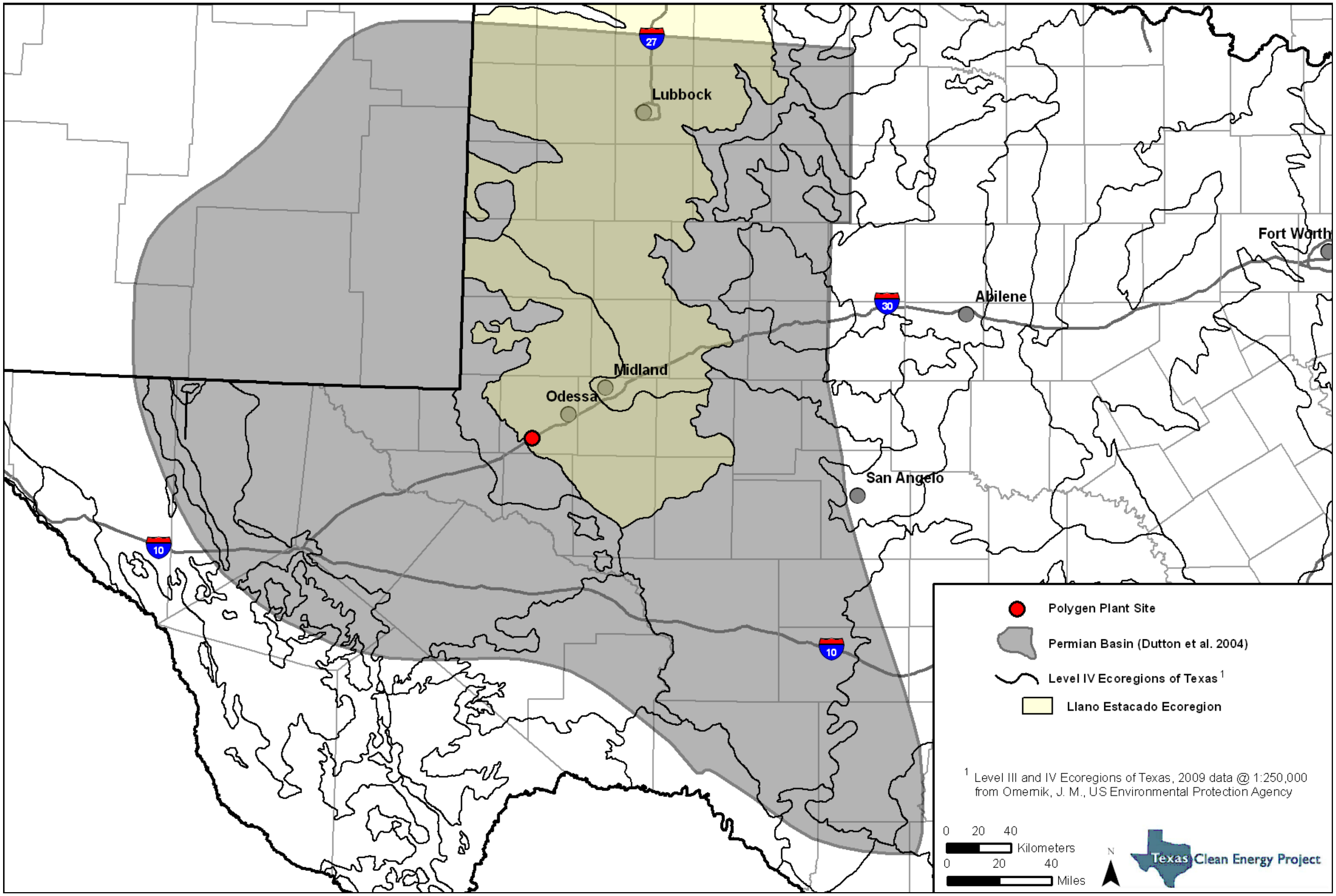

Figure 3.1. Location of the TCEP in the Permian Basin.

3.1.1 Polygen Plant Site

The proposed polygen plant site is a nearly rectangular, 600-ac (243-ha) parcel of land. Site elevation ranges from 2,920 to 2,969 ft (890–905 m) above mean sea level, with a ground slope of less than 0.5 percent (DOE 2007). The site is located in a rural setting that historically has been occupied by ranching and oil and gas industry activities; it is dominated by Mesquite Shrub-Grassland vegetation (see Section 3.8 for details), which is not rare or unique in this region.

The proposed polygen plant site was donated to Summit by the Odessa Chamber of Commerce in April 2010; however, several utility, oil, and gas companies continue to lease easements for access to subsurface oil and gas resources. RRC records reveal six permitted or developed natural gas and oil wells are located on the proposed polygen plant site; however, only one oil well and one gas well remain active (SWCA Environmental Consultants [SWCA] 2010). Crude oil pipeline, natural gas pipeline, and condensate pipeline systems are also present on the site. Other existing structures on the site include gravel roads, abandoned oil- and gas-related structures, and overhead electricity distribution lines. No other structures or improvements are known to have historically occurred at the site (Peyton et al. 2010). No prime or unique farmland soils exist in the plant site, and the site is free from hazardous or radioactive materials, chemicals, or wastes that would be subject to regulation under the Comprehensive Environmental Response, Compensation, and Liability Act the Resource Conservation and Recovery Act or the Nuclear Regulatory Commission (Horizon Environmental Services 2006a).

The polygen plant site's southern boundary borders CR 1216 and is less than 0.5 mi (0.8 km) from I-20. A UPRR line also runs along the site's southern border. Other existing structures at the polygen plant site include gravel roads, abandoned oil- and gas-related structures, pipelines, and overhead electricity distribution lines.

Oil and gas development and ranching activities are the predominant land uses in the area. Remnant oil well pad sites and associated industrial structures are present in the area around the polygen plant site, with concentrations occurring mainly west and south of the site. Neighboring properties include undeveloped industrial space and facilities that support the oil and gas industry. The community of Penwell, Texas, is located immediately south of the proposed polygen plant site. The community has a population of approximately 41 individuals (U.S. Census Bureau 2002), but recent accounts indicate that as few as a dozen people remain in residence in the community (DOE 2007). There are seven occupied residences in Penwell, the closest of which is approximately 0.25 mi (0.40 km) from the polygen plant site (SWCA 2010a). The community has four to five businesses, including a post office and operating oil and gas industrial entities.

3.1.2 Linear Facilities

The TCEP would require the construction of linear facilities consisting of one electrical transmission line, one or more process water pipelines, a natural gas pipeline, a CO_2 pipeline, two access roads, and a rail spur. This EIS addresses six options for potential transmission line corridors, four options for potential water supply pipeline corridors, one option for a potential natural gas corridor, one option for a potential CO_2 pipeline corridor, two options for access roads, and one option for a rail spur. For locations of the proposed and existing linear facilities, see Figure 2.1.

To the fullest extent possible and to limit the need for new ROW, the proposed corridors for the linear facilities were located along existing linear facilities including roads, transmission lines, and pipelines.

3.1.3 Polygen Plant Site Access

Improved roads exist close to the proposed polygen plant site. The nearest improved road that provides access to the site is FM 1601. Although this road could serve as the access road connecting the polygen plant site to the I-20 interchange, its use would require construction of an underpass, overpass, or at-grade intersection with the UPRR line.

Summit's preferred plant access would be at the northeast corner of the proposed polygen plant site. Ector County has agreed to build an access road to the site on the eastern side of the property. This road would be accessed from FM 866, which also connects to I-20. Use of FM 866 would require the construction of approximately 3.7 mi (5.6 km) of new road.

A rail line owned by UPRR borders the polygen plant site to the south. Access to the plant site from this rail line would require construction of a rail spur to connect the main UPRR line to the plant's internal rail loop.

3.2 Impacts Assessment Background and Definitions

Summit's proposed project and its options, as described in Chapter 2, could cause changes or modifications to the existing environment. The analysis in this chapter provides a quantitative or qualitative comparison (depending on the available data and nature of the impact) of the proposed project and its options and describes the extent of those impacts in the context of the existing environment.

Under the No Action Alternative, the TCEP would not be constructed or operated. The No Action Alternative forms the baseline against which the potential impacts associated with DOE's Proposed Action (and Summit's proposed project) are compared. However, should the TCEP not be developed, Summit has stated that the site would be sold and it is possible that the purchaser of the site would develop that tract for industrial, commercial, or residential uses that could impose effects similar to those that would be imposed by the TCEP.

For the analysis, DOE used data gathered during field surveys, existing data, and appropriate scientific methodologies. DOE conducted a site reconnaissance of the polygen plant site on April 7 and 8, 2010, followed by a data collection survey of the project area on July 5 through July 9, 2010. A third field investigation was conducted on November 2 and 3, 2010. DOE documented the existing conditions on the proposed polygen plant site and along the various proposed linear facilities.

Available existing data that were used in the analysis include but are not limited to: landscape-level data such as U.S. Geological Survey land use/land cover data; Texas Natural Resources Information System public spaces and parks data, National Hydrography Dataset (NHD) data, Soils Survey Geographic Database soils data, state agency information on wildlife habitat boundaries, and available county parcel zoning data.

RPS Group, on behalf of Summit, conducted the air quality analysis including dispersion modeling for the project using the American Meteorological Society and EPA Regulatory Model (AERMOD) in preparation of the air emissions permit application. The air quality analysis also evaluated potential human health effects from project emissions using TCEQ effects screening limits (ESL) (TCEQ 2010a).

3.2.1 Region of Influence

ROIs vary by resource or use depending on the geographic extent of the resources or use and the extent of the effects of the proposed project on a resource or use. In some cases, the ROI is the proposed polygen plant site and linear facilities only (for example, soils) because that is the extent of the effect of the proposed project on the resource. In other cases, the ROI is much larger, encompassing administrative or natural boundaries (for example, socioeconomic conditions or wildlife and habitat) because effects on the resource extend beyond the project physical boundaries. The ROI for each resource or use is defined in the Background section for each resource description.

3.2.2 Types of Impacts

Impacts (or effects) are modifications to the existing environment and effects on humans brought about by an action. Impacts can be beneficial or adverse; they can result from the action directly or indirectly; and they can be temporary, permanent, or cumulative in nature.

Direct impacts from a proposed project affect a specific resource, and generally occur at the same time and place. *Indirect impacts* can result from one resource affecting another (e.g., soil erosion and sedimentation affecting water resources) or can occur later in time or removed in location. Indirect impacts described in this EIS are those that are reasonably expected to occur. *Cumulative effects* result from the incremental effects of an action when added to other past, present, and reasonably foreseeable future actions. Direct and indirect effects are described in the Environmental Impacts sections for each resource area. Cumulative effects are discussed in Chapter 5. Disclosures of irreversible and irretrievable commitment of resources and the impacts of the proposed project's short-term resource use on the long-term productivity of the project area are discussed in Chapter 6.

3.2.3 No Action Alternative

For the purposes of analysis, the No Action Alternative is assumed to be equivalent to a "no build" alternative, meaning that the TCEP would not be developed and rural land uses, including residential development, grazing, dispersed recreation, and light commercial and industrial development, would continue in the project area. Summit has stated that, should the TCEP not go forward, the polygen plant site would be sold. It is possible that the purchaser of the site could develop that tract for industrial, commercial, or residential uses that could impose impacts to existing environmental conditions.

3.2.4 General Assumptions

The following are the general assumptions used for this EIS. Assumptions associated with a specific resource (e.g., wildlife habitat) are included in the impacts analysis for that resource.

- Acreages were calculated using computer-based geographic information systems (GIS); there may be a slight variation in total acres among resources. These variations are negligible and did not affect the analyses.
- All acreages and percentages presented in this chapter pertain to all lands in the polygen plant site and associated linear facilities, unless otherwise specified.
- The impacts analysis takes into account the mitigation measures to which Summit has committed and which are described in Chapter 2 (see Section 2.5).
- Summit's proposed project and its options incorporate the implementation of applicable controls and measures.
- Summit would meet all federal, state, and local regulatory requirements.

3.3 Air Quality and Greenhouse Gas Emissions

3.3.1 Background

This section identifies and describes the air quality and GHG emissions that could be affected by the construction and operation of the polygen plant and linear facilities. This section also presents the environmental impacts of the proposed project on regional air quality and human health. Additional mitigation measures that could be implemented to further reduce potential adverse consequences are presented.

3.3.2 Region of Influence

The ROI for air quality encompasses a 31-mi (50-km) radius around the proposed polygen plant. It is the same as the Area of Significant Impact used for the air dispersion modeling for the TCEP. For consistency, the term ROI is used in this section.

3.3.3 Methodology and Indicators

Various state and federal air quality standards and emissions limits have been established to minimize air pollutant emissions and resulting adverse air quality impacts, including the potential for human health impacts. Potential impacts and their indicators are shown in Table 3.1.

Table 3.1. Indicators of Potential Air Quality Impacts

Potential Impact	Impact Indicator
Emissions of criteria air pollutants and HAP	Tons of emissions per year for each air contaminant
Change in air quality related to the National Ambient Air Quality Standards (NAAQS)	
Consumption of Prevention of Significant Deterioration (PSD) increments as defined by the Clean Air Act	
Reduction in visibility and increase in regional haze in Class I areas*	
Deposition of N_2 and sulfur in Class I areas*	
Conflict with local or regional air quality management plans	
Emissions of GHGs (CO_2 emissions)	
Solar loss, fogging, icing, or salt deposition on nearby residents	Estimated total solids emission rate, frequency of plumes
Discharge of odors into the air	Odor sources and estimated quantity

*A Class I area is defined under the Clean Air Act as a national park greater than 6,000 ac (2,428 ha), wilderness area or national memorial park greater than 5,000 ac (2,024 ha), or international park that existed in 1977.

Construction of the TCEP and its linear facilities would increase dust, airborne chemicals, and vehicular emissions in the ROI. During construction of the project, temporary and localized increases in concentrations of nitrogen dioxide (NO_2), CO, SO_2, volatile organic compounds, PM with aerodynamic diameters equal to or less than 0.00039 in (10 micrometers) (PM_{10}), and fine PM with aerodynamic diameters equal to or less than 0.000098 in (2.5 micrometers) ($PM_{2.5}$) would result from exhaust emissions of workers' vehicles, heavy construction equipment, diesel generators, and other machinery and tools. Increased emissions of dust would also result from clearing, excavating, and grading activities associated with construction. A qualitative analysis was performed for the air quality impacts associated with construction.

Plant operations would also result in emissions of air pollutants and GHGs. Although the TCEP would produce lower air pollutant emissions as compared to conventional coal-fueled plants or older IGCC plants, unplanned upsets and subsequent startups would result in the emission of a large portion of the total air pollutants emitted during early years of plant operation. Plant upsets include any serious malfunction in the IGCC process that would result in the sudden shutdown of the turbine and other plant components, requiring subsequent plant restart. Emissions would be expected to decrease each year, however, as operator learning and experience would reduce the frequency and types of unplanned restart events. Air dispersion modeling was based on year-round plant operation (8,760 hours per year); plant maintenance and unplanned restarts as a result of plant upsets were assumed to occur 60 times per year.

> A **Title V Major Source** is defined as any source emitting or having the potential to emit 1) 100 tn (91 t) per year or more of any criteria pollutant; 2) 10 tn (9 t) per year or more of any HAP or 25 tn (22 t) per year of any combination of HAPs.

The proposed project would be a new Title V Major Source as defined by the PSD regulations and the Clean Air Act and would emit NO_x, SO_2, PM_{10}, $PM_{2.5}$, CO, and H_2SO_4 in quantities that trigger PSD review for these constituents. Operational impacts of the project were evaluated on the basis of estimated emissions of specified air pollutants as processed with an air dispersion model for Class II areas, as required by PSD review requirements. PSD Class I visibility impairment analysis was not required for the TCEP because the polygen site is greater than 62 mi (100 km) away from the nearest Class I area.

In addition to air pollutant emissions from plant operations, workers' and plant vehicles would provide an ongoing source of exhaust and dust emissions for the life of the project. A qualitative assessment of fugitive dust and emissions was used to determine impacts from these sources. Plume emissions from cooling towers were also qualitatively assessed to estimate the likelihood of localized decreases in visibility in the region from solids deposition.

A health effects evaluation was also performed for the emissions of HAPs from the TCEP's operations using the TCEQ ESLs. Other air quality impacts analyses performed for the proposed project were an ozone (O_3) impacts analysis and a review of SO_2, H_2SO_4, and H_2S emissions.

The following sections provide a summary of the PSD Class II area modeling and ESL analysis results. A detailed description of the AERMOD modeling approach used for TCEP, including modeling assumptions and data, is presented in *Air Quality Analysis: Permit Nos. 92350 and Prevention of Significant Deterioration (PSD)-TX-1218 Integrated Gasification Combined-Cycle Power Plant*, provided for the TCEP air permit application (RPS Group 2010) and incorporated into this EIS by reference.

3.3.3.1 MODELING APPROACH

Air dispersion modeling for the project was conducted using AERMOD. This is the EPA regulatory default model for local (within 31 mi [50 km] of the project area) air quality analysis. Model inputs and control parameter options were selected in accordance with protocols established in:

- EPA Guidelines on Air Quality Models;

- TCEQ Air Quality Modeling Guidelines (Revised, February 1999, RG-25);
- *TCEQ Modeling and Effects Review Applicability: How to Determine the Scope of Modeling and Effects Review for Air Permits* (October 2001, RG-324); and
- written guidance (Texas Natural Resource Conservation Commission 1998 Memorandum: Background Concentration Determination for Use in NAAQS Analyzes; TCEQ Draft Ozone Procedures; 2010 EPA Memorandum: Modeling Procedures for Demonstrating Compliance with $PM_{2.5}$ NAAQS).

The receptor grids used for the modeling analyses are as follows:

- 82-ft (25-m) spacing on the entire polygen plant site
- 82-ft (25-m) spacing extending from the property line out 328 ft (100 m) and within 1,640 ft (500 m) of the nearest source
- 328-ft (100-m) spacing within 328 ft (100 m) to 3,280 ft (1,000 m) of the sources;
- 1,640-ft (500-m) spacing within 3,280 ft (1,000 m) to 1,640 ft (500 m) of the sources
- 3,280-ft (1,000-m) spacing within 16,404 ft (5,000 m) to greater than 49,212 ft (15,000 m) of the sources (an additional grid out to greater than 85,302 ft [26,000 m] was used for the SO_2 1-hour AOI modeling)

The air dispersion modeling ROI for the NAAQS/PSD increment analysis included on-site and off-site sources within 31 mi (50 km) of the proposed polygen plant site. This modeling was performed to determine whether NAAQS and PSD increments would be exceeded by TCEP operations. Predicted pollutant concentrations at each receptor, spaced at 82-ft (25-m) intervals within the polygen plant site and at progressively wider spacing outside of plant site boundaries, were compared to significant impact levels (SILs) as defined by EPA (EPA 2010a, 2010b, 2010c, 2010d). Additional information on the development of the receptor grid is provided in the *Air Quality Analysis: Permit Nos. 92350 and Prevention of Significant Deterioration (PSD)-TX-1218 Integrated Gasification Combined-Cycle Power Plant*, provided for the TCEP air permit application (RPS Group 2010) and incorporated into this EIS by reference.

Dust emissions during the operation of the TCEP would result from windblown dust generated from disturbed areas and dust generated from vehicle traffic on unpaved roads and other surfaces. Most of the dust generated from the project area during construction would be controlled through mitigation, such as through the use of spray trucks or a dust palliative. However, incidents of windblown dust are unpredictable and typically occur several times per year, most often during the late winter and early spring. At such times, short-duration, windblown dust plumes in the region significantly impair visibility. These dust plumes result from exposed soils that are picked up during strong wind events. The TCEP would not contribute more windblown dust than would other dry desert or agricultural areas, and the implementation of dust controls would make the TCEP less susceptible to release of windblown dust than native bare soil or the agricultural areas near the polygen plant site. Consequently, dust emissions were not considered in modeling.

3.3.3.2 EFFECTS SCREENING LIMITS

The TCEP air quality analysis also evaluated potential human health effects from project emissions using TCEQ ESLs (TCEQ 2010a). Health-based ESLs are set at levels below that which has been shown to cause adverse health effects in humans or laboratory animals. This establishes a basis to determine whether the constituent concentrations in TCEP's emissions could affect human health.

The TCEQ uses a three-tiered ESL process to assess effects on human health from air emissions:

- Tier I: Estimated off-site short-term and long-term (as applicable) concentrations are compared to applicable ESLs. If the estimated concentration is less than the ESL, the concentration would not harm human health and no further review occurs.

- Tier II: If an ESL exceedance is predicted to occur in Tier I, the receptor type at the site of exceedance is evaluated. There are two types of receptors: industrial and nonindustrial. If the maximum predicted concentration at an industrial receptor is less than 2× ESL or if the maximum concentration at a nonindustrial receptor is less than the ESL, the concentrations would not harm human health, and no further review occurs.
- Tier III: If an ESL exceedance is predicted to occur in Tier II, additional case-specific factors that have a bearing on the predicted concentration are considered. The frequency of exceeding the ESL at a receptor is determined for 2×, 4×, and 10× ESL. The receptor/magnitude/frequency combination is subsequently evaluated for potential adverse effects on human health.

3.3.4 Affected Environment

3.3.4.1 WIND

Wind speed and direction are important components in determining air quality impacts. Winds in the ROI predominately flow from the south-southeast and from the southeast, and to a lesser extent from the southwest. The frequency, direction, and speed of winds in 2005 at the Midland Airport weather station (25 mi [40 km] east of the polygen plant site) are illustrated in Figure 3.2. Windy conditions during the late winter and early spring contribute to naturally occurring windblown dust in the region, although dust storms may be exacerbated by land disturbances that expose soil and/or result in the removal of vegetation.

3.3.4.2 LOCAL AND REGIONAL AIR QUALITY

National Ambient Air Quality Standards

As directed by the federal Clean Air Act, EPA has established NAAQS for six criteria pollutants (see Table 3.2). These standards were adopted by EPA to protect public health (primary standards) and public welfare (secondary standards). The six pollutants are CO, NO_2, O_3, PM (PM_{10} and $PM_{2.5}$), SO_2, and lead. States are required to adopt standards that are at least as stringent as the NAAQS. Texas ambient air quality standards are identical to the NAAQS (40 C.F.R. §§ 50.4–50.16; and 30 Texas Administrative Code [TEX. ADMIN. CODE] Chapter 101, § 21).

Recent Air Quality Monitoring Data and National Ambient Air Quality Standards Exceedances

The TCEQ Monitoring Operations Division maintains a network of air quality monitoring sites throughout the state. An assessment of existing criteria pollutants levels in the region is based on data collected and reported by the TCEQ in 2009 (TCEQ 2009). The only monitoring station in Ector County is for $PM_{2.5}$. Therefore, conservative representative monitoring data were obtained from other monitors in the state, following TCEQ guidance for background concentration determination in NAAQS analyses (RPS Group 2010). The monitoring stations were selected based on the comparisons of population and emissions of the counties where the monitors are located to Ector County. A summary of the representative monitoring results are provided in Table 3.3.

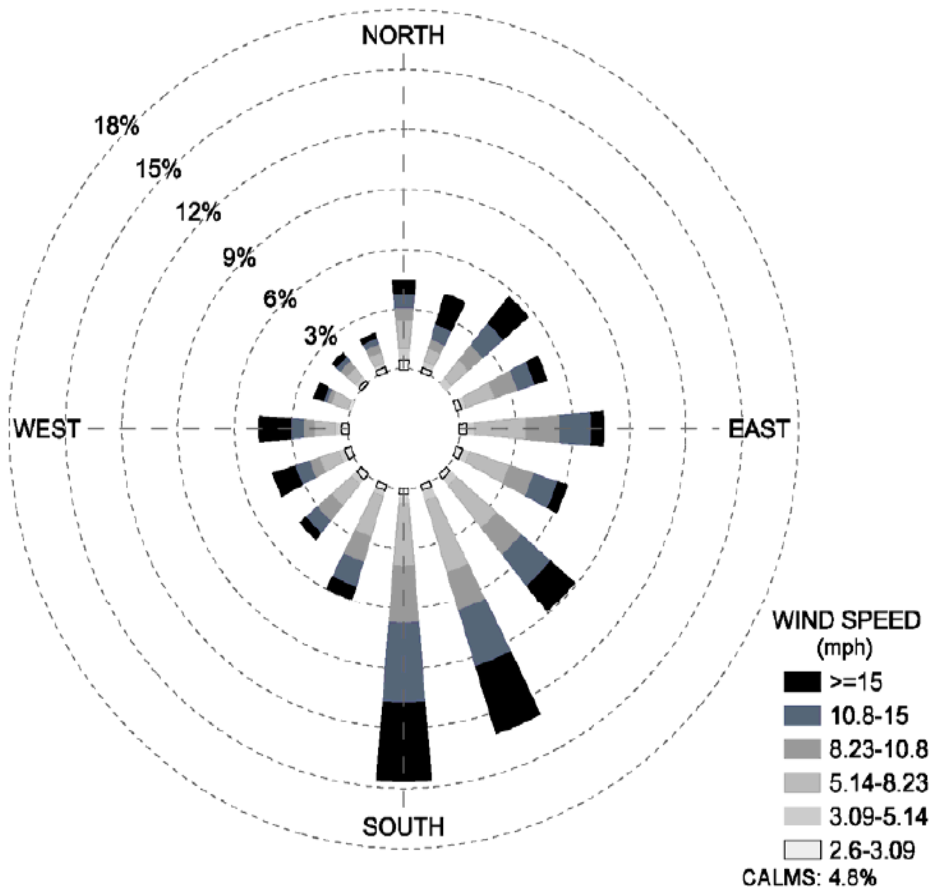

Figure 3.2. Distribution of winds (percent) at the Midland Airport.

Table 3.2. National Ambient Air Quality Standards

Pollutant	Averaging Time	Primary µg/m³ (ppm)	Secondary µg/m³ (ppm)
CO	1-hour	40,000 (35)	–*
	8-hour	10,000 (9)	–
NO_2	Annual	100 (0.053)	100 (0.053)
	1-hour	188 (0.10)	–
O_3	(1-hour)†	(0.12)	(0.12)
	8-hour	(0.075)	(0.075)
PM_{10}	24-hour	150	150
	(annual)‡	50	50
$PM_{2.5}$	24-hour	35	35
	Annual	15	15
SO_2	1-hour§	196 (0.075)	–
	3-hour§	–	1,300 (0.5)
	(24-hour)§	365 (0.14)	–
	(annual)§	80 (0.03)	–
Lead	Calendar quarter	1.5	1.5
Lead	Rolling 3-month average	0.15	0.15

Source: 40 C.F.R. Part 50.
Note: µg/m³ = micrograms per cubic meter.
* No standard.
† O_3 1-hour standard revoked by EPA on June 15, 2005.
‡ PM_{10} Annual standard revoked effective December 17, 2006.
§ On June 2, 2010, EPA established a new 1-hour SO_2 standard, effective August 23, 2010, which is based on the 3-year average of the annual 99th percentile of 1-hour daily maximum concentrations. EPA also revoked both the existing 24-hour SO_2 standard of 0.14 ppm and the annual primary SO_2 standard of 0.030 ppm, effective August 23, 2010. The secondary SO_2 standard was not revised at this time; however, the secondary standard is undergoing a separate review by EPA.

Table 3.3. Air Monitoring Data for Texas Commission on Environmental Quality Monitoring Sites (2009)

Monitoring Site	**CO**		**O_3**		**PM_{10}**		**$PM_{2.5}$**		**NO_2**		**SO_2***	**Lead†**
NAAQS	**Maximum Concentration 1-hour 40,000 μg/m³**	**Maximum Concentration 8-hour 10,000 μg/m³**	**Maximum Concentration 1-hour 0.12 ppm**	**Fourth Highest Concentration 8-hour 0.075 ppm**	**Maximum Concentration 24-hour 150 μg/m³**	**Arithmetic Annual Mean Revoked**	**Maximum Concentration 24-hour 35 μg/m³**	**Arithmetic Annual Mean 15 μg/m³**	**Maximum Concentration 1-hour 188 μg/m³**	**Arithmetic Annual Mean 100 μg/m³**	**Arithmetic Annual Mean 80 μg/m³**	**Rolling 3-month average 0.15 μg/m³**
Washington Street, Laredo, Webb County	3,013	1,858	–	0.052	–	–	–	–	–	–	–	–
700 Zaragosa Street, Laredo, Webb County	3,145	2,219	–	–	–	–	–	–	–	–	–	–
14790 CR 1145, Tyler, Smith County	–	–	–	–	–	–	–	6.86	18.80	7.50	–	–
2600 B Webberville Road, Austin, Travis County	–	–	–	–	41	18	–	–	–	–	–	–
12200 Lime Creek Road, Austin, Travis County	–	–	–	–	41	14	–	–	–	–	–	–
Barrett and Monahans Streets, Odessa, Ector County	–	–	–	–	–	–	16.20	–	–	–	–	–

Note: Dashed line (–) indicates that the air pollutant was not monitored at the monitoring site. μg/m³ = micrograms per cubic meter.
* 2009 monitoring data were not collected for SO_2.
† 2009 monitoring data were not collected for lead.

As shown in Table 3.3, the air quality in Ector and surrounding Webb, Smith, and Travis Counties is generally good, with pollutant levels below the NAAQS. The major air pollutants in the region are CO, PM, volatile organic chemicals, and O_3 from vehicular travel along local paved roads and I-20. Hydrocarbon emissions also occur from oil and gas wells and related transmission and storage facilities.

Duke Energy Field Services is the only existing large emissions point source within 1.0 mi (1.6 km) of the polygen plant site. Within a 10-mi (16-km) radius, the Block 31 Gas Plant, Walton Compressor Station, Shell Western E and P Incorporated, Sands Hills Gas Plant, Odessa Cement Plant, and several active and abandoned limestone quarries are present. These existing sources contribute to concentrations of airborne pollutants and dust in the region.

Description of Criteria Air Pollutants

Carbon Monoxide

CO is formed from the combustion of carbon-based products, especially in an O_2 deficient atmosphere. Of the criteria pollutants, CO is one of the most commonly occurring pollutants in Ector County. Motor vehicles are the primary source of CO in Ector County.

Ozone

Stratospheric O_3 occurs naturally, but it can also be formed from the reaction of volatile organic compounds and NO_X in the presence of heat and sunlight. In 2009, maximum concentrations of O_3 were moderate, but did not exceed the 8-hour standard at the nearest monitoring station in Webb County.

Particulate Matter

PM_{10} and $PM_{2.5}$ occurs from a variety of activities such as construction, agriculture, industrial processes, vehicular travel, and wind erosion. Because of the rural nature of the area and the limited number of mobile and point sources, PM_{10} and $PM_{2.5}$ concentrations are low to moderate in this region, as indicated by the monitoring results in Ector, Smith, and Travis Counties.

Nitrogen Dioxide

NO_2 is a gas that forms primarily when fuel is burned at high temperatures; common sources include vehicle exhaust, industry, and power plant emissions. NO_2 is a precursor to O_3 and can contribute to haze and visibility reduction. Ambient concentrations of NO_2 are well below the standard in this region, as indicated by the monitoring station in Smith County.

Sulfur Dioxide

SO_2 exists as a gas associated with the burning of sulfur-bearing coal, oil, or diesel fuel. In the atmosphere, it can combine with water vapor and O_2 gas to form a weak H_2SO_4, which precipitates as acid rain that can adversely affect the environment. Ambient concentrations of SO_2 are extremely low in Ector County due to the lack of major sources. For that reason, SO_2 is not included in Ector County monitoring efforts.

Lead

No lead sources are identified in Ector County; therefore, lead is not included in recent Ector County monitoring efforts (TCEQ 2009).

Clean Air Act Attainment Status

Based on the NAAQS, all air basins (or portions thereof) are designated as either in attainment or not in attainment with respect to criteria air pollutants (42 U.S.C § 7407). A particular geographic region may be designated an attainment area for some air pollutants and nonattainment for others. Ector County is part of the Midland-Odessa-San Angelo Intrastate Air Quality Control Region, which is in attainment for the six criteria air pollutants and has no history of nonattainment. Regionally, the closest nonattainment area is approximately 215 mi (346 km) away, in El Paso County.

3.3.4.3 HAZARDOUS AIR POLLUTANTS

HAPs, also known as air toxics, are pollutants that can cause health effects (e.g., cancer) in humans or may cause adverse environmental and ecological effects. In 2001, EPA developed a national network for monitoring ambient levels of air toxic emissions. Based on the latest National-Scale Air Toxics Assessment in 2002, cancer, neurological, and respiratory risks from HAP emissions to residents in the ROI are estimated to be very low (average total risk is less than 1 in a million). Most HAP emissions in Ector County originate from background sources and petroleum compounds from oil and gas wells; mobile sources account for most of the remaining HAP emissions. Primary HAPs for the county are toluene, xylene, benzene, hexane, 2,2,4-trimethylpentane, methanol, formaldehyde, and vinyl acetate.

Radionuclide Emissions

Coal, which would be combusted as part of polygen plant operations, is largely composed of organic matter but also contains some trace elements such as uranium and thorium that are naturally radioactive. Analyses of the types of coals that would be used in the polygen plant show that concentrations of uranium and thorium fall in the range from slightly below 1 to 4 ppm. Although there are research gaps related to the ultimate fate of radionuclides in advanced coal technologies, EPA has determined that current levels of radionuclide emissions (both parent elements and various decay products) from coal-fueled boilers represent a level of risk that protects the public health with a margin of safety. Consequently, the consequences of TCEP radionuclide emissions were not evaluated.

Mercury

The TCEP could be subject to the Clean Air Mercury Rule because it would generate approximately 275 MW of electricity and would sell more than one-third of its potential electric output. The rule established standards of performance that limit Hg emissions from coal-fueled power plants. However, that rule was vacated by a federal court and new rules are scheduled to be proposed by March 2011.

3.3.4.4 GREENHOUSE GASES

In *Massachusetts v. EPA, et al*., 549 U.S. 497 (2007), the U.S. Supreme Court ruled that GHGs meet the Clean Air Act's definition of a pollutant and that EPA has authority to regulate GHGs. Recent federal regulation (40 C.F.R. Part 98, Reporting of GHG Emissions) requires annual monitoring, record-keeping, and reporting of GHG emissions for large sources and suppliers. Because the TCEP would be an electrical generating unit emitting more than 27,558 tn (25,000 t) of GHG emissions per year, it would be required to report emissions of CO_2 under Subpart C of this rule. Also, because the polygen plant would be a supplier of CO_2, the amount of CO_2 captured in the process and its end use (urea production and EOR) would be reported annually.

TCEQ issued a PSD construction permit for the TCEP on December 28, 2010. As a result, the TCEP is not affected by EPA's Tailoring Rule and related EPA actions, which determined that GHG emissions became subject to regulation under the federal Clean Air Act as of January 2, 2011. EPA's regulatory actions regarding GHGs have been challenged in court by various parties, including the State of Texas. If the PSD permit for the TCEP had been issued after January 2, 2011, then, depending on the outcome of legal challenges to EPA's regulatory actions, the PSD permit issued to the TCEP could have included limits on GHG emissions reflecting the best available control technology for control of those emissions. The PSD permit issued for TCEP does not contain limits on GHG emissions, and no best available control technology determination for GHG emissions from the TCEP was required. However, the TCEP is designed to capture 90 percent of the carbon content of the coal used to power the generation of electricity. This would result in a lower rate of CO_2 emissions per MW/hour than any existing coal-fired power plant, or a typical natural gas–fired power plant.

The State of Texas does not currently have a climate change or GHG action plan.

3.3.4.5 PROXIMITY TO CLASS I AND II AREAS

There is no Class I area in the air quality ROI. The closest Class I area is the Carlsbad Caverns National Park, located 108 mi (174 km) west of the polygen plant.

The ROI is located in a Class II area, and is required to comply with PSD increments for pollutant concentrations. Allowable PSD increments currently exist for three criteria air pollutants: SO_2, NO_2, and PM (both PM_{10} and $PM_{2.5}$). The final rule for PSD increments for annual and 24-hour $PM_{2.5}$ was published by EPA on October 20, 2010. However, the "trigger date" of the new increments is October 20, 2011, which is one year after the date of promulgation of this final rule (permit must be issued by that date). As a result, the TCEP is not subject to the new $PM_{2.5}$ increment requirements at this time.

3.3.4.6 AIR QUALITY MANAGEMENT PLANS

No local air quality management plans exist for the ROI.

3.3.5 Environmental Impacts of Summit's Proposed Project

Direct impacts to air quality would result from construction vehicle exhaust and dust-generating activities (e.g., soil excavation and site grading) during project construction, and stationary source emissions (combustion turbine, flare, gasifier, cooling towers, sulfur recovery system, and coal handling) during project operations.

3.3.5.1 SENSITIVE RECEPTORS

The proposed polygen plant site is primarily rural and has generally been used for oil and gas production, ranching, and agricultures activities. There are no sensitive receptors such as schools or hospitals within 1.0 mi (1.6 km) of the polygen plant site; however, there are seven residences in and around Penwell, to the south of the proposed plant site. All other sensitive populations are over 10 mi (16.1 km) east of the polygen plant site in the city of Odessa.

3.3.5.2 PROJECT EMISSIONS

Summary of Emissions during Construction

During construction, operation of worker vehicles and construction equipment and vehicles would result in localized and short-term criteria pollutant emissions. In addition, land clearing and excavation, road surface construction, and cut-and-fill operations would generate dust (PM_{10} and $PM_{2.5}$). Construction impacts would be minimized through the implementation of dust controls such that impacts attributable to dust emissions would be localized and temporary.

Summary of Emissions during Operations

A summary of the maximum operational emissions from the TCEP is provided in Table 3.4. Maximum annual emissions would exceed both PSD and Title V Major Source thresholds for NO_x, SO_2, CO, PM_{10}, $PM_{2.5}$, and H_2SO_4 (i.e., 100 tn [91 t] per year). Plant-wide emissions of HAPs are below the major source thresholds of 10 tn (9 t) per year for individual HAPs and 25 tn (23 t) per year for total combined HAPs (see Table 3.6). Operational emissions for the TCEP would increase existing county-wide criteria pollutant emissions, ranging from 2 percent for NO_2 to 20 percent for SO_2 and $PM_{2.5}$.

Combustion turbine operations would be the largest contributor to polygen plant NO_2 and H_2SO_4 emissions, and gasifier flares during plant startup would be the largest source of CO and SO_2 emissions. Because the frequency of unplanned plant startups should progressively decrease from year one onward, estimated CO and SO_2 emissions would be expected to decrease over time.

PM emissions are typically the greatest for large industrial processes with high air flow. For the TCEP, the combustion turbine and urea granulation stack meet these criteria and would contribute the highest PM load, even with control technologies installed.

Table 3.4. Annual, Maximum Operation Emissions by Air Contaminant

Source	NO_2 Emissions (tn [t] per year)	CO Emissions (tn [t] per year)	SO_2 Emissions (tn [t] per year)	PM_{10} Emissions (tn [t] per year)	$PM_{2.5}$ Emissions (tn [t] per year)	H_2SO_4 Emissions (tn [t] per year)
Combustion turbine (including startup) and duct burner	165.79 (150.40)	310.97 (282.11)	78.10 (70.85)	118.80 (107.77)	118.80 (107.77)	11.96 (10.85)
	240.20 (108.95)*	1,705.80 (773.74)*	–	–	–	–
Combustion turbine lube oil vent	–	–	–	0.22 (0.20)	0.22 (0.20)	–
Steam turbine lube oil vent	–	–	–	0.22 (0.20)	0.22 (0.20)	–
H_2SO_4 plant vent	11.57 (10.50)	0.51 (0.46)	10.19 (9.24)	2.68 (2.43)	2.68 (2.43)	2.68 (2.43)
Urea granulation stack	–	–	–	199.20 (180.71)	199.20 (180.71)	–
Coal mill dryer vent train (×2)	33.50 (30.39)	61.42 (55.72)	3.18 (2.88)	41.68 (37.81)	41.68 (37.81)	–
Cooling tower	–	–	–	5.82 (5.28)	0.04 (0.036)	–
Gasifier flare startup	11.99 (10.88)	545.24 (494.63)	159.46 (144.67)	–	–	–
	133.26 (60.45)*	6,058.17 (2,747.94)*	1,771.78 (803.61)*	–	–	–
Gasifier flare (×2)	0.24 (0.22)	1.22 (1.11)	<0.01 (<0.01)	–	–	–
Natural gas fired auxiliary boiler	1.06 (0.96)	2.31 (2.10)	0.18 (0.16)	0.47 (0.43)	0.47 (0.43)	–
Railcar unloading	–	–	–	0.02 (0.018)	<0.01 (<0.01)	–
Coal unloading conveyor	–	–	–	0.02 (0.018)	<0.01 (<0.01)	–
Crusher feed conveyor (×2)	–	–	–	0.02 (0.018)	<0.01 (<0.01)	–
Coal crusher building	–	–	–	0.06 (0.05)	0.06 (0.05)	–
Plant feed conveyor (×2)	–	–	–	0.16 (0.15)	0.02 (0.018)	–

Table 3.4. Annual, Maximum Operation Emissions by Air Contaminant

Source	NO_2 Emissions (tn [t] per year)	CO Emissions (tn [t] per year)	SO_2 Emissions (tn [t] per year)	PM_{10} Emissions (tn [t] per year)	$PM_{2.5}$ Emissions (tn [t] per year)	H_2SO_4 Emissions (tn [t] per year)
Coal transfer tower	–	–	–	1.13 (1.03)	1.13 (1.03)	–
Tripper feed conveyor (×2)	–	–	–	0.02 (0.018)	<0.01 (<0.01)	–
Silo fill tripper conveyor (×2)	–	–	–	0.02 (0.018)	<0.01 (<0.01)	–
Gasifier feed silo (×2)	–	–	–	0.02 (0.018)	<0.01 (<0.01)	–
Slag storage pile (×2)	–	–	–	0.26 (0.24)	0.04 (0.36)	–
Slag transfer tower(×2)	–	–	–	0.01 (<0.01)	<0.01 (<0.01)	–
Slag transfer conveyor	–	–	–	<0.01 (<0.01)	<0.01 (<0.01)	–
Slag loadout conveyor	–	–	–	<0.01 (<0.01)	<0.01 (<0.01)	–
Slag rail loading station	–	–	–	<0.01 (<0.01)	<0.01 (<0.01)	–
Urea storage conveyor	–	–	–	1.45 (1.32)	0.22 (0.20)	–
Urea transfer tower (×2)	–	–	–	1.12 (1.02)	1.12 (1.02)	–
Urea tripper conveyor	–	–	–	1.01 (0.92)	0.15 (0.14)	–
Urea storage building	–	–	–	0.52 (0.47)	0.08 (0.07)	–
Urea reclaim conveyor	–	–	–	2.32 (2.10)	0.35 (0.32)	–
Urea loadout conveyor	–	–	–	0.43 (0.39)	0.07 (0.06)	–
Urea rail loading station	–	–	–	0.56 (0.51)	0.56 (0.51)	–
CO_2 compressor bypass vent [†]	–	243.09 (220.53)	–	–	–	–

Table 3.4. Annual, Maximum Operation Emissions by Air Contaminant

Source	NO_2 Emissions (tn [t] per year)	CO Emissions (tn [t] per year)	SO_2 Emissions (tn [t] per year)	PM_{10} Emissions (tn [t] per year)	$PM_{2.5}$ Emissions (tn [t] per year)	H_2SO_4 Emissions (tn [t] per year)
Diesel-fired emergency generator(×2)	1.02 (0.93)	0.60 (0.54)	<0.01 (<0.01)	0.04 (0.036)	0.04 (0.036)	–
Diesel fire water pump engine	0.03 (0.027)	0.05 (0.045)	<0.01 (<0.01)	<0.01 (<0.01)	<0.01 (<0.01)	–
Fugitives: raw syngas	–	7.31 (6.63)	–	–	–	–
Fugitives: clean syngas	–	0.13 (0.12)	–	–	–	–
Fugitives: acid gas	–	0.01 (<0.01)	–	–	–	–
Active/live coal storage pile	–	–	–	0.52 (0.47)	0.08 (0.07)	–
Inactive coal storage pile	–	–	–	1.24 (1.12)	0.18 (0.16)	–
Proposed project total annual emissions	225.00 (204.12)	1,173.00 (1,064.13)	251.10 (227.79)	380.00 (344.73)	367.00 (332.94)	15.00 (13.61)
2005 Ector County emissions	12,777 (11,591)	26,573 (24,107)	2,105 (1,910)	6,175 (5,602)	1,800 (1,633)	n/a
Estimated increase in current emissions	2%	4%	20%	6%	20%	n/a

Note: No significant lead sources were identified in ROI; therefore, lead was not carried forward for analysis. O_3 was analyzed separately using TCEQ guidance, the results of which are not comparable for inclusion in this table (see Other Air Quality Impacts Section 3.3.5.3). n/a = not available.
*Maximum short-term emissions rates (lbs [kg]/hour) during startup, shutdown, and maintenance.
†Annual emissions are based on venting 5 percent of the time during maintenance operations (438 hours per year).

Project Significant Impact Level Exceedances

Emissions of the criteria air pollutants would exceed the threshold for PSD review; therefore, ground-level concentrations that would be caused by the TCEP emission sources were modeled and compared with EPA-established SILs to determine if more detailed analysis was required. The highest modeled concentration for each criteria air pollutant is shown in Table 3.5. The maximum NO_2 (annual), CO (1-hour and 8-hour), and SO_2 (annual) modeling results were lower than the respective SILs, indicating an extremely low likelihood of a significant air quality impact; therefore, no further analysis was conducted. The maximum NO_2 (1-hour), PM_{10} (24-hour), $PM_{2.5}$ (24-hour and annual), and SO_2 (1-hour, 3-hour, and 24-hour) modeling results were higher than the respective SILs, however, and triggered the NAAQS and PSD increment modeling analysis.

Table 3.5. TCEP Sources Modeling Results by Air Contaminant

Pollutant	Regulation	Averaging Period	Maximum Concentration (μg/m³)	Modeling SIL (μg/m³)
NO_2	NAAQS	1-hour*	**94.40**	7.50
		Annual	0.30	1.00
CO	NAAQS	1-hour	1,718.00	2,000.00
		8-hour	400.00	500.00
PM_{10}	NAAQS	24-hour	**10.80**	5.00
		Annual†	**1.30**	1.00
$PM_{2.5}$	NAAQS	24-hour	**5.50**	1.20
		Annual	**0.79**	0.30
SO_2	TEX. ADMIN. CODE Chapter 112	30-min	83.80	–
	NAAQS	1-hour	**52.20**	7.80§
		3-hour	**58.40**	25.00§
		24-hour*	**18.30**	5.00
		Annual†	0.20	1.00
H_2S	TEX. ADMIN. CODE Chapter 112	1-hour	6.90	n/a
H_2SO_4	TEX. ADMIN. CODE Chapter 112	1-hour	0.60	n/a
		24-hour	0.20	n/a
Lead	NAAQS	3-month rolling average	<0.01	n/a

Note: n/a = not available; bolded text in shaded cells indicates that modeling results exceeded SIL. μg/m³ = micrograms per cubic meter.
* The SILs used for the 1-hour NO_2 and 1-hour SO_2 NAAQS demonstration were based on the EPA proposed interim SILs (EPA 2010a, 2010b).
† NAAQS for annual PM_{10}, and 24-hour and annual SO_2 have been revoked by EPA.
§ The 1-hour value is the average at each receptor over five years modeled, whereas the 3-hour value is the maximum from one year.

Project Contributions to National Ambient Air Quality Standards and Prevention of Significant Deterioration Exceedances

A full NAAQS/PSD increment analysis was conducted for the four criteria pollutants that exceeded their respective SILs: NO_2, PM_{10}, $PM_{2.5}$, and SO_2. Emission sources included in the modeling were the on-site sources at the proposed polygen plant site (including upset emissions from plant startup, shutdown, and maintenance operations) and off-site sources in the ROI. Based on the modeling results, operational emissions from the TCEP would not lead to an exceedance of either the PSD increment or the NAAQS for any criteria air pollutants in the region (Table 3.6). However, plant operations would incrementally increase the concentration of those constituents, ranging from an increase (over background concentrations) of up to 9 percent for PM_{10} to 200 percent for NO_2 at receptors with the highest modeled concentration. Additional information regarding the use of receptor grids in NAAQS/PSD analysis is provided in the *Air Quality Analysis: Permit Nos. 92350 and Prevention of Significant Deterioration (PSD)-TX-1218 Integrated Gasification Combined-Cycle Power Plant*, provided for the TCEP air permit application (RPS Group 2010) and incorporated into this EIS by reference.

Table 3.6. National Ambient Air Quality Standards and Prevention of Significant Deterioration Modeling Results by Air Contaminant

Pollutant	Period	Background Concentration ($\mu g/m^3$)	Modeling Result ($\mu g/m^3$)	Total Concentration ($\mu g/m^3$)	Increase from Background (%)	PSD Allowable Increment ($\mu g/m^3$)	NAAQS Standard ($\mu g/m^3$)
NO_2	1-hour	39.60	81.60	121.00	206	–	188.00
PM_{10}	24-hour	41.00	11.90	53.00	29	30.00	150.00
	Annual	18.00	1.65	20.00	9	17.00	– *
$PM_{2.5}$	24-hour	18.00	11.70	30.00	62	–	35.00
	Annual	8.10	1.17	9.00	14	–	15.00
SO_2	1-hour	–	131.00	131.00	–	–	196.00
	3-hour	–	124.00	124.00	–	512.00	1,200.00
	24-hour	–	71.80	71.80	–	91.00	– *

Note: $\mu g/m^3$ = micrograms per cubic meter.

* NAAQS for annual PM_{10} and 24-hour SO_2 have been revoked by EPA.

Project Effects Screening Limits Results

HAP emissions from TCEP operations that could have a negative effect on human health were screened using TCEQ's ESLs. As shown in Table 3.7, the maximum predicted concentrations for all identified toxic compounds were below their respective ESLs, except for Tier I short-term coal dust. However, because the Tier II maximum concentration at a nonindustrial receptor was lower than the Tier I short-term ESL, the coal dust concentrations met the Tier II requirements for public health and no further analysis was performed, consistent with TCEQ regulations.

Mercury

TCEP operations would produce an estimated 0.02 tn (0.018 t) of Hg per year after 95 percent removal of Hg occurred through the syngas cleanup system. Upon plant startup, the TCEP would be required to comply with the Texas State plan for Clean Air Mercury Rule, as well as meet the federal new source performance standard emission limits. Continuous monitoring for Hg would also be required.

Greenhouse Gas Emissions

TCEP would produce electricity and hydrogen fuel while emitting CO_2. Annual noncaptured CO_2 emissions from TCEP operations would be approximately 300,000 tn (272,155 t) per year of CO_2 (Summit 2010a). This estimate of TCEP emissions is based on the total amount of CO_2 to be generated by the TCEP, minus the CO_2 removal that would occur as a result of the carbon capture technology and subsequent injection for EOR.

Table 3.7. Effects Screening Limits Modeling Results by Hazardous Air Pollutant

HAP	Annual Emission Rate	Tier I: Short-term Impacts		Tier I: Annual Impacts		Tier II: Nonindustrial
	(tn [t] per year)	Maximum Concentration (µg/m^3)	ESL (µg/m^3)	Maximum Concentration (µg/m^3)	ESL (µg/m^3)	Maximum Concentration (µg/m^3)
NH_3	–	133.30	170.00	1.70	17.00	–
COS*	2.61 (2.37)	12.20	135.00	0.29	2.60	–
Hg*	0.02 (0.018)	0.001	0.25	<0.01	0.03	–
Hydrogen chloride*	3.83 (3.47)	0.06	190.00	<0.01	8.40	–
Hydrogen fluoride*	2.31 (2.10)	0.04	18.00	<0.01	0.60	–
Formaldehyde*	2.96 (2.69)	0.13	15.00	0.16	3.30	–
Propane	–	59.60	18,000.00	0.24	1,800.00	–
Diesel	–	96.60	1,000.00	0.47	100.00	–
Urea	–	45.80	50.00	0.74	5.00	–
Coal dust†	–	**10.70**	**9.00**	0.26	0.90	7.70
Silica	–	9.70	14.00	0.11	0.27	–
Methanol*	–	129.90	2,620.00	3.12	262.00	–

Note: µg/m^3 = micrograms per cubic meter.
* HAPs identified under National Emission Standards for HAPs.
† **Bolded text in shaded cells** indicates that maximum predicted results exceed ESL.

Local Plume Visibility, Shadowing, Fogging, and Water Deposition

As previously stated, the polygen plant would be greater than 62 mi (100 km) from the nearest Class I area; therefore, no PSD Class I visibility impairment analysis is required.

TCEP would have two main sources of water vapor plumes: the gas turbine exhaust stack and the cooling tower. The height of the cooling tower would be less than the height of the gas turbine exhaust stack. Because of its reduced height, the cooling tower presents a greater concern than the gas turbine exhaust stack for impacts such as ground-level fogging, water deposition, and solids deposition (including precipitates).

Cooling tower "fogging" occurs when the condensed water vapor plume comes in contact with the ground for short time periods near the tower. Evaporated water would be pure water, although water droplets carried with the exhaust air (called drift) would have the same concentration of impurities as the water entering and circulating through the tower. Water treatment additives could contain anti-corrosion, anti-scaling, anti-fouling, and biocidal additives that could create emissions of volatile organic compounds, PM, and toxic compounds. The drift is not expected to cause excessive pitting or corrosion of metal on nearby structures or equipment because of the relatively small amount of water released and the presence of trace amounts of anti-corrosion additives. Similarly, the treatment additives are not expected to cause noticeable adverse impacts to local biota, owing to the very small amounts that would be released.

Deposition of solids could occur because the TCEP would use process water that may contain total dissolved solids and other PM. Effects from vapor plumes and solids deposition would be most pronounced within 300 ft (91 m) of the vapor source and would decrease rapidly with distance from the source. The greatest concern would be for the creation of traffic hazards on FM 1601 and I-20 as a result of the vapor plume and solids deposition. However, I-20 is located more than 300 ft (91 m) from the proposed plant site, and only 80 ft (24 m) of FM 1601 would be within the buffer zone where it connects with CR 1216 in Penwell. Nearby residences could also be affected by fogging, water deposition, icing, or solids deposition under rare meteorological events. Given the prevailing winds are from south to north, Summit would build the wet cooling towers on the northern side of the plant facilities, if possible, to reduce impacts to existing roads, residences, and to plant operations from cooling tower fogging or icing conditions. There is also a very small potential for localized fog generation to occur from the solar evaporation ponds, if the ponds are chosen as the brine water disposal method.

The drift rate and associated deposition of solids would be reduced by employing baffle-like devices, called drift eliminators, to limit losses to less than 0.01 percent of the circulation rate. TCEP would also comply with the Texas Administrative Code visibility and opacity requirements to minimize visible NO_x and PM in stack emissions.

<u>Odors</u>

TCEP operations would produce two odorous compounds: H_2S and NH_3. Both gases would normally only be emitted as small quantities of fugitive emissions (e.g., through valve or pump packing); however, depending on the wind direction, even small volumes of H_2S and NH_3 odor could create a nuisance for the seven residences within 1.0 mi (1.6 km) of the polygen plant site. Although the likelihood of a large, accidental release, such as a pipe rupture, is low, such an event would result in odors that would be noticeable beyond the boundaries of the TCEP. Texas regulates H_2S odors under nuisance laws; upon receipt of an odor complaint, the TCEQ would investigate the odor for frequency, intensity, duration, and offensiveness. There are no odor regulations for NH_3.

Other odors could be emitted from activities such as equipment maintenance, coal storage, and coal handling. However, these potential odors would be limited to the plant site and would not affect off-site areas.

3.3.5.3 OTHER AIR QUALITY IMPACTS

Based on additional air quality analyses conducted for the air permit application, the project would not be expected to cause noticeable impacts on economic growth, soil, and vegetation. Construction and operation of the TCEP would not limit additional industrial development or economic growth in the region. Modeled ESL concentrations are also within acceptable ranges to protect soil and vegetation (RPS Group 2010).

Following TCEQ guidance, an O_3 impacts analysis was also conducted and it was determined that the proposed polygen plant would be compliant with the 8-hour O_3 standard. In addition, the emissions of sulfur compounds from the TCEP facilities would not exceed the state standards for sulfur compound concentrations.

3.3.6 Mitigation

Project emissions during construction and operation would not cause an exceedance of NAAQS and PSD increments and would not be expected to cause noticeable air quality or human health impacts. Therefore, additional mitigation has not been identified beyond the required compliance with state and federal air quality regulations, as well as implementation of standard construction controls identified in Chapter 2, Table 2.8.

3.4 Climate

3.4.1 Background

This section identifies and describes the climate that could affect or be affected by the construction and operation of the polygen plant and linear facilities. This section also presents the environmental impacts of the proposed project and the No Action Alternative. Additional mitigation measures that could be implemented to further reduce potential adverse consequences are presented.

Climate is defined as average weather patterns over a period of time ranging from a few months to thousands of years. Climate fundamentally shapes our surroundings. Temperature, precipitation, winds, and meteorological events (e.g., first and last frosts and beginning and end of rainy seasons) all influence the distribution of water, soils, plants, and wildlife across the globe. Consequently, climate can have dramatic effects on local ecosystems, infrastructure, and human health. Climate can also affect the operations of industrial facilities such as the proposed TCEP.

3.4.2 Region of Influence

The climate ROI is the project area comprising the polygen plant site and utility and transportation linear facilities.

3.4.3 Methodology and Indicators

The impacts analysis for climate and meteorology impacts used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. Potential impacts and their indicators are shown in Table 3.8.

Table 3.8. Indicators of Potential Climate and Meteorology Impacts

Potential Impact	Impact Indicator
Impacts to TCEP construction from temperature variations and extremes Impacts to TCEP operation or generation of safety hazards from temperature variations and extremes	Expected temperature range
Impacts to TCEP construction from severe weather events Impacts to TCEP operation or generation of safety hazards from severe weather events	Probability of severe weather events such as tornado, floods, or drought conditions Acres of polygen plant site and linear facilities in the floodplain

3.4.4 Affected Environment

3.4.4.1 EXISTING CLIMATE

Temperatures in southeastern Ector County, Texas, are typical of semiarid climates, ranging from the low 30s (degrees Fahrenheit) (just below 0 degrees Celsius) during the winter to the mid 90s (degrees Fahrenheit) (mid-30s degrees Celsius) during the summer. Precipitation in the region is low. Although it is typically in the form of rain, traces of snow, sleet, and hail have been reported. Rainfall occurs primarily during spring and early summer thunderstorms. Due to the flat topography, local flooding can occur during rains, but is typically short in duration. Precipitation amounts are minimal in the region during the remainder of the year, and droughts occur on a frequent basis.

Averaging the temperature and precipitation data for the three locations that characterize the climatology in the project area (stations in Odessa, Midland, and Grandfalls, Texas) yields an average high temperature of 77.9 degrees Fahrenheit (25.5 degrees Celsius), an average low temperature of 49.5 degrees Fahrenheit (9.7 degrees Celsius), and an average precipitation level of 14.1 in (35.8 cm) annually.

3.4.4.2 SEVERE WEATHER EVENTS

Severe weather events for the project area are tornadoes, floods, and drought. The TCEP is located more than 300 mi (483 km) inland (northwest) of the Gulf Coast. For this reason, coastal hurricanes do not occur in the region.

The National Oceanic and Atmospheric Administration reports tornado activity in the U.S. The Fujita Scale is a standard qualitative metric to characterize tornado intensity based on the damage caused. This scale ranges from F0 (weak) to F6 (violent). From 1950 to 2009, 37 tornadoes were reported in Ector County, including 30 F0 tornadoes, three F1 tornadoes, and four F2 tornadoes (National Oceanic and Atmospheric Administration 2010a).

The polygen plant is located outside of the 100-year floodplain. The National Oceanic and Atmospheric Administration database shows that, from 1993 to 2006, 60 floods were reported in Ector County. Thirty-six of these floods caused no damage, 18 caused damage between $5,000 and $30,000, and three caused damage between $75,000 and $300,000. The most severe flood occurred in the early fall of 2004 with approximately $2 million of damage. Total flood damage in Ector County since 1993 is $3.2 million.

Texas has suffered notable periods of drought since the 1930s with extended periods of severe to extreme drought in 1933–1935, 1950–1957, 1962–1967, 1988–1990, 1996, and 1998–2002. These droughts were more common and widespread in the Rio Grande Basin in the western part of the state. A statewide network of data collection sites, operated by state and federal agencies, has been established to monitor drought conditions. These sites provide real-time climate, steam flow, aquifer, and reservoir information to water management professionals to develop drought mitigation and response plans.

3.4.5 Environmental Impacts of Summit's Proposed Project

3.4.5.1 CONSTRUCTION IMPACTS

Severe temperature or weather conditions could temporarily delay construction of the polygen plant if some aspects of construction and material deliveries could not be performed during unusually cold or wet weather. However, impacts would be minimal and temporary, because the region's climate is relatively mild. A strong thunderstorm, flood, or tornado could also cause construction delays. Based on historical tornado activity in Ector County, there could be six F1 or greater tornadoes in the county over the lifespan of the TCEP. The probability of a tornado greater than F1 intensity across Ector County is approximately one every eight years, and the polygen plant covers only 0.04 percent of the combined land area of the county. Therefore, the chance for significant direct and indirect impacts from a tornado during construction would be low. The risks posed to construction safety by climate and severe weather would be mitigated through compliance with all applicable industry standards and with federal, state, and local regulatory requirements.

Severe or extreme drought conditions could increase the potential for wildfires in the area. Drought conditions would also increase the number of water trucks needed to reduce fugitive dust emissions and to support other construction activities. In dry, hot weather, construction workers could need to wear a dust mask and work for shorter time intervals between breaks.

3.4.5.2 OPERATIONAL IMPACTS

Historically, summer temperatures are generally very warm, winters are relatively mild, and significant snowfalls are rare. The polygen plant site would be designed to operate under the expected range of temperature and precipitation conditions.

The possibility of a strong tornado in the region poses the potential for both direct and indirect impacts on plant operations. A strong tornado could directly impact plant operations if sufficient damage were incurred at the plant site, resulting in infrastructure loss or potential release of H_2SO_4 or other hazardous materials stored on-site. Indirect impacts could occur if a strong tornado struck nearby communities and affected the ability of workers or supplies to reach the polygen plant site. The probability of a tornado greater than F1 intensity across Ector County is approximately one every eight years, and the polygen plant covers only 0.04 percent of the land area of the county. Therefore, the chance for significant direct and indirect impacts from a tornado during operations would be low.

It is also very unlikely that a flood would cause a direct or indirect impact to operations at the polygen plant site because it is located outside of the 100-year floodplain. The risks posed to operational safety would be mitigated through compliance with all applicable industry standards and with federal, state, and local regulatory requirements.

Severe or extreme drought conditions could increase the potential for wildfires in the area. Ready availability of water is crucial for both fire protection and daily plant operations. The preferred process water option (WL1) is to use municipal waste water, which would continue to be available during droughts. If the municipal waste water supply became insufficient during a drought, the deficit could be covered by using brackish ground water (WL4) if the FSH main waterline is constructed.

Certain meteorological conditions could influence a slight potential for induced microclimate affects, such as shadowing, fogging, or icing of the wet cooling tower vapor plume, or fog generation over the solar evaporation pond. Such localized occurrences would be infrequent and usually last only a few hours.

3.4.6 Mitigation

Given the prevailing winds are from south to north, Summit would build the wet cooling towers on the northern side of the plant facilities if possible, to reduce impacts to existing roads, residences, and to plant operations from cooling tower fogging or icing conditions.

3.5 Soils, Geology, and Mineral Resources

3.5.1 Background

This section identifies and describes soils, geology, and mineral resources that could be affected by the construction and operation of the polygen plant and linear facilities. This section also presents the environmental impacts of the proposed project and the No Action Alternative. Additional mitigation measures that could be implemented to further reduce potential adverse consequences are presented.

3.5.2 Region of Influence

There are three ROIs considered for soils, geology, and mineral resources:

- The soils ROI applies to all soils within a 1.0-mi (1.6-km) radius of the proposed polygen plant site and linear facilities. Further, in accordance with TCEQ requirements for Class I injection wells, DOE examined potential soils impacts up to 2.5 mi (4 km), the area of review required by the TCEQ, from the brine water injection well locations that could be constructed on the polygen plant site.
- The geology ROI was used to evaluate the potential for geologic events (e.g., earthquakes, landslides, and sinkholes) that could affect the construction and operation of the TCEP. The analysis considered impacts for the proposed polygen plant (including the 2.5-mi [4-km] radius for the proposed Class I waste water injection wells) and associated linear facilities. For EOR activities, DOE examined geologic impacts in the EOR fields that would use the CO_2 captured at the TCEP and sold by Summit. Because the specific EOR fields are currently unknown, this ROI includes the oil reservoirs in the Permian Basin currently served by, or within a short distance of, the Kinder Morgan pipeline network. Summit has engaged in preliminary discussions with potential buyers of the TCEP CO_2, all of which are located in Texas (Hattenbach 2011). Therefore, DOE assumes that only those 20 counties in Texas associated with Kinder Morgan EOR fields could be affected (Figure 3.3).
- The mineral resources ROI consists of the area that would be occupied by the proposed polygen plant and related linear facilities and the EOR fields in the Permian Basin that would use the CO_2 captured at the TCEP and sold by Summit for EOR. The mineral resources ROI at EOR sites could extend as deep as 15,000 ft (4,572 m) below the surface depending on which oil reservoir is under production. As with the geology ROI, DOE assumes that only those 20 counties in Texas associated with Kinder Morgan EOR fields could be affected (Figure 3.3).

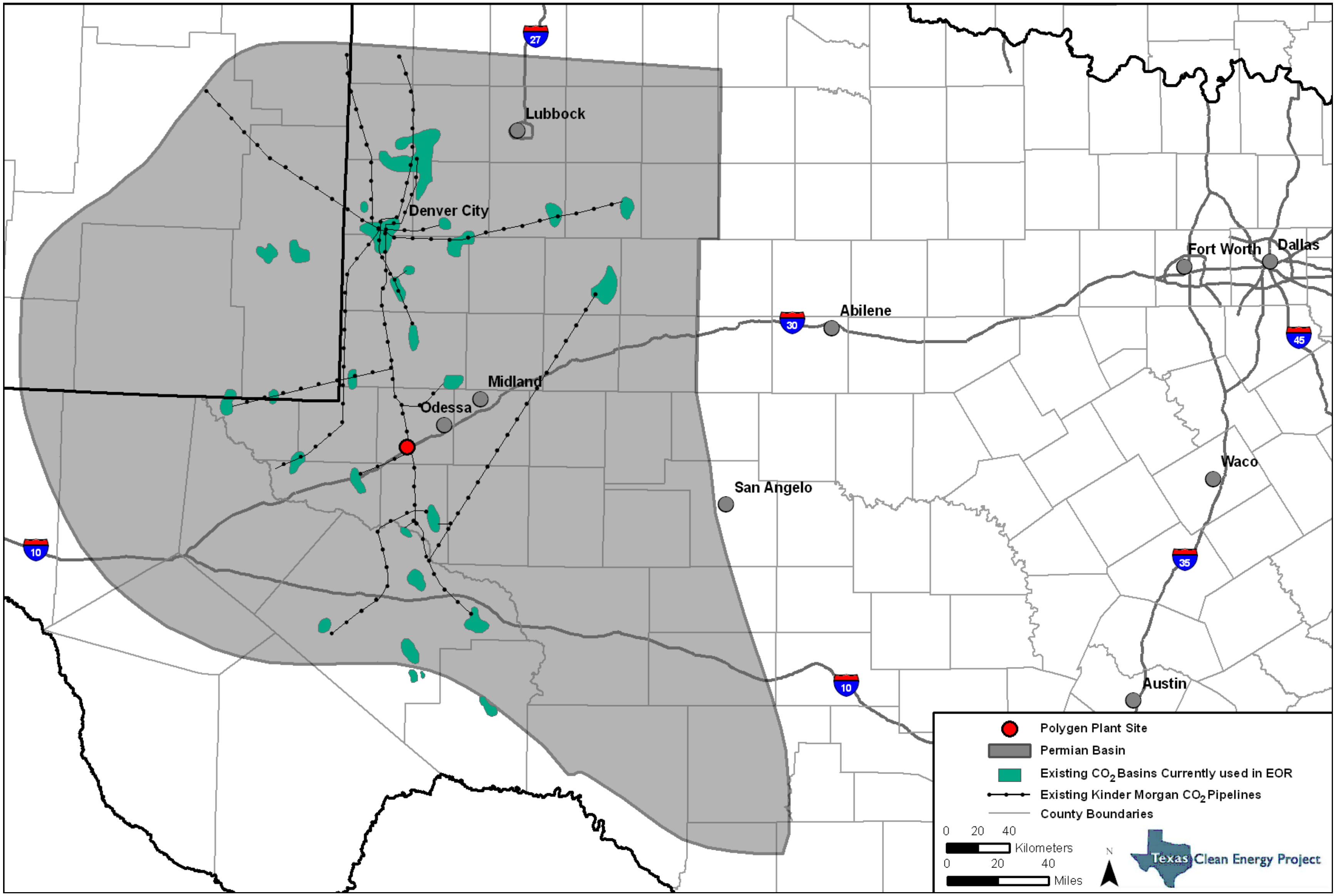

Figure 3.3. Distribution of carbon dioxide pipelines in the Permian Basin.

3.5.3 Methodology and Indicators

The impacts analysis for soils, geology, and mineral resources used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. Table 3.9 shows these potential impacts and their indicators.

Table 3.9. Indicators of Potential Soils, Geology, and Mineral Resource Impacts

Potential Impact	Impact Indicator
Permanent and temporary removal of soils	Acres of soil disturbance
Erosion of soils	
Conversion of prime farmland soils	
Change in soil characteristics and composition	
Contamination of soil from spills of hazardous materials	Acres of soil contamination
Disturbance to the polygen plant and linear facilities from geologic-related events (e.g., earthquakes, landslides, sinkholes)	Acres of project area disturbance
Restricted access to mineral resources	Acres of surface disturbance
Alteration of geologic formations	Area of subsurface disturbance

3.5.4 Affected Environment

3.5.4.1 SOILS

Soils in the ROI have been mapped by the Natural Resources Conservation Service. A complete list of soil types in the surface ROI, and the total surface area of soil types that could be impacted by the TCEP, are included in the site assessment report developed for the TCEP (SWCA 2010a) and incorporated by reference.

The potential for wind and water erosion are two important considerations relating to project impacts to soils. The wind and water erosion potential in the soils ROI are summarized in Table 3.10. In general, most of the soils have a moderate wind and water erosion potential.

Table 3.10. Wind and Water Erosion Potential of Soils as Total Land Area and Percentage of Area Potentially Affected in the Soils Region of Influence

Erosion Potential	Wind Erosion (ac [ha])	Percent	Water Erosion (ac [ha])	Percent
High	17,435 (7,056)	11	1,473 (596)	1
Moderate	116,735 (47,241)	75	122,198 (49,452)	79
Low	20,224 (8,184)	13	31,524 (12,757)	20
n/a	971 (371)	1	170 (69)	0
Total	**155,365 (62,874)**	**100**	**155,365 (62,874)**	**100**

Note: n/a = not available.

The Natural Resources Conservation Service defines prime farmland as land that has the best combination of physical characteristics for producing food, feed, forage, and oil seed crops (crops that are grown primarily for the oil contained in the seeds such as soybeans) and is available for these uses (Natural Resources Conservation Service 2007). None of the soil map units in soils ROI around the polygen plant site are considered to be prime or unique farmland soils. There are, however, two areas in the construction ROW of WL1 that contain prime farmland soils. Randall clay soils account for 0.49 ac (0.20 ha) and Stegall loam soils, if irrigated, account for 1.91 ac (0.77 ha) along the eastern extent of WL1. Neither area is currently under cultivation.

Horizon Environmental Services performed a Phase 1 environmental site assessment on the proposed polygen plant site in April 2006. The results of that assessment do not indicate any recorded or observed soil contamination on the polygen plant site (Horizon Environmental Services 2006).

3.5.4.2 GEOLOGY

The proposed polygen plant site is located in the flat to shallowly sloping northern flank of the Pecos River Basin just west of the Concho Ridge, which forms the divide between Monahans Draw and the Colorado River drainage basin (Wermund 1996). The elevation of the polygen plant site varies from 2,969 ft (905 m) to 2,920 ft (890 m) above mean sea level.

The near-surface geologic units of the geology ROI are described in Table 3.11. On the surface, the polygen plant site and linear facilities occur almost entirely on geologic units consisting of unconsolidated caliche, windblown sand, and alluvial deposits. Texas Water Development Board (TWDB) drilling records confirm the presence of the Lower Cretaceous Antlers Sand Formation at a depth of 77 ft (23 m) below the surface, followed by the Cox Sandstone and the Dockum Group at progressively lower depths (TWDB 2010a).

Table 3.11. Near-surface Geology Units in the Geology Region of Influence

Geologic Unit	Description	Thickness
Windblown sand	Sand and silt in sheets, dunes, and ridges	Various
Quaternary alluvium	Siliceous and igneous pebbles of various ages	Approximately 50 ft (15 m) on polygen plant site
Antler Sand	Fine to coarse-grained sandstone with some cross-bedding	Up to 90 ft (27 m)
Cox Sandstone	Medium to fine-grained sandstone with some silt and quartz pebble interbeds	Up to 40 ft (12 m)
Dockum Group	Shale and siltstone with sandstone and gravel beds Micaceous with reddish brown to yellow-orange beds of various thickness	Up to 275 ft (84 m)

The TCEP could involve on-site brine water injection and would involve off-site EOR activities that could affect geologic formations thousands of feet below the surface. Table 3.12 provides descriptions of subsurface geology in the Permian Basin down to 15,000 ft (4,572 m) below ground level and a general description of those stratigraphic units as either being potential ground water sources in the area, potential barriers to fluid migration (for example, an anhydrite deposit), potential targets for brine water injection (for example, deep brine aquifers), or potential suitable formations for EOR/sequestration activities (in other words, rock layers with oil reservoirs).

Table 3.12. Generalized Stratigraphy of the Permian Basin

System	Series		Stratigraphic Unit	Description
Quaternary	–		Cenozoic Pecos Alluvium	Potential ground water source
Tertiary	–		Volcanic Rocks	Potential ground water source
Cretaceous	Gulf		Undifferentiated	Potential ground water source
	Comanche	Trinity Washita	Undifferentiated	Potential ground water source
		Fredericks-burg	Undifferentiated	Potential ground water source
Triassic	Dockum		Undifferentiated	Potential ground water source
Permian	Ochoan		Dewey Lake Red Beds	Potential barrier to fluid migration (siltstone)
			Rustler Formation	Potential ground water source
			Salado Formation	Potential barrier to fluid migration (halite and anhydrite deposits)
			Castile Formation	Potential barrier to fluid migration (anhydrite deposit)
	Guadalupian		Tansill Formation	Potential barrier to fluid migration (anhydrite and dolomite)
			Yates Formation	Potentially suitable for EOR/sequestration
			Seven Rivers Formation	Potentially suitable for EOR/sequestration
			Queen Formation	Potential target for brine water injection Potentially suitable for EOR/sequestration
			Grayburg Formation	Potential target for brine water injection Potentially suitable for EOR/sequestration
			San Andres Formation	Potential target for brine water injection Potentially suitable for EOR/sequestration
	Leonardian		Holt	Potentially suitable for EOR/sequestration
			Glorieta	Potentially suitable for EOR/sequestration
			Clear Fork	Potentially suitable for EOR/sequestration
			Abo/Wichita	Potentially suitable for EOR/sequestration
	Wolfcampian		Wolfcamp	Potentially suitable for EOR/sequestration
Pennsylvanian	Virgilian		Cisco	Potentially suitable for EOR/sequestration
	Missourian		Canyon	Potentially suitable for EOR/sequestration
	Desmoinian		Strawn	Potentially suitable for EOR/sequestration

Table 3.12. Generalized Stratigraphy of the Permian Basin

System	Series	Stratigraphic Unit	Description
	Atokan	Atoka	Potentially suitable for EOR/sequestration
Mississippian	Chesterian	Barnett	Potentially suitable for EOR/sequestration
Devonian	Famennian	Woodford	Potentially suitable for EOR/sequestration
	Pragian, Lochkovian	Thirtyone	Potentially suitable for EOR/sequestration
Silurian	Pridolian, Lodlovian, Wenlockian, Llandoverian	Wristen Group	Potentially suitable for EOR/sequestration
Ordovician	Ashgillian	Fusselman	Potentially suitable for EOR/sequestration
	Caradocian	Montoya	Potentially suitable for EOR/sequestration
	Llandeilian, Llanvirnian	Simpson Group	Potentially suitable for EOR/sequestration
	Arenigian, Tremadocian	Ellenburger	Potentially suitable for EOR/sequestration

Note: Thicknesses of individual stratigraphic units and the entire stratigraphic column vary significantly depending on the specific location in the Permian Basin.

The Queen, Grayburg, and Upper San Andres Formations beneath the proposed polygen plant site have been identified as potentially viable injection zones for the brine water injection well option. These formations have sufficient thickness and permeability to accept within their pore spaces the projected supply of brine water. They are also thought to be sufficiently isolated from aquifers that permitting obstacles would be unlikely. The Rustler Formation, which is a potential drinking water source, is separated from the Queen Formation by approximately 1,000 ft (1,609 m) of strata consisting of five barrier formations: Salado, Castile, Tansill, Yates, and Seven Rivers Formations (see Table 3.12).

Although earthquakes do occur in Texas, the state has a relatively low risk from earthquake activity. There are three areas in the state where most earthquake activity occurs (University of Texas Institute for Geophysics 2010). West Texas is one of these areas and has experienced three natural earthquakes since the 1930s. The city of Valentine in Jeff Davis County experienced an earthquake with a magnitude of 6.0 on the Richter scale in 1931. An earthquake with a 5.3 magnitude occurred near the city of Alpine in Brewster County in 1995. In addition, an earthquake with a 4.6 magnitude occurred approximately 50 mi (80 km) northwest of the polygen plant site along the New Mexico border in Andrews County in 1992. Smaller quakes induced by over-pressurization of fluid injection associated with oil and gas production and waste disposal activities have also been known to occur in West Texas. Although these quakes are typically between 3.0 and 4.0 in magnitude, the largest (4.6) occurred in 1978 approximately 110 mi (177 km) northeast of the proposed polygen plant site near the city of Snyder, Scurry County, Texas (University of Texas Institute for Geophysics 2010).

3.5.4.3 MINERAL RESOURCES

Although the proposed polygen plant site contains sand, gravel, and clay deposits, none of these are economically extractable. Of the six permitted or developed natural gas and oil wells on the proposed plant site, two are currently active (one oil well and one gas well).

The TCEP would be located almost in the center of the Permian Basin geologic province, which encompasses all or parts of 54 counties in West Texas and New Mexico (see Figure 3.3). The Permian Basin remains one of the largest oil-producing regions in the U.S. According to the Texas Bureau of Economic Geology, cumulative production through 2000 was 28.9 billion barrels (Dutton et al. 2004). The Permian Basin accounted for 17 percent of total U.S. oil production in 2002, and contains approximately 22 percent of proven domestic oil reserves. It is also the location of 29 percent of estimated, future, domestic reserve growth. Although production from the Permian Basin peaked in the early 1970s, cumulative production to date represents approximately 27 percent of the original oil in place (Dutton et al. 2004).

Carbon Sequestration and Enhanced Oil Recovery

After oil production began to drop from peak levels in the 1970s, companies began to explore technologies to further recover oil from depleted reservoirs. Initial production relies on pressure of the fluids in the reservoir to push fluids toward a producing well (fluids flow from areas of high fluid pressure toward areas of low fluid pressure, such as a producing well). In addition to the fluid pressure of the oil itself, natural gas pressure would push the oil from above and water pressure would push the oil from below, with the result that the oil (and other fluids) would move toward producing wells. After time, the pressure that drives the flow of oil dissipates or the quantity of mobile oil decreases such that the remaining oil ceases to flow. Most of the oil (usually 40–90 percent) still remains trapped in the reservoir in the pore spaces (NETL 2009). The industry learned that they could inject water or natural gas to help push or sweep some of the remaining oil (as much as 10–30 percent) toward the producing wells (NETL 2009).

Following a successful pilot program in the 1970s at the Scurry Area Canyon Reef Operators Committee oil field in the city of Snyder, Scurry County, Texas, field operators in the Permian Basin learned that CO_2 could be injected (usually alternated with water injection) to move more oil to producing wells. This became known as EOR and could be used to recover another 5–20 percent by flooding the reservoir with CO_2 (Holtz et al. 1999). CO_2, an abundant by-product of nearby natural gas production and processing facilities, had previously been vented to the atmosphere. CO_2 contains properties of both a liquid and a gas under the specific temperature and pressure conditions of deep oil reservoirs, where it becomes miscible (or mixable) with oil. Injecting pressurized CO_2 into an oil reservoir causes some of the CO_2 to dissolve into the oil, which changes the oil's viscosity (or the measure of the ease of flow) and allows this oil to move toward production wells. Water injection is often alternated with CO_2 injection to increase fluid pressure and to help move the oil toward the producing wells. CO_2 that is dissolved in the recovered oil can be captured, compressed, and recycled back to the injection wells for other cycles of use. Generally, CO_2 and water are injected into the reservoir in the same volume that oil is recovered, such that average fluid pressure in the reservoir is approximately the same as the initial fluid pressure in the reservoir. With each cycle of injection of CO_2, a portion of the CO_2 becomes trapped in the reservoir. As more oil is produced, more CO_2 is trapped, leaving the CO_2 permanently stored underground. The CO_2 EOR process is illustrated in Figure 3.4 (NETL 2009).

The geologic conditions that cause oil and natural gas to become trapped and stored in underground reservoirs also make those reservoirs suitable for both EOR and long-term CO_2 sequestration. Environmental concerns about EOR with CO_2 primarily focus on leakage of CO_2 from the reservoir into ground water. Since 1972, the Scurry Area Canyon Reef Operators Committee oil field, which is located approximately 100 mi (161 km) northeast of the proposed polygen plant site, has been intensively monitored for impacts to ground water (Smyth et al. 2006). Monitoring results indicate that no systematic impacts to ground water have occurred as a result of CO_2 injection practices (Smyth et al. 2009).

By the mid 1980s, demand for CO_2 for use in EOR had increased dramatically. Major oil companies had constructed hundreds of miles of CO_2 pipelines to transport CO_2 from natural underground reservoirs from as far away as Utah, Colorado, and Oklahoma to the Permian Basin. Today, approximately 2,200 mi (3,541 km) of CO_2 supply pipelines converge in Denver City, Texas, approximately 80 mi (129 km) north of the proposed polygen plant site (see Figure 3.3). Denver City is the world's largest CO_2 pipeline hub. By 1999, more than 50 oil fields in Texas and New Mexico were being supplied through the CO_2 distribution system originating from Denver City (Holtz et al. 1999).

As of 2007, more than 3,600 mi (5,794 km) of CO_2 pipelines were constructed in the U.S., most of which service the Permian Basin (Folger and Parfomak 2007). The current supply capacity to the Permian Basin is more than 1 billion ft^3 (28.3 million m^3) per day (Kinder Morgan 2010a). Currently, more than 1.6 billion ft^3 (45.3 million m^3) of CO_2 are injected per day into Permian Basin oil fields, resulting in an additional daily recovery of 170,000 barrels. Demand has exceeded supply since 2009 and is estimated to exceed current supply by approximately 500 million ft^3 (14.2 million m^3) per day. EOR in the Permian Basin has the potential to substantially contribute to future domestic oil production.

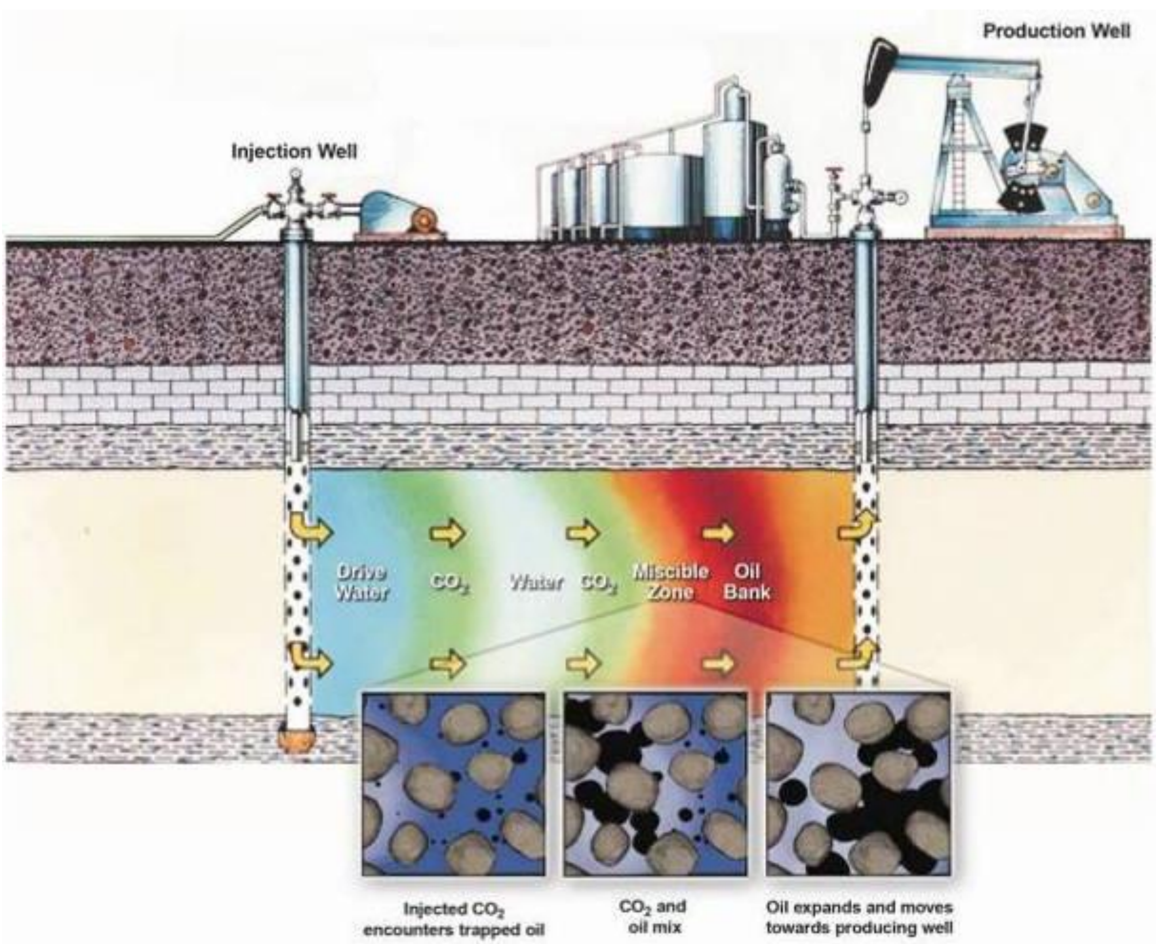

Figure 3.4. Carbon dioxide enhanced oil recovery process (NETL 2009).

Enhanced Oil Recovery Injection/Carbon Dioxide Sequestration Sites

The TCEP's CO_2 would be delivered to the existing Kinder Morgan Central Basin Pipeline system where it would co-mingle with CO_2 from other sources. Over the commercial life of the project, TCEP CO_2 may be injected into any of the more than 1,300 individual oil and gas reservoirs in the Permian Basin through the Kinder Morgan distribution system. CO_2 would likely be injected into multiple geological formations at various locations throughout the Texas portion of the Permian Basin fed by the Kinder Morgan distribution lines (see Figure 3.3; Hattenbach 2011). Regardless of the formations that would ultimately be affected, certain generalizations can be made based on similarities among the formations. Table 3.12, above, identifies the specific formations that are suitable candidates for EOR/sequestration activities.

The TCEP's CO_2 would be sold to multiple oil field operators who would pay Kinder Morgan for pipeline transportation services. Oil field operators would decide based on a variety of operating and market factors whether to offer to purchase TCEP's CO_2. Summit would be required to ensure that field operators to which it sold the captured CO_2 would meet MVA requirements and tax benefit requirements (as described in Section 2.4.4.3).

Most reservoirs in the Permian Basin share the following geologic conditions that favor successful oil reservoir sequestration (Dutton et al. 2004):

- Reservoirs tend to be several thousand feet below the ground surface.
- Reservoirs are hydrogeologically isolated from any potable water aquifer (i.e., there are one or more thick and laterally continuous, low-permeability rock units between the reservoir and any potential drinking water supply), as indicated by the fact that the reservoirs contain trapped oil and gas that could not move upward over geologic time.
- Natural structures such as faults and interformational fractures that would allow upward fluid migration into shallow aquifers are rare in the region.
- Geologic hazards, including faults through the reservoirs and overlying strata, are rare in the region.
- Generally, reservoirs are confined by geologic structures such as faults or basin margins, which would prevent potential lateral migration of injected CO_2.

3.5.5 Environmental Impacts of Summit's Proposed Project

3.5.5.1 SOILS

Disturbance to soils would primarily occur during construction of the polygen plant and associated linear facilities. Potential impacts during construction would include permanent or temporary removal of soils, erosion of soils, contamination of soils from hazardous material spills, changes in soil composition due to the introduction of fill materials, and conversion of prime farmland.

Site grading to obtain the construction elevations would be an initial construction activity. During construction, soil would be removed for any foundations required for the project's structures. This soil would be placed on a temporary storage site, protected from erosion and runoff, and would be reused as topsoil replacement or as fill. Removing and replacing these soils would likely result in changes to soil composition and characteristics, such as rain water infiltration rate. Fill material would be moved from other portions of the polygen plant site to provide a level bed for the on-site rail loop and plant facilities. Soils impacts would be permanent for areas converted into impervious surface areas (e.g., facilities, structures, pads, rail loop and parking). Construction-related impacts to soils in areas not converted to impervious surfaces would be temporary, and these areas would be restored after construction is completed.

Most of the soils in the project area have a moderate ranking for both wind and water erosion potential (see Table 3.10). During construction activities, there would be the potential for wind erosion and the generation of dust. Controls, such as the stabilization of disturbed areas and wetting of exposed soils, would be used to minimize these impacts. Once construction is finished, the disturbance to soils would be reduced. As disturbed areas become revegetated or otherwise stabilized, further impacts to soils would be negligible.

The potential for soil contamination from spills of hazardous materials during operations would be low based on the use of proper storage facilities and implementation of spill response controls and procedures. An SPCC plan would be prepared in accordance with 40 C.F.R. § 112.7. Personnel would be trained to respond to petroleum and chemical spills and the necessary spill control equipment would be available on site. A very slight potential exists for the deposition of salts with drift from the wet cooling tower option.

The TCEP would have a negligible impact to prime farmland because the proposed polygen plant site contains no prime farmland and only WL1 would temporarily affect approximately 2.4 ac (1.0 ha) of prime farmland. Prime farmland soils (not currently in agricultural production) at this location would be segregated and returned to their original locations upon completion of construction.

3.5.5.2 GEOLOGY

Polygen Plant Site

Geologic units exposed on the proposed polygen plant site consist of sand, gravel, and clay deposits. The relatively flat surface topography of the polygen plant site and lack of karst geology substantially reduces the likelihood of any potential impacts from landslides or other slope failures during construction or plant operations. Similarly, because the area has a low risk of significant seismic events (infrequent, most with a Richter magnitude below 5.0), the probability of effects from seismicity would be low. The polygen plant site should not be affected by subsidence (sinking or lowering of the ground surface), because most factors known to cause subsidence, such as karst geology or geological faulting, are not present.

Karst geology is characterized by barren, rocky ground, caves, sinkholes, underground rivers, and the absence of surface streams and lakes. It results from the excavating effects of underground water on massive soluble limestone. The term originally applied to the Karst, a limestone area on the Dalmatian coast on the Adriatic Sea, but has been extended to mean all areas with similar features. Karst geology is found in widely scattered sections of the world, including the Midwest, Texas, Kentucky, and Florida in the U.S.

Brine Water Injection Wells

If concentrated brine water injection wells were constructed on the site, brine and displaced native fluids could migrate from the target strata into other adjoining strata there. This risk is very low as the geologic characteristics of the potential brine aquifers or reservoirs that would accept the brine water would be sufficient to prevent leakage into overlying drinking water aquifers and the target aquifers/reservoirs in the deeper strata in themselves are highly saline. Reservoirs that would be used are hydrogeologically isolated from any potable water aquifers (i.e., there are one or more thick and laterally continuous, low-permeability rock units between the reservoir and any potential drinking water supply). There would be sufficient vertical separation (over 1,000 ft [1,609 m]) and five barrier formations between the target injection zone and potential drinking water aquifers to allow injection well operations at the polygen plant site. The brine water injection wells, if used, would be used to dispose of brine water that is expected to be nonhazardous. The wells would be located, constructed, and operated as Class I wells in accordance with EPA and TCEQ regulations.

Seismic events caused by the deep well injection of brine water would be unlikely. Operational procedures would be developed to limit injection pressures to levels below the formation fracturing pressure, and formation response to injection would be monitored to detect potential seismic activity. In any event, the magnitude of induced seismic activity seen in similar scenarios (no greater than magnitude 4.6) is unlikely to cause damage to the polygen plant or other facilities in the area.

Although target formations will alter over geologic time through rock-water chemical reactions, and although some chemical constituents could be mobilized, these changes are unlikely to result in adverse environmental effects due to the depth of target formations and the presence of overlying geologic seals.

Linear Facilities

Unconsolidated caliche, windblown sand, and alluvial deposits comprise most of the surface area that would be affected by all of the linear facility options. Potential impacts to geologic resources and from events such as earthquakes, landslides, and subsidence would be the same for construction and operation of the proposed linear facilities, as discussed above for the polygen plant site.

Enhance Oil Recovery Sequestration Site(s)

Although specific EOR sequestration sites are not known, based on the geology of the Permian Basin, geologic impacts as a result of using TCEP's CO_2 for EOR in the Permian Basin would not be expected. Although over-pressuring of geologic formations due to CO_2 injection could induce seismic activity, field operators would monitor and limit injection fluid pressures to levels below the formation fracturing pressure to avoid this condition and would monitor for seismic activity. Based on experience with EOR in the Permian Basin, land surface subsidence or heaving would not be expected to occur.

3.5.5.3 MINERAL RESOURCES

Polygen Plant Site

Six permitted or developed natural gas and oil wells exist on the proposed polygen plant site, although only two are currently operating. Access to and the condition of those facilities would be maintained by the well operators. Summit would accommodate these wells in the polygen plant design and site layout. There are no other economically extractable mineral resources on the polygen plant site. Consequently, the project would not unduly hinder access to mineral resources beneath the plant site.

Brine Water Injection Wells

An option to dispose of brine water is to inject it into reservoirs below the polygen plant site or in other areas in the Permian Basin that are known to be oil-bearing. The risk of potential economic loss is very low because the prospects for oil recovery from those formations are poor, as the target strata and surrounding strata have been explored for hydrocarbons and found not to have economical deposits. Prior to the submission of a Class I waste water injection well permit application to the TCEQ, a detailed review of conditions at the injection well sites would be undertaken to select injection intervals that do not contain economically viable quantities of oil or natural gas.

Linear Facilities

Minor obstructions to mineral resource access along the linear facilities could occur during construction and operational phases of the project. Extraction of petroleum resources could occur from locations outside the ROW, so access would not be hindered. Access to any other economically extractable mineral resource in the ROW would require local relocation of the linear facility or maintenance of facility support; or the resource would not be accessible in the ROW.

EOR Sequestration Site(s)

Use of CO_2 produced by the proposed TCEP and sold by Summit for EOR would likely have a beneficial impact to continued production from oil and gas reservoirs in the Permian Basin that are within a reasonable connector pipeline distance of the Kinder Morgan pipeline system. The demand for CO_2 in the basin already exceeds the supply. The addition of TCEP's CO_2 to the supply market would help field operators maintain petroleum reservoir fluid pressures, which could benefit the production of oil and gas in reservoirs by further forcing the migration of oil and gas toward extraction wells.

Mineral resources and rock strata could be affected by the injection of CO_2 for EOR. Reservoir fluid acidity (pH) and concentrations of dissolved mineral matter would change, and relatively minor amounts of mineral matter would dissolve and precipitate at different distances from the points of injection. Oil and gas in deeper formations could be accessed without undue corrosion and safety problems if suitable drilling practices, well casing materials, and well casing cements were used on wells that penetrated through the CO_2 floods to reach deeper resources. The costs of such wells would increase.

3.5.6 Mitigation

Mitigation measures that Summit would implement as part of the construction and operation of the TCEP are described in Table 2.8 in Chapter 2. Additional mitigation measures that Summit could implement or that DOE could require as a condition of approval to further reduce impacts to soils, geology, or mineral resources include segregating prime farmland soils during construction and returning them to their original locations upon completion of construction.

3.6 Ground Water Resources

3.6.1 Background

This section identifies and describes the ground water resources that could be affected by the construction and operation of the polygen plant and linear facilities. This section also presents the environmental impacts of the proposed project and the No Action Alternative. Additional mitigation measures that could be implemented to further reduce potential adverse consequences are presented.

3.6.2 Region of Influence

Process water for the proposed polygen plant could be obtained from one of several options. Although the preferred option for process water is to use recycled municipal waste water from the GCA Odessa South Facility in Odessa, Texas (WL1), three other options (WL2–WL4) would use ground water. In addition, construction and operation of on-site brine water injection wells and injection of CO_2 for EOR would have the potential to affect ground water resources. Thus, three ROIs are considered for ground water resources:

- The process water ROI consists of the aquifers that could be used to obtain water for plant processes. The polygen plant would require a minimum of 3.5 million gal (13 million L) per day and a maximum of 5.5 million gal (21 million L) per day. The aquifers that could be used for process water are the Capitan Reef Complex Aquifer (Oxy Permian, WL2) and the Edwards-Trinity (Plateau) Aquifer (FSH, WL3, and WL4) (Figures 3.5 and 3.6).
- The project area ROI consists of the aquifers that underlie the proposed polygen plant site and linear facility options. This would include the areas within a 2.5-mi (4.0-km) buffer around the plant site and along each linear facility corridor. This ROI also includes the required 2.5-mi (4.0-km) area of review required by the TCEQ for the potential on-site deep injection wells. The Dockum, Edwards-Trinity (Plateau), Ogallala, and Pecos Valley Aquifers underlie these areas (Figures 3.5 and 3.6).
- The EOR ROI consists of the aquifers at the EOR fields that would use CO_2 produced by the TCEP. Because the specific EOR fields are currently unknown, this ROI includes the oil reservoirs in the Permian Basin currently served by, or within a short distance of, the Kinder Morgan pipeline network. Summit has engaged in preliminary discussions with potential buyers of the TCEP CO_2, all of whom are located in Texas (Hattenbach 2011). Therefore, DOE assumes only those aquifers associated with Permian Basin EOR fields in Texas would be addressed. These aquifers include the Capitan Reef Complex, Dockum, Edwards-Trinity (High Plains), Edwards-Trinity (Plateau), Pecos Valley, Ogallala, and Rustler Aquifers (Figures 3.5 and 3.6).

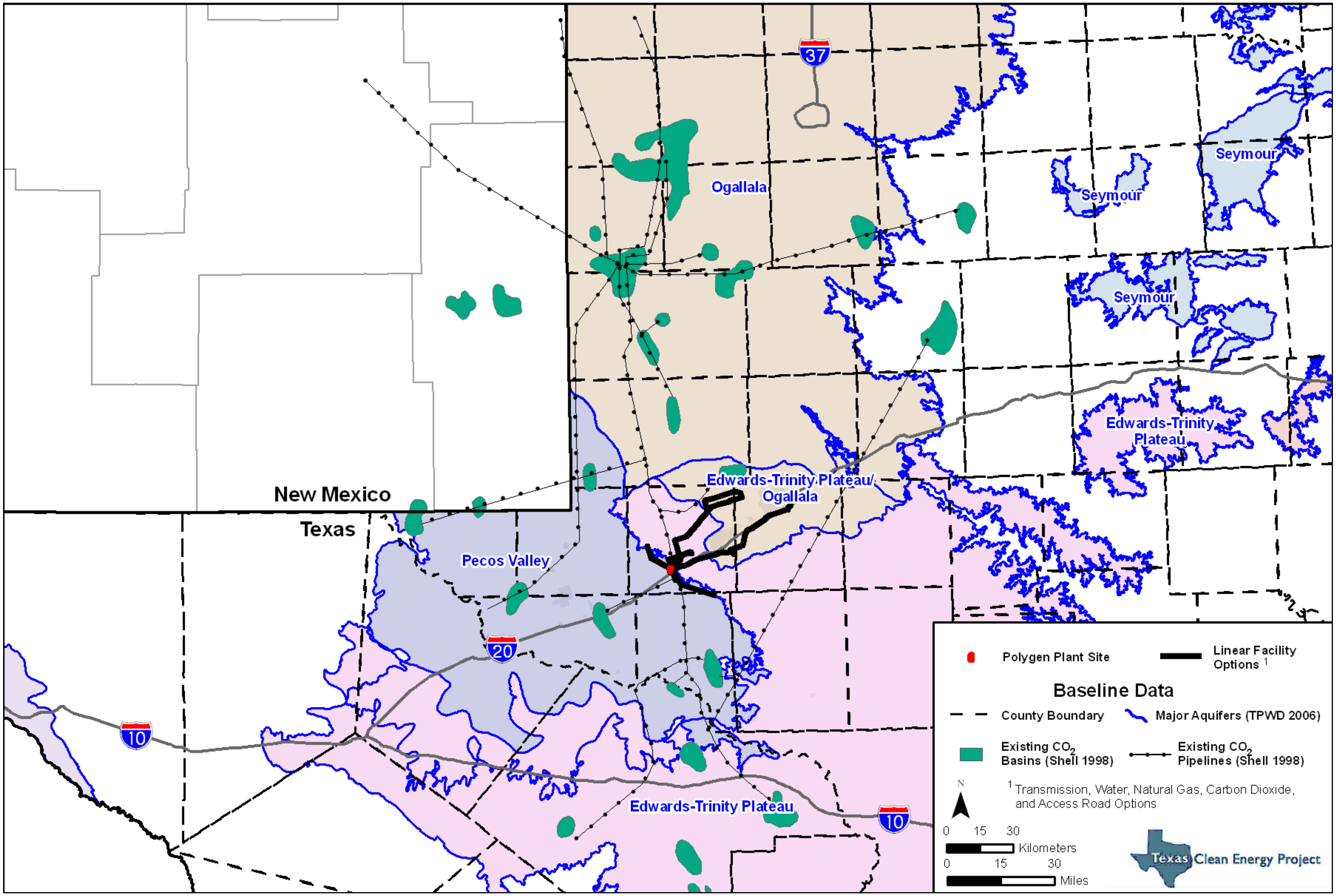

Figure 3.5. Major aquifers in the ground water regions of influence.

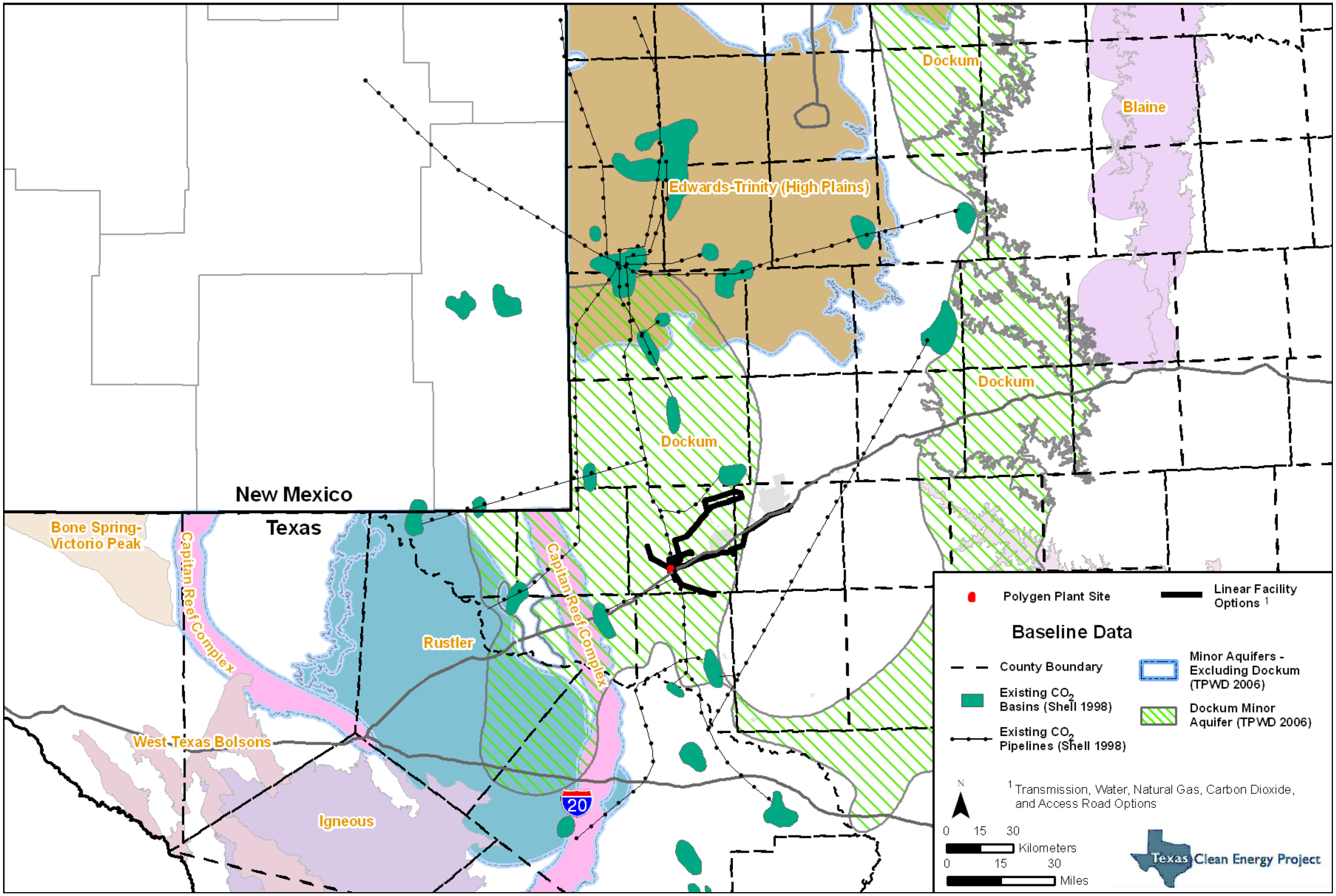

Figure 3.6. Minor aquifers in the ground water regions of influence.

3.6.3 Methodology and Indicators

3.6.3.1 IMPACT INDICATORS

The impacts analysis for ground water resources used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. Potential impacts to ground water resources and their indicators are shown in Table 3.13.

Table 3.13. Indicators of Potential Impacts to Ground Water Resources

Potential Impact	Impact Indicator
Reduction in ground water supplies that could affect the availability of a ground water source to existing water rights holders	Volume of ground water used
Reduction in ground water supplies that could interfere with ground water recharge	
Reduction in ground water supplies that could reduce discharge rates to existing springs or seeps	
Reduction in ground water recharge from temporary or permanent impervious cover (e.g., buildings, roads)	Acres of impervious cover
Contamination of ground water through surface spills that would infiltrate to ground water	Water quality conditions
Contamination of ground water from leaks in buried pipelines or wells (particularly injection and/or abandoned oil/gas wells)	
Contamination of ground water from injection of CO_2 for EOR	
Reduction in ground water quality from movement of poor quality ground water into areas of higher quality ground water due to pumping or injection	

3.6.3.2 REGULATORY REQUIREMENTS

EPA administers the Sole Source Aquifer Protection Program under section 1424(e) of the Safe Drinking Water Act of 1974. EPA defines a sole- or principal-source aquifer as an aquifer that supplies at least 50 percent of the drinking water consumed in the area overlying the aquifer (EPA 2007). These areas have no alternative drinking water source (or sources) that could physically, legally, and economically supply all who depend on the aquifer for drinking water. A designation as a sole-source aquifer protects an area's ground water resource by requiring EPA to review certain proposed projects in the designated area. All proposed projects receiving federal funds are subject to review to minimize danger to sole-source aquifers.

In Texas, ground water resources are regulated by the TCEQ and by Ground Water Conservation Districts, which are locally governed districts that manage ground water supplies. Priority Ground Water Management Areas are areas designated and delineated by TCEQ that are experiencing, or are expected to experience in the next 25 years, critical ground water problems, including shortages of surface water or ground water, land subsidence resulting from ground water withdrawal, or contamination of ground water supplies.

The proposed polygen plant site and the ground water wells serving the Oxy Permian pipeline system are not in the regulatory jurisdiction of any Ground Water Conservation District, nor have any Priority Ground Water Management Areas been designated in Winkler or Ector County (EPA 2010; TWDB 2010b). No designated sole-source aquifers occur in project area (EPA 2007). Wells serving the proposed FSH system and a portion of the FSH pipeline lie in the Middle Pecos Ground Water Conservation District (TWDB 2010b). None of the remaining linear facilities fall in an established Ground Water Conservation District.

The construction, testing, and operation of Class I injection wells that could be used in disposal of waste process water from the polygen plant is regulated by the TCEQ, and would require a permit pursuant to the Texas Water Code, Chapter 27, and the Texas Health and Safety Code, Chapter 361. Potential impacts were assessed for a 2.5-mi (4.0-km) radius around each well.

The construction, testing, and operation of injection wells used in oil and gas recovery is regulated by the RRC under 16 TEX. ADMIN. CODE Chapter 3, Rule 3.46 to enforce drinking water standards promulgated by EPA. Current RRC requirements for Class II wells include making best efforts to identify all wells in a 0.25-mi (0.40-km) radius of the proposed injection well and providing evidence that all abandoned wells intersecting the injection formation have been plugged. EOR operators who may purchase CO_2 from the TCEP would be regulated by the RRC to enforce drinking water standards promulgated by EPA.

3.6.4 Affected Environment

The TWDB state water plan involves 16 regional planning groups that review water use projections and water availability for their regions. Ector County lies in Region F, which includes Crane, Midland, Upton, and 28 other counties in West Texas. The largest withdrawals of ground water in the region are for irrigation and municipal uses. Most recent studies indicate that the total Region F water use in 2010 was 202 billion gal (765 billion L) or 620,000 ac-ft per year with 157 billion gal (596 billion L) or 483,600 ac-ft per year (or 78 percent) coming from ground water withdrawal (TWDB 2010c).

With the exception of the Edwards-Trinity (Plateau) Aquifer, ground water levels in the area are generally declining because the rate of withdrawal is greater than the rate of recharge. Springs in Ector, Crane, Midland, and some surrounding counties have stopped flowing as a result of water table drawdown (Brune 2002).

In addition, there have been reports of contamination of shallow aquifers from oil field activities (Brune 2002). A review of the *2008 Joint Groundwater Monitoring and Contamination Report* yielded 59 instances of ground water contamination in Ector County (Texas Groundwater Protection Committee 2008). However, a survey of TCEQ records found no cases of contaminated ground water within 10 mi (16 km) of the proposed polygen plant site (TCEQ 2006).

The following sections summarize the properties of the major and minor aquifers that are potentially affected by the TCEP. Edwards-Trinity (Plateau), Ogallala, and Pecos Valley are major aquifers (see Figure 3.5), whereas the Capitan Reef Complex, Dockum, Edwards-Trinity (High Plains), and Rustler are minor aquifers (see Figure 3.6).

3.6.4.1 EDWARDS-TRINITY (PLATEAU) AQUIFER

The Edwards-Trinity (Plateau) Aquifer is a major aquifer that spans from the Hill Country of central Texas to the Trans-Pecos region of West Texas and provides water to 38 counties. This aquifer is located immediately to the north and east of the polygen plant site (see Figure 3.5) and is the process water source for WL3 and WL4. The aquifer also underlies eight linear facilities in the project area ROI and several oil fields in the EOR ROI.

The maximum saturated thickness of the aquifer is greater than 800 ft (244 m). The chemical quality of water in the Edwards-Trinity (Plateau) Aquifer can range from fresh to slightly saline. Most of the Edwards-Trinity (Plateau) Aquifer lies beneath water-table conditions; however, where it is fully saturated and exhibits low permeability, artesian water conditions are present. Irrigation activities account for approximately 70 percent of the ground water usage from the aquifer, with municipal water use and livestock supplies accounting for the remainder. Water well yields can range from 50 gal (189 L) per minute where the saturated thickness is thin to greater than 1,000 gal (3,785 L) per minute. Water levels have remained relatively stable because recharge has normally maintained the relatively low volumes of pumping throughout the aquifer (TWDB 2001). Annual supply from the Edwards-Trinity (High Plains) Aquifer in Pecos County (source area for WL3 and WL4) is approximately 37 billion gal (142 billion L) or 114,849 ac-ft.

3.6.4.2 OGALLALA AQUIFER

The Ogallala Aquifer is a major aquifer in the High Plains of Texas, which provides water to all or parts of 46 counties. This aquifer is located approximately 12 mi (19 km) to the northeast of the polygen plant site (see Figure 3.5). Although it would not be used as a process water supply source for the TCEP, this aquifer underlies three linear facilities in the project area ROI and several oil fields in the EOR ROI.

The Ogallala has a saturated thickness of up to 600 ft (183 m). Although many communities use the Ogallala Aquifer as their sole source of drinking water, approximately 95 percent of the water is used for irrigation. This aquifer supplies water to wells with yields on average of approximately 500 gal (1,893 L) per minute and a maximum of approximately 2,000 gal (7,571 L) per minute. The chemical quality of the water in the aquifer is generally fresh; however, fluoride content is commonly high and selenium concentrations can locally exceed drinking water standards. Since the expansion of irrigated agriculture in the mid 1940s, a greater amount of water has been pumped from the aquifer than has been recharged. As a result, some areas have experienced water-level declines in excess of 100 ft (30 m) from predevelopment to 1990 (TWDB 2001). However, more recently reduced pumpage in some areas of the High Plains has resulted in a reduction in the rate of water-level decline.

3.6.4.3 PECOS VALLEY AQUIFER

The Pecos Valley Aquifer is a major aquifer located in the upper portion of the Pecos River Valley of West Texas and provides water to nine counties including Ector and Crane. Although it would not be a process water supply source for the TCEP, the Pecos Valley Aquifer lies beneath the polygen plant site, five linear facilities, and several oil fields in the EOR ROI (see Figure 3.5).

The Pecos Valley Aquifer has a saturated thickness of approximately 250 ft (76 m). Approximately 80 percent of the ground water pumped from this aquifer is used for irrigation, with the remainder used for municipal supplies, industrial use, and power generation. Moderate to large yields of ground water can generally be expected from wells utilizing this aquifer. Water from this aquifer is typically hard because sulfate and chloride are the predominant constituents. Naturally occurring arsenic and radionuclides exceed primary drinking water standards and some deterioration of quality has resulted from past petroleum industry and irrigation activities. Water level declines have historically occurred in excess of 200 ft (60 m) in south-central Reeves and northwest Pecos Counties, but have moderated since the mid 1970s due to a decrease in irrigation pumpage (TWDB 2001).

3.6.4.4 CAPITAN REEF COMPLEX AQUIFER

The Capitan Reef Complex is a minor aquifer in West Texas that is located approximately 25 mi (40 km) to the west of the polygen plant site (see Figure 3.6). This aquifer is the process water source for WL2.

The Capitan Reef Complex Aquifer is a slender, arc-shaped aquifer approximately 10–14 mi (16–23 km) wide that extends from two locations in Texas northward into New Mexico where it provides water to the city of Carlsbad. This aquifer generally contains poor quality water, and yields a wide range of quantities of moderately saline to brine water. The saturated thickness of this minor aquifer widely varies. Most of the ground water pumped from this aquifer in Texas is used for oil reservoir EOR water-flooding operations. A small amount is used for irrigation of salt-tolerant crops. Over the last 70 years, water levels have declined in some areas as a result of localized production (TWDB 2001).

3.6.4.5 DOCKUM AQUIFER

The Dockum Aquifer is a minor aquifer that is located in West Texas and the Texas panhandle. It underlies much of the Ogallala Aquifer, the northern extent of the Edwards-Trinity (Plateau) Aquifer, and the eastern extent of the Pecos Valley Aquifer. This aquifer would not be a source of TCEP process water but lies beneath the entire project area ROI and several oil fields in the EOR ROI (see Figure 3.6).

In 1947, ground water depth of the Dockum Aquifer was measured at 205.6 ft (62.7 m) at a well located immediately south of the proposed polygen plant site (Texas Board of Water Engineers 1937; TWDB 2006); however, recent estimations suggest the ground water depth has dropped to approximately 320 ft (98 m) (TWDB 2003). The quality of the Dockum water is generally poor and contains sodium levels that may be damaging to irrigated land (TWDB 2003). In Ector County, water quality of the Dockum Aquifer ranges from fresh to brackish (TWDB 2003). Irrigation and public supply use is limited. Recharge to the Dockum Aquifer occurs primarily by precipitation and stream flow across the outcropping strata and where permeable portions of the aquifer are overlain by other aquifers such as the Pecos Valley Aquifer.

3.6.4.6 EDWARDS-TRINITY (HIGH PLAINS) AQUIFER

The Edwards-Trinity (High Plains) Aquifer is a minor aquifer in northwest Texas that underlies the Ogallala Aquifer and is located approximately 65 mi (105 km) north of the polygen plant site (see Figure 3.6). This aquifer lies beneath several oil fields in the EOR ROI. Most of the water wells in this aquifer provide water for irrigation and have yields ranging from 50 to 200 gal (189–757 L) per minute (Ashworth and Hopkins 1995).

3.6.4.7 RUSTLER AQUIFER

The Rustler Aquifer is a minor aquifer in the Trans-Pecos region of West Texas and is located approximately 45 mi (72 km) to the west of the polygen plant site (see Figure 3.6). This aquifer lies beneath several oil fields in the EOR ROI. The aquifer is principally located in Loving, Pecos, Reeves, and Ward Counties where it yields water for irrigation, livestock, and EOR water-flooding operations in oil-producing areas of the Permian Basin. High dissolved-solids concentrations render the water unsuitable for human consumption (Ashworth and Hopkins 1995).

3.6.5 Environmental Impacts of Summit's Proposed Project

3.6.5.1 GROUND WATER QUANTITY

Polygen Plant Site

The polygen plant would require water during construction, process water during operation, and potable water during both construction and operation phases. The largest demand would be for process water, which is currently estimated to require an annual minimum of 3.5 million gal (13 million L) per day with a peak demand of 5.5 million gal (21 million L) per day. This demand could be minimized using the brine concentrator and filter press disposal technology and the dry cooling tower options. Four delivery options from the three sources of process water were evaluated for the TCEP. These water sources are

- treated domestic effluent from the GCA Odessa South facility (WL1);
- ground water from the Oxy Permian water supply (WL2); or
- ground water from the FSH water supply project (WL3 and WL4).

The water that comprises the treated effluent from the City of Midland Wastewater Treatment Plant and the GCA Odessa South Facility originates primarily from surface lakes and is supplemented periodically by ground water prior to municipal use. Because this water would be produced and used regardless of the TCEP, no direct impacts to ground water quantity would occur under WL1. The waste water effluent is currently disposed of through application to agricultural lands and a small percentage of the effluent that is not cycled into the atmosphere through evapotranspiration may recharge shallow ground water. The agricultural lands are owned by the City of Midland and the land application of the waste water is being used as an alternative to securing a discharge permit for the effluent. Agricultural irrigation would be reduced or terminated altogether if WL1 were to be implemented, which would have a small impact to the percentage of recharge to the underlying shallow aquifer.

Oxy Permian) is a network of pipelines that provides brackish ground water from the Capitan Reef formation for EOR water flood projects in the Permian Basin. The closest source of the Oxy Permian water to the polygen plant site is a group of ground water wells near the town of Kermit, Winkler County, Texas, which is located approximately 29 mi (47 km) northwest of the TCEP. The Oxy Permian system is not utilized at its full capacity and the demand for water for use in secondary oil recovery has been slowly declining. The oil wells are producing a higher ratio of water to oil as the level in the oil reservoirs drops. The greater amount of water being produced means the oil companies need less supplemental water so the demand from the Oxy Permian water system is declining. Current estimates are that the pumping rate may be as low as 50 percent of what it was at its highest level (Smith 2010). Because the amount of water pumped for the Oxy Permian Water Supply has steadily decreased, the impacts of additional pumping for use as TCEP process water under WL2 would be small.

Water from the FSH line would derive from Edwards-Trinity (Plateau) Aquifer ground water, which is currently permitted for agricultural use on FSH farms. This water has already been accounted for in the 2011 Texas Water Plan, and the pipeline project represents a potential change in the use for the water rather than a new demand on water (Brock 2011). FSH would scale back, and eventually eliminate, the agricultural operations in their present form as the water was converted from irrigation to municipal use. There is very little recharge of the water currently used for irrigation by FSH back into the aquifer due to impermeable strata below the farm (Thornhill Group, Inc. 2008). The pipeline would originate approximately 68 mi (109 km) southwest of the TCEP near the town of Fort Stockton. The primary users of water from this source would be the Cities of Midland and Odessa; the TCEP would use approximately 10 percent of the total volume of this proposed water source (FSH 2010). Because no additional ground water would be withdrawn from the aquifer and because there is very little recharge of the water currently used for irrigation, the TCEP's use of 10 percent of the total volume would have a negligible impact to the Edwards-Trinity (Plateau) Aquifer.

The construction and operation of the TCEP would result in the creation of up to 150 ac (60 ha) of impervious surface area. Although this additional impervious area could hinder recharge to the Pecos Valley Aquifer beneath the proposed polygen plant, intermediate layers of low permeability shale located below the polygen plant site currently hinder ground water recharge. Because of the size of the Pecos Valley Aquifer recharge area and the existing recharge conditions, the impact of the additional impervious surface area to ground water recharge would be negligible.

Linear Facilities

The proposed new access roads would result in approximately 23.6 ac (9.5 ha) of new impervious cover. As with the polygen plant site, this new impervious cover would hinder aquifer recharge, but that impact is expected to be minor due to the size of the surrounding aquifer recharge area. Vegetation along the areas disturbed during construction of the process water, natural gas, and CO_2 pipelines would be restored after construction and would result in little to no impervious cover.

3.6.5.2 GROUND WATER QUALITY

Polygen Plant Site

During construction and operation of the polygen plant, petroleum, oils, lubricants, and other materials could be spilled onto the ground surface and potentially impact ground water resources. However, required SPCC plans and spill prevention measures would be employed. These measures would help minimize the chance of fuel, oils, lubricants, and other potentially hazardous materials being released and would encourage proper disposal of waste materials. In the event of a spill, it is unlikely that these materials would reach ground water resources before cleanup due to the depth of the ground water table (estimated to be 320 ft [98 m] below ground). In addition, intermediate layers of low permeability shale located below the polygen plant site would impede liquids discharged at the surface from reaching the water table.

As discussed in Chapter 2, the TCEP would use a ZLD system that would reduce the overall need for raw process water through water reuse and prevent the discharge of process reject water to the land surface. This system would treat and reuse the process water wastes through multiple cycles of use, with salt from the brine water being disposed of through one of the proposed technologies in Chapter 2. Of the concentrated brine disposal option, the brine concentrator–filter press and solar evaporation ponds present a remote possibility that salt deposited in landfills could eventually leach into ground water.

Leakage of brine water to shallow ground water from solar evaporation ponds could occur from leaks in piping, valves, liners, or other components of the system. To minimize these risks, the systems would be built using required containment technology and would require monitoring. The required containment technology combined with the distance down to ground water and the presence of multiple layers of low permeability shale make it unlikely that the operation of the solar evaporation ponds would have significant impacts to ground water resources. If salt-laden brine water leaks downward into any potential water supply aquifers for drinking water, the contaminated portion of the underground aquifer would become more saline and likely would become unfit for drinking water. Clean-up would involve installation of one or more pumping wells into the contaminated area of the aquifer and pumping the contaminated water back to the surface where it would then require either proper disposal or re-introduction into the plant's ZLD system (after the leaking system has been repaired).

Brine water injection wells would be built to TCEQ Class I standards, which include tubing and packer designs with annular monitoring and complete annular cementing from the injection interval to land surface. Meeting these design, construction, and monitoring requirements would reduce the potential for leakage of the injected brine water and upward displacement of poor-quality ground water into overlying water-supply aquifers. Further, a thick sequence of rock strata between the formations that would receive the TCEP brine water and the potentially usable water supply would impede any upward movement of injected brine water. If either injected salt-laden water or native brine in a deep reservoir is displaced into any potential water supply aquifers for drinking water, the contaminated portion of the underground aquifer would become more saline and likely would become unfit for drinking water. Clean-up would involve installation of one or more pumping wells into the contaminated area of the aquifer and pumping the contaminated water back to the surface where it would then require proper disposal. Contaminated water that is recovered could be processed through the plant's ZLD system only after the problem with the injection well is corrected.

Linear Facilities

Impacts from the construction of the linear facilities would include the potential for fuel, oils, lubricants, and other potentially hazardous construction materials being released to the surface or subsurface (e.g., railcar maintenance area). As with the polygen plant site, it is not likely that such materials would seriously degrade ground water due to the implementation of the required SPCC plan and spill controls, the presence of multiple layers of low permeability shale, and the depth of the ground water below the surface.

The construction of process water, natural gas, and CO_2 pipelines would require hydrostatic testing to certify the material integrity of the pipeline before use. These tests consist of pressurizing the pipeline with water and checking for pressure losses from pipeline leakage. Contractors would perform hydrostatic testing in accordance with U.S. Department of Transportation pipeline safety regulations and all other applicable permits. The source and quantity of water for hydrostatic testing would be dependent on the available water sources. After the tests, the used hydrostatic test water would be analyzed and disposed of appropriately based on its chemical composition.

Operation and maintenance of the pipelines would comply with TPDES permit requirements and SPCC plans, if applicable. A release from a water pipeline carrying treated effluent would be rapidly detected and repaired. There could be a small localized area of discharge of the treated effluent. Because the use of this water for irrigation has been approved by the TCEQ, such effluent has been deemed safe and would not pose a threat to ground water. Releases from either the CO_2 pipeline or natural gas pipeline would not affect ground water resources. Minor oil spills associated with the operation and maintenance of the power transmission lines could also occur. As with the pipelines, ground water impacts associated with spills along the power transmission lines would not be likely due to the depth of the ground water, presence of low permeability shale layers, and compliance with the required SPCC plans and spill controls.

Traffic accidents on project roads could result in hazardous materials spills. The spill response measures developed for the polygen plant site would be executed to control runoff and to clean-up hazardous materials spills. As noted earlier, the depth to ground water and presence of low permeability shale layers would prevent such spills from reaching the ground water.

Sequestration Sites

Impacts of the injection of CO_2 in deep geologic reservoirs would be expected to be low. The potential for CO_2 to naturally leak from the geologic reservoir into overlying shallow aquifers is low due to the depth and geologic characteristics of the potential sequestration sites (Smyth et al. 2006). Further, the CO_2 captured from the TCEP would be injected into oil reservoirs in quantities that would not cause the fluid pressures in the reservoir to significantly exceed the original natural pressures in those reservoirs, so pressure to drive the CO_2 upward would be lacking. These formations have held oil over geologic time, showing a high degree of integrity for long-term storage.

Although the most likely pathway for upward migration of CO_2 is through improperly abandoned deep wells that penetrate the main seal over the reservoir where CO_2 would be injected, RRC requires that abandoned injection wells be identified and properly plugged, which significantly reduces the potential for CO_2 leakage. Pursuant to RRC requirements, purchasers of the CO_2 would test any wells in the receiving fields prior to injection for EOR.

The sequestration of CO_2 associated with the TCEP would be the result of the EOR process. Because CO_2 is a valuable commodity in the EOR process, the potential users of the TCEP CO_2 would actively manage their EOR processes as a closed-system and strive to prevent the loss of any CO_2 in the process. Additionally, after long-term monitoring of the Scurry Area Canyon Reef Operators Committee oil field in Snyder, Scurry County, Texas, the Bureau of Economic Geology found that no systematic impacts to ground water occurred as a result of CO_2 injection practices (Smyth et al. 2009). The Scurry Area Canyon Reef Operators Committee oil field is located in the Permian Basin (approximately 100 mi [161 km] northeast of the proposed polygen site) and is considered to be representative of other likely Permian Basin CO_2 EOR sites (Smyth et al. 2006), including those sites that would use TCEP CO_2. Based on the experience at Scurry Area Canyon Reef Operators Committee oil field and the other information presented above, DOE anticipates minimal ground water impacts to the Capitan Reef Complex, Dockum, Edwards-Trinity (High Plains), Edwards-Trinity (Plateau), Pecos Valley, Ogallala, and Rustler Aquifers would occur as a result of the injection of TCEP CO_2 for use in EOR processes.

3.6.6 Mitigation

Additional mitigation has not been identified beyond the required compliance with state and federal air quality regulations, as well as implementation of standard construction controls identified in Chapter 2, Table 2.8.

3.7 Surface Water Resources

3.7.1 Background

This section identifies and describes the surface water resources that could be affected by the construction and operation of the polygen plant and linear facilities. This section also presents the environmental impacts of the proposed project and the No Action Alternative. Additional mitigation measures that could be implemented to further reduce potential adverse consequences are presented.

Surface water resources include wetlands, water bodies, waterways, and floodplains. Each of these resources provides benefits related to water quality, wildlife and aquatic life habitat, and flood protection. A number of federal and state laws and regulations include thresholds for protection of surface water resources. These thresholds are described in Chapter 7, Permitting and Licensing Requirements.

> **Wetlands** are areas inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands typical of this region of Texas include areas along intermittent and perennial waterways, temporarily flooded areas, marsh complexes in large basins, seeps and springs, desert playas, abandoned stream channels, fringe wetlands around water bodies, and natural ground surface depressions (U.S. Army Corps of Engineers 2008, 2010).
> **Water bodies** are geographic depressions or impoundments that hold water. They can be shallow or deep. Water bodies typical of this region of Texas include natural ponds and playa lakes and impoundments along waterways, but can also include man-made ponds associated with ranching, oil and gas activities, industrial cooling facilities, and municipal waste water filtration systems. Water bodies in this region are generally ephemeral, and when not inundated with water, they either function as wetlands or are dry.
> **Waterways** are linear geographic features that convey flowing water. Well-known waterway types are rivers, streams, and creeks, but can also include man-made features such as ditches, canals, swales, pipes, and aqueducts (U.S. Army Corps of Engineers 2007).
> **Waters of the U.S.** are surface waters that are chemically, physically, and/or biologically connected to other water resources, as the definition applies to the jurisdictional limits of the U.S. Army Corps of Engineers under the Clean Water Act.
> **Floodplains** are areas that can be inundated periodically due to rain fall events. Floodplains are designated by the Federal Emergency Management Agency.

3.7.2 Region of Influence

The ROI consists of the polygen plant site, areas where the linear facilities would intersect surface water resources, and areas downstream (300 ft [91 m) of each intersection. The downstream area is included because such areas could be affected by increases in surface water runoff and downstream movement of eroded soils.

3.7.3 Methodology and Indicators

To characterize the existing environment and analyze potential impacts to surface water, DOE reviewed the FutureGen EIS (DOE 2007), USFWS National Wetland Inventory maps (USFWS 1994), U.S. Geological Survey NHD geodatabases (U.S. Geological Survey 2010a), Federal Emergency Management Agency floodplain data (City of Midland 2010; Federal Emergency Management Agency 1991a, 1991b), U.S. Geological Survey topographic maps (TWDB 2010d), aerial photographs (TWDB 2010e), available water quality reports, and conducted a limited site reconnaissance.

The impacts analysis for surface water resources used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. The potential impacts to surface water resources and their indicators are shown in Table 3.14.

Table 3.14. Indicators of Potential Impacts to Surface Water Resources

Potential Impact	Impact Indicator
Filling of wetlands, waterways, or water bodies, or otherwise alter drainage patterns that would affect these resources, thus triggering a permitted or regulated activity	Acres of fill in wetlands, waterways, or water bodies
Conflict with applicable storm water or regional water quality management plans or goals, or contaminate public water supplies and other surface waters exceeding (i.e., degrading) water quality criteria or standards	Water quality conditions
Violation of any federal, state, or regional discharge limitations, which could affect drainage patterns, flooding, and erosion and sedimentation	Volume of discharge into surface waters
Affect the capacity of surface water resources	
Conflict with established water rights or regulations protecting surface water for future beneficial uses	Volume of surface water used
Conflict with applicable flood management plans or ordinances, or alter floodways, floodplains, flood hazard areas, or otherwise impede or redirect flows such that human health, the environment, or personal property is affected	Acres of impacts within mapped floodplains or flood hazard areas
Affect or modify federally and/or state-listed protected water bodies such as wild and scenic rivers	Acres of disturbance within protected water bodies

3.7.4 Affected Environment

Existing surface water conditions are described in this section. The project area spans 23 subwatersheds as identified in Figure 3.7. Data on water quality conditions for the ROI were derived from studies along Monahans Draw. These studies conclude that water quality is typical of an intermittent stream that receives storm water runoff from municipal and industrial sources and within which treated municipal effluent dominates stream flow (James 1988; Larson 1996). Overall, they found the water quality to be reasonably good with elevated concentrations of nutrients, certain metals, and organics for short distances downstream from municipal outfalls.

> **Watersheds** are the land area that drains water to a particular stream, river, or lake. It is a land feature identified by tracing a line along the highest elevations between two areas on a map, often a ridge (U.S. Geological Survey 2011).
> **Subwatersheds** are a smaller geographic section of a larger watershed unit with a drainage area between 2–15 square mi (mi^2) (5–39 square km [km^2]) and whose boundaries include all the land area draining to a point where two second order streams combine to form a third order stream (EPA

3.7.4.1 WETLANDS, WATERWAYS, WATER BODIES, AND WATER QUALITY

Polygen Plant Site

There are no surface waters on the polygen plant site (DOE 2007; SWCA 2010a). The nearest surface waters are ephemeral headwaters to Monahans Draw and Landreth Draw. Data from the NHD, U.S. Geological Survey maps, and aerial photography show the Monahans Draw headwaters to be approximately 4.2 mi (6.7 km) to the northeast and the Landreth Draw headwaters approximately 11.8 mi (19.0 km) to the southeast of the polygen plant site (Figure 3.8). The closest major water body is the upper Pecos River, located approximately 30 mi (48.3 km) south of the project area.

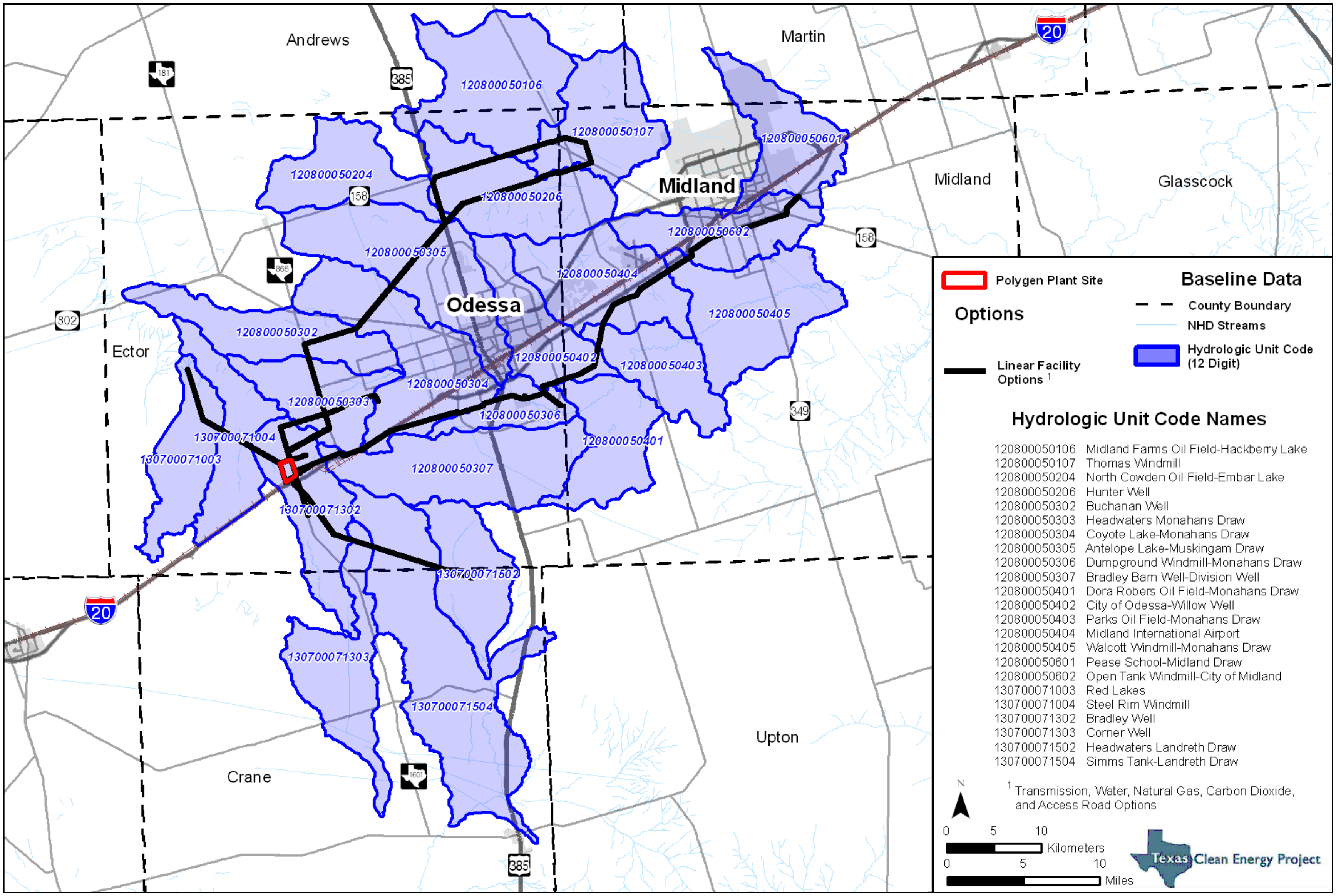

Figure 3.7. Subwatersheds in the project area.

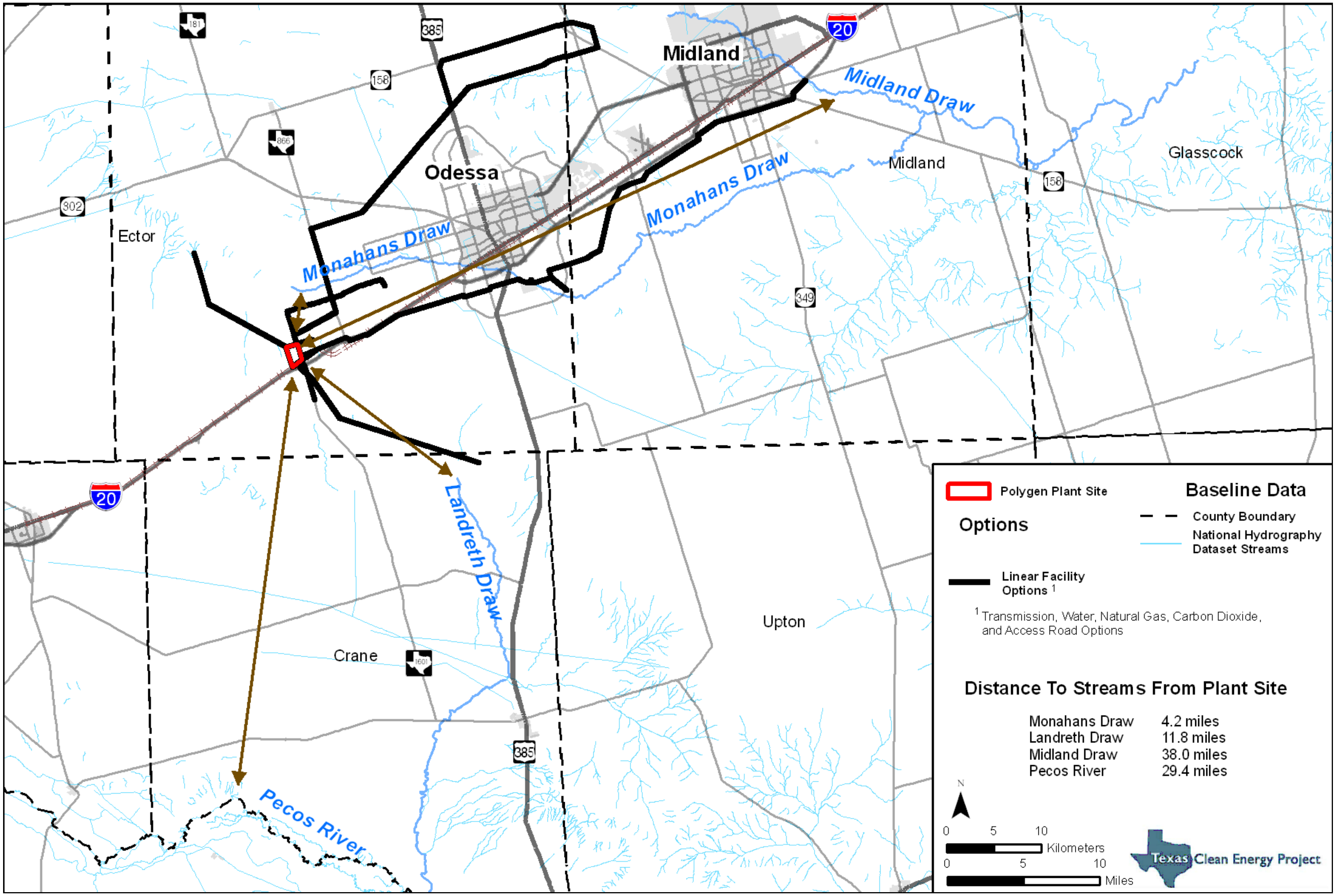

Figure 3.8. Proximity of major surface waters to the polygen plant site and linear facilities.

Linear Facilities

WL1 and WL3 are the only linear facilities with wetlands or water bodies within their proposed corridors (Table 3.15; Figure 3.9). The NHD, U.S. Geological Survey topographic maps, and/or aerial photographs suggest linear facility options potentially cross other surface waters, but an evaluation of these areas did not reveal surface water indicators. The total area of wetlands and water bodies within the combined corridors is approximately 2.16 ac (0.87 ha).

Table 3.15. Summary of Existing Wetland/Water Body Conditions for Specific Linear Facility Options

Linear Facility Option	Inset on Figure 3.9	Wetland/Water Body Type*	Area (ac [ha])[†]
WL1	B	PSS1K: Wetland Fringe to Monahans Draw Impoundment (artificial hydrology from effluent discharge)	0.20 (0.08)
WL1	B	R5AB3K: Monahans Draw Impoundment (artificial hydrology from effluent discharge)	0.54 (0.22)
WL1	C	PEM1Cxs: Ephemeral Borrow Pit (water body)	0.84 (0.34)
WL3	A	PEM2C: Ephemeral Playa[‡]	0.58 (0.23)
Total			**2.16 (0.87)**

* Wetland types follow Cowardin et al. (1979): PSS1K = palustrine scrub-shrub, persistent, artificially flooded; R5AB3K = riverine, unknown perennial, aquatic bed, rooted vascular, artificially flooded; PEM1Cxs = palustrine emergent, persistent, seasonally flooded, excavated, spoil; PEM2C = palustrine emergent, nonpersistent, seasonally flooded.

[†] Wetland acreages were derived from field reconnaissance, NHD data, National Wetland Inventory maps, and aerial photograph interpretation and not from field delineation.

[‡] Wetland acreage was derived from GIS analysis of aerial photography only, as access to the surface water was unavailable.

From its headwaters 5 mi north of Penwell in Ector County, Texas, Monahans Draw runs east for approximately 45 mi (72 km) to its confluence with Midland Draw in Midland County, Texas. Monahans Draw is broad and shallow with a sandy substrate and over its course, transitions from a dry, ephemeral swale (upstream of the GCA Odessa South Facility) to a seasonally intermittent waterway. Effluent discharge from the GCA Odessa South Facility and rainfall runoff drive the intermittent nature of Monahans Draw as the historical springs and seeps have not flowed since the late 1930s (Brune 1981). Because it is not perennial, Monahans Draw is not a state-owned streambed. However, Monahans Draw is still an important drainage in the region; carrying flood flows and contributing to the overall dynamics of the local watershed and ultimately, the Colorado River.

Where Monahans Draw intersects WL1 (Insert B on Figure 3.9), it primarily functions as a wetland (Figure 3.10). This is due to the impounding of effluent discharge from the GCA Odessa South Facility (Figure 3.11). The overall nature and quality of this wetland is low because invasive and/or noxious species, such as broadleaf cattail (*Typha latifolia*), saltcedar (*Tamarix* sp.), and burningbush (*Bassia scoparia*) are dominant.

Additionally, the hydrologic regime is highly variable and driven primarily by the effluent discharge with rainfall events providing a secondary source of hydrology. Using the same observation point (South Dixie Boulevard upstream of the GCA discharge), DOE noted that Monahans Draw had high stream flow in June 2010, following a period of above-normal rainfall. Then shortly thereafter, in August 2010, Monahans Draw had no stream flow (Figure 3.12).

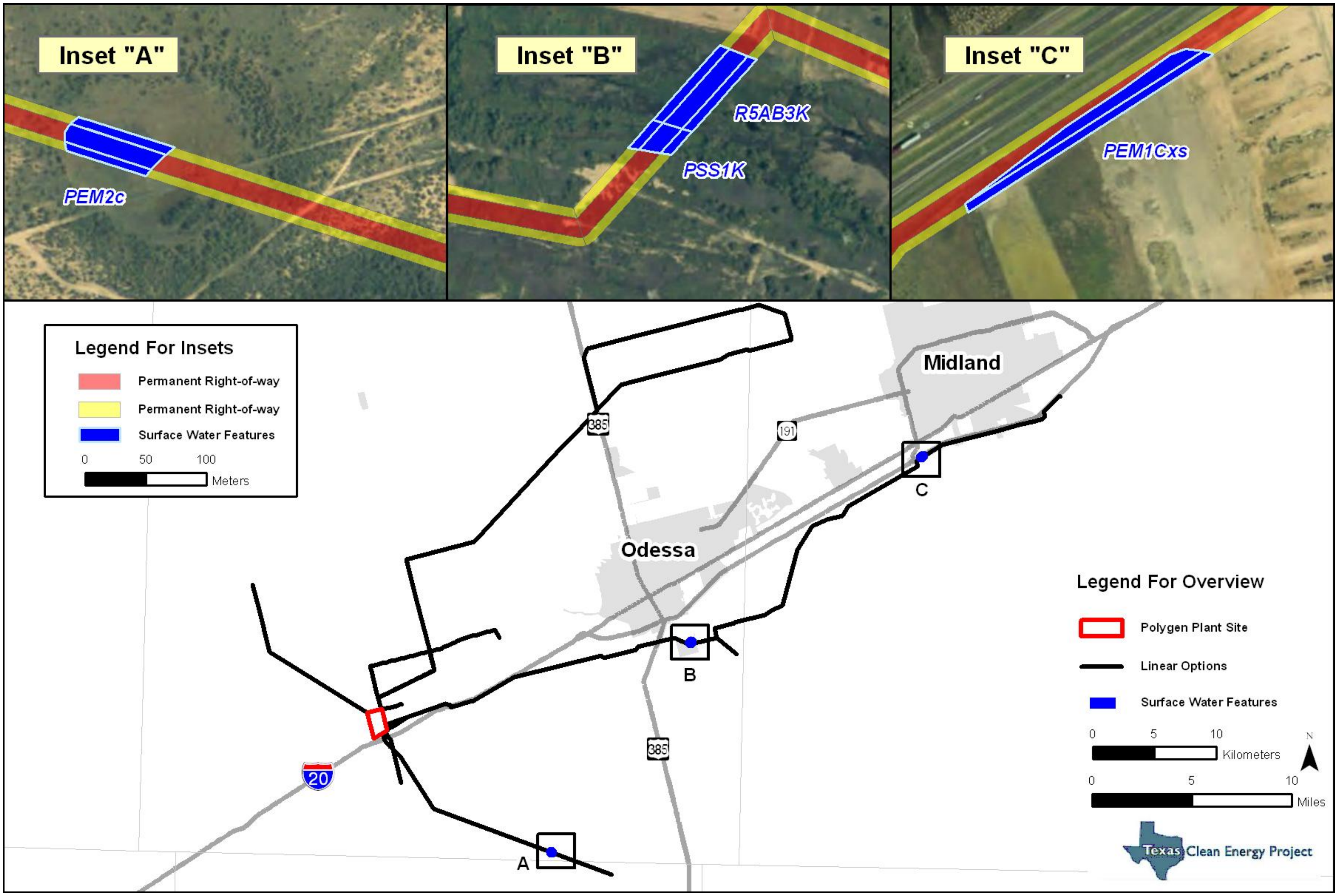

Figure 3.9. Existing surface water conditions along the TCEP linear facility options.

Figure 3.10. Monahans Draw Impoundment (dominated with broadleaf cattail), as viewed facing northwest toward the proposed waterline crossing.

Figure 3.11. Effluent discharge from Gulf Coast Waste Disposal Authority Odessa South Facility into Monahans Draw Impoundment.

Figure 3.12. Changes in Monahans Draw stream flow (above, as viewed from South Dixie Boulevard) and stages of wetland conditions (below, as viewed near the proposed WL1 crossing).

During this same period, the impoundment near the proposed WL1 crossing (also upstream of the GCA discharge) went from being inundated to only having pockets of saturation and inundation (see Figure 3.12). Therefore, in the absence of effluent discharge, periods of above normal rainfall may provide temporary, ephemeral wetland habitat for aquatic species. It is the artificial hydrology from GCA discharge that provides for a more consistent source of water that supports aquatic species habitat and attracts wildlife in this arid habitat.

All other surface waters, including the ephemeral playa lake and borrow pit (Insets A and C, respectively, on Figure 3.9), which could be crossed by the linear facilities are isolated and have evidence of past and current disturbances (e.g., excavation, livestock use, roads, etc.; see Figure 3.9; Figure 3.13).

Figure 3.13. Borrow pit with ephemeral water (PEM1Cxs Water Body, Inset C on Figure 3.9).

3.7.4.2 FLOODPLAINS

Polygen Plant Site

The polygen plant site is located outside of the 100-year floodplain. In fact, the entire subwatershed (Bradley Well) in which the plant site is located (see Figure 3.7) has limited floodplains with only a few closed topographic systems associated with ephemeral playas or ephemeral drainages. Based on topographic maps, the site has low relief—a difference of approximately 30 ft (9 m) across the site—with general surface drainage to the south-southwest.

Linear Facilities

Access roads would not be located in any known floodplains (City of Midland 2010; Federal Emergency Management Agency 1991a, 1991b). All of the proposed power transmission line alternatives and WL1 and WL2 would intersect mapped floodplains, but most of the floodplains are in closed topographic systems associated with ephemeral playas or depressional areas (i.e., they are not associated with waterways). The process water, natural gas, and CO_2 pipelines would be buried, thus no permanent aboveground structures would be placed within the 100-year floodplains, and construction would therefore not result in increases to the 100-year flood elevation or present barriers to floodway passage.

3.7.5 Environmental Impacts of Summit's Proposed Project

3.7.5.1 WETLANDS, WATER BODIES, WATERWAYS, AND WATER QUALITY

Polygen Plant Site

The absence of surface water resources in or adjacent to the polygen plant site eliminates the possibility of direct impacts and reduces the risk of indirect impacts. Indirect impacts to surface waters in the ROI during construction or operation of the polygen plant site would be unlikely for the following reasons:

- No discharge of storm water would occur. Storm water generated during construction and operation would be collected in on-site storm water retention basins, which would be located in the southwestern corner of the polygen plant site. Based on topographic maps, the southwestern corner is currently where all natural overland storm water drains. Additionally, the TCEP would comply with all existing regulatory requirements, such as storm water construction permits (maintaining and treating all storm water on-site).
- The TCEP would not discharge industrial waste water into surface waters. A ZLD system or deep well injection would treat all brine water and recycle it back into the polygen plant. Alternatively, brine water would be injected in deep geologic formations underneath the polygen plant site.

Impacts to surface waters in the ROI during operation of the plant site would be low. For any spilled materials such as coal or other by-products that were entering or leaving the polygen plant site, Summit would comply with existing regulatory requirements regarding remediation of spills and would follow guidelines outlined in a SPCC plan to reduce the potential for such materials to reach water bodies off-site. For windblown particulates such as those from coal and slag handling facilities and plant emissions, Summit would enclose coal and slag handling facilities and incorporate dust suppression sprayers and other dust collection systems. These measures would reduce the potential for deposition of PM on off-site water bodies.

The preferred water source for the TCEP is treated effluent from the GCA Odessa South Facility (WL1), but the Oxy Permian Process (WL2) or the FSH waterline (WL3 and WL4) could also supply process water to the TCEP. The current discharge volume (minimum monthly average discharge of 2.0 million gal [7.5 million L] per day) from the GCA Odessa South Facility to Monahans Draw would not be decreased as a result of the TCEP, because additional flow to the GCA Odessa South Facility would be provided from the City of Midland Wastewater Treatment Plant (Levine 2010). Thus, TCEP process water use would not affect Monahans Draw or any other surface water resource in the ROI.

Linear Facility Options

Impacts to surface waters or surface water quality from the construction or operation of the linear facility options would be unlikely. Once construction was complete, there would be no permanent aboveground structures in or adjacent to surface waters. Restoration procedures, such as soil stabilization and revegetation, would stabilize and restore the impacted area. The ROW adjacent to Monahans Draw would likely be maintained in a state that is cleared of woody vegetation, but considering the dominant species is saltcedar—a non-native, noxious, and invasive species—this could be considered a beneficial environmental consequence.

Construction of linear facilities could result in short-term impacts including increased turbidity and sedimentation, streambed disturbance, and removal of streambank vegetation. These impacts and their intensity would be minimal because:

- Construction would affect a maximum of 1.42 ac (0.57 ha) of wetlands (Table 3.16). This area excludes WL1, as construction across Monahans Draw (which is shown on Insert B on Figure 3.9) would occur in a manner to avoid potential adverse impacts to the 0.74 ac (0.30 ha) associated with Monahans Draw. Either traditional open-cut trenching methods or horizontal directional drilling would be used. Horizontal directional drilling methods would allow the construction activity to take place without obtaining a Clean Water Act Section 404 permit, whereas traditional trenching methods would require a permit. A permit is not required for the ephemeral playa lake and borrow pit (Insets A and C, respectively, on Figure 3.9) because they are isolated and nonjurisdictional.
- The construction activities affecting surface water resources would comply with existing regulatory requirements, such as storm water construction permits, that mandate runoff controls and erosion management. This would result in elimination or significant reduction of potential adverse impacts.

3.7.5.2 FLOODPLAINS

Analysis of impacts to floodplains showed that flooding has a low potential to occur due to the low frequency of local flood occurrences in Ector and Midland Counties (H20 Partners 2010). No permanent aboveground structures would be placed in the 100-year floodplains, and construction would therefore not result in increases to the 100-year flood elevation or present barriers to floodway passage. Floodplain impacts from linear facilities are limited because these facilities cross only minimal floodplain areas and the only aboveground structures would be temporary access roads during construction (transmission line structures would be placed outside of floodplains). Temporary access roads would be removed upon construction completion but designed to meet all applicable flood management requirements while in use during construction.

Table 3.16. Environmental Impacts to Surface Water Resources from Construction and Operation of Linear Facilities

Linear Facility Option	Inset on Figure 3.9	Temporary ROW*		Operational ROW†	
		Wetland Type‡	Area (ac [ha])§	Wetland Type‡	Area (ac [ha])§
WL1	B	PSS1K: Wetland Fringe to Monahans Draw Impoundment (artificial hydrology from effluent discharge)	0.10 (0.04)	PSS1K: Wetland Fringe to Monahans Draw Impoundment (artificial hydrology from effluent discharge)	0.10 (0.04)
WL1	B	R5AB3K: Monahans Draw Impoundment (artificial hydrology from effluent discharge)	0.26 (0.11)	R5AB3K: Monahans Draw Impoundment (artificial hydrology from effluent discharge)	0.28 (0.11)
WL1	C	PEM1Cxs: Ephemeral Borrow Pit (water body)	0.41 (0.17)	PEM1Cxs: Ephemeral Borrow Pit (Water Body)	0.43 (0.17)
WL3	A	PEM2C: Ephemeral Playa#	0.28 (0.11)	PEM2C: Ephemeral Playa¶	0.30 (0.12)
Total			**1.05 (0.42)**		**1.11 (0.45)**

* These include additional ROWs needed for construction only.
† These include maintained ROWs.
‡ Wetland types follow Cowardin et al. (1979): PSS1K = palustrine scrub-shrub, persistent, artificially flooded; R5AB3K = riverine, unknown perennial, aquatic bed, rooted vascular, artificially flooded; PEM1Cxs = palustrine emergent, persistent, seasonally flooded, excavated, spoil; PEM2C = palustrine emergent, nonpersistent, seasonally flooded.
§ Wetland acreages were derived from field reconnaissance, NHD data, National Wetland Inventory maps, and aerial photograph interpretation. DOE has not conducted a delineation of these resources.
¶ The perennial hydrology of these surface water features is due to the effluent discharge from the GCA Odessa South Facility.
# This wetland acreage was derived from GIS analysis of aerial photography only, as access to the surface water was unavailable.

3.7.6 Mitigation

Mitigation measures that Summit would implement as part of the construction and operation of the TCEP are described in Table 2.8 of Chapter 2. Additional mitigation measures that Summit could implement or that DOE could require as a condition of approval to further reduce impacts to surface water resources are:

Floodplain (TL1, TL2, TL5, and TL6):

- Designing the transmission line to span resource
- Coordinating with local floodplain administrators
- Conducting construction activities during dry or low flow conditions

Wetlands (WL1) and floodplain (WL3):

- Crossing wetland area at narrowest point to disturb the least amount of wetland vegetation.
- Using restoration and stabilization controls in affected areas to pre-construction conditions for open-cut methods or maintenance activities. In the case of WL1, TCEP representatives could coordinate with GCA to divert the effluent discharge around the construction area to

avoid downstream flow of sediment, and then return the discharge to normal conditions once the construction area is stabilized.

- Coordinating with local floodplain administrators.
- Conducting construction activities during dry or low flow conditions.
- Using erosion and siltation controls to minimize short-term impacts when maintenance activities requiring access to buried portions of pipelines occur in floodplains or wetlands.

3.8 Biological Resources

3.8.1 Background

This section identifies and describes the biological resources that could be affected by the construction and operation of the polygen plant and linear facilities. This section also presents the environmental impacts of the proposed project and the No Action Alternative. Additional mitigation measures that could be implemented to further reduce potential adverse consequences are presented.

Biological resources can be affected by the disturbance, injury, or death of individuals and by the destruction or disturbance, either temporarily or permanently, of habitat. In addition to addressing these possible impacts, this section addresses the potential for the introduction or spread of non-native or invasive species. Chapter 7, Permitting and Licensing Requirements, summarizes the federal and state laws, regulations, and executive orders applicable to biological resources.

3.8.2 Region of Influence

The ROI for biological resources is the area in which direct and indirect impacts have the potential to occur during TCEP construction and operation. It covers terrestrial and aquatic habitat, migratory birds, and federally and state-protected species. The ROI encompasses the total acreage of the polygen plant site and linear facility ROWs and a 0.5-mi (0.8-km) buffer zone around these areas to account for potential disturbance from project noise or vibration. In addition, the ROI for impacts to aquatic species includes areas where the linear facilities would intersect surface water resources, and areas downstream (at least 300 ft [91 m]) of each intersection. The downstream area is included because such areas could be affected by increases in surface water runoff and downstream movement of eroded soils which could adversely affect aquatic species.

3.8.3 Methodology and Indicators

3.8.3.1 METHODS OF ANALYSIS

Terrestrial Species

Terrestrial species and habitat were identified during various site visits noted in Section 3.2 to the proposed polygen plant site and accessible areas of the linear facilities. DOE recorded the wildlife and vegetative species present, the condition of the terrestrial community, and presence or absence of noxious or invasive species. In addition, a literature review was conducted to confirm wildlife species likely to occur in the ROI (Garrett and Barker 1987; Lockwood and Freeman 2004; Schmidly 2004). Bird species that commonly occur in the ROI were determined based on existing habitat types in the ROI and a literature review of the *Texas Ornithological Society Handbook of Texas Birds* (Lockwood and Freeman 2004).

Aquatic Species

DOE surveyed the proposed polygen plant site and accessible areas of the linear facilities for aquatic communities. There are no aquatic resources or communities on the proposed polygen plant site. However, for the accessible aquatic communities along the linear facilities, DOE documented wildlife and vegetative species, the condition of the aquatic community, and presence or absence of noxious or invasive species. See the surface water resources section (Section 3.7) for the methodology used for the assessment of wetlands, water bodies, and waterways. In addition, a literature review was conducted to confirm aquatic species likely to occur in the ROI (Garrett and Barker 1987; Lockwood and Freeman 2004; Schmidly 2004).

Migratory Birds

In three field investigations, DOE documented the potential for migratory bird species to occupy habitat in and adjacent to the project area.

Rare, Threatened, and Endangered Species

Federal- and state-listed threatened and endangered species with potential to occur in Ector, Midland, and Crane Counties, Texas, were identified through review of county-by-county lists of such species produced by USFWS (2010) and TPWD (2010). These USFWS and TPWD county lists provide baseline information to assess which threatened and endangered species have potential to occur in the ROI. DOE conducted three field investigations of the project area and reviewed aerial photographic and topographic maps to verify the presence of habitat for the identified species. DOE also reviewed the TPWD Natural Diversity Database to locate known occurrences of species that are considered rare, threatened, or endangered under Texas law. DOE gathered this information and developed a habitat evaluation to determine the potential for federal- and state-listed species to occur in the ROI (SWCA 2010b).

3.8.3.2 ASSESSMENT INDICATORS

The impacts analysis for biological resources used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. Potential impacts and their quantitative indicators are shown in Table 3.17.

Table 3.17. Indicators of Potential Impacts to Biological Resources

Potential Impact	Impact Indicator
Displacement of individuals (wildlife) or loss of habitat	Acres of surface disturbance
Loss of vegetation species or communities	
Direct removal of individuals; increased risk of direct mortality for some species	
Disturbance by project construction or operation resulting in changes to wildlife behavior	Acres within 0.5 mi (0.8 km) of project operations or construction zones
Increased risk of direct mortality (avian species) due to collisions with transmission lines	Linear feet and dimensions of new transmission lines
Increased risk of direct mortality (terrestrial wildlife species) from traffic	Linear feet of new roads Annual average daily traffic (AADT) numbers
Introduction of noxious or invasive species	Perimeter of surface disturbance and use (linear feet)

3.8.4 Affected Environment

The existing conditions for terrestrial and aquatic species, migratory birds, and rare, threatened, and endangered species are generally the same throughout the ROI; therefore, the following descriptions of existing biological resources apply to the project area in its entirety.

3.8.4.1 TERRESTRIAL SPECIES

The TCEP would be constructed and operated in the High Plains ecoregion of Texas (Griffith et al. 2007). This ecoregion is characterized by smooth and slightly irregular plains scattered with playa lakes, which are isolated wetlands in shallow depressions. Specifically, the ROI lies in the more arid subregions of the High Plains ecoregion, including both the Llano Estacado and Arid Llano Estacado subregions. Most of the project area is located in the Arid Llano Estacado subregion (Figure 3.14), which is drier than the Llano Estacado. The Llano Estacado subregion is located in northeast Midland County and includes the eastern extent of WL1 (Figure 3.14). DOE assumes that the terrestrial species occurring in these two subregions have the potential to occur the ROI.

Vegetation

The Llano Estacado and Arid Llano Estacado subregions are both described as a short-grass prairie vegetated primarily by buffalograss (*Bouteloua dactyloides*) and grama species (*Bouteloua* spp.). However, a significant portion of the two subregions has been altered by oil and gas production, ranching, and agricultural activities, in the past 100 years, which has caused fragmentation of the habitat and encroachment of shrub species such as mesquite (*Prosopis glandulosa*) and narrowleaf yucca (*Yucca angustissima*). This disturbance is evident throughout the ROI, which now fully supports the Mesquite Shrub-Grassland vegetation community known to occur in the two subregions. Invasive and noxious species (as defined under federal and state laws) are also present in the ROI, with cover ranging from 0 percent to approximately 70 percent, based on a visual estimate conducted during field investigations.

Observed invasive or noxious species in the project area include bermudagrass (*Cynodon dactylon*), burningbush, common sunflower (*Helianthus annuus*), Russian thistle (*Salsola tragus*), johnsongrass (*Sorghum halepense*), and saltcedar.

The dominant shrub species in the Mesquite Shrub-Grassland vegetation community observed in the ROI is mesquite, with fewer creosotebush (*Larrea divaricata*), four-winged saltbush (*Atriplex canescens*), broom snakeweed (*Gutierrezia sarothrae*), littleleaf sensitive-briar (*Schrankia uncinata*), lotebush (*Ziziphus obstusifolia*), sand sagebrush (*Artemisia filifolia*), and narrowleaf yucca. Shrubs in this dominant community range from 2 to 7 ft (0.6–2.1 m) in height, with densities ranging from 30 percent to 70 percent and interspersed with patches of bare ground (SWCA 2010b).

Common herbaceous vegetation in the Mesquite Shrub-Grassland vegetation community found in the ROI includes common sunflower, Russian thistle, silverleaf nightshade (*Solanum elaeagnifolium*), Texas croton (*Croton texensis*), and western ragweed (*Ambrosia psilostachya*). Dominant grass species include bermudagrass, little bluestem (*Schizacharium scoparium*), plains bristlegrass (*Setaria leucopila*), sand dropseed (*Sporobolus cryptandrus*), sideoats grama (*Bouteloua curtipendula*), silver bluestem (*Bothriochloa saccharoides*), and oldfield threeawn (*Aristida oligantha*).

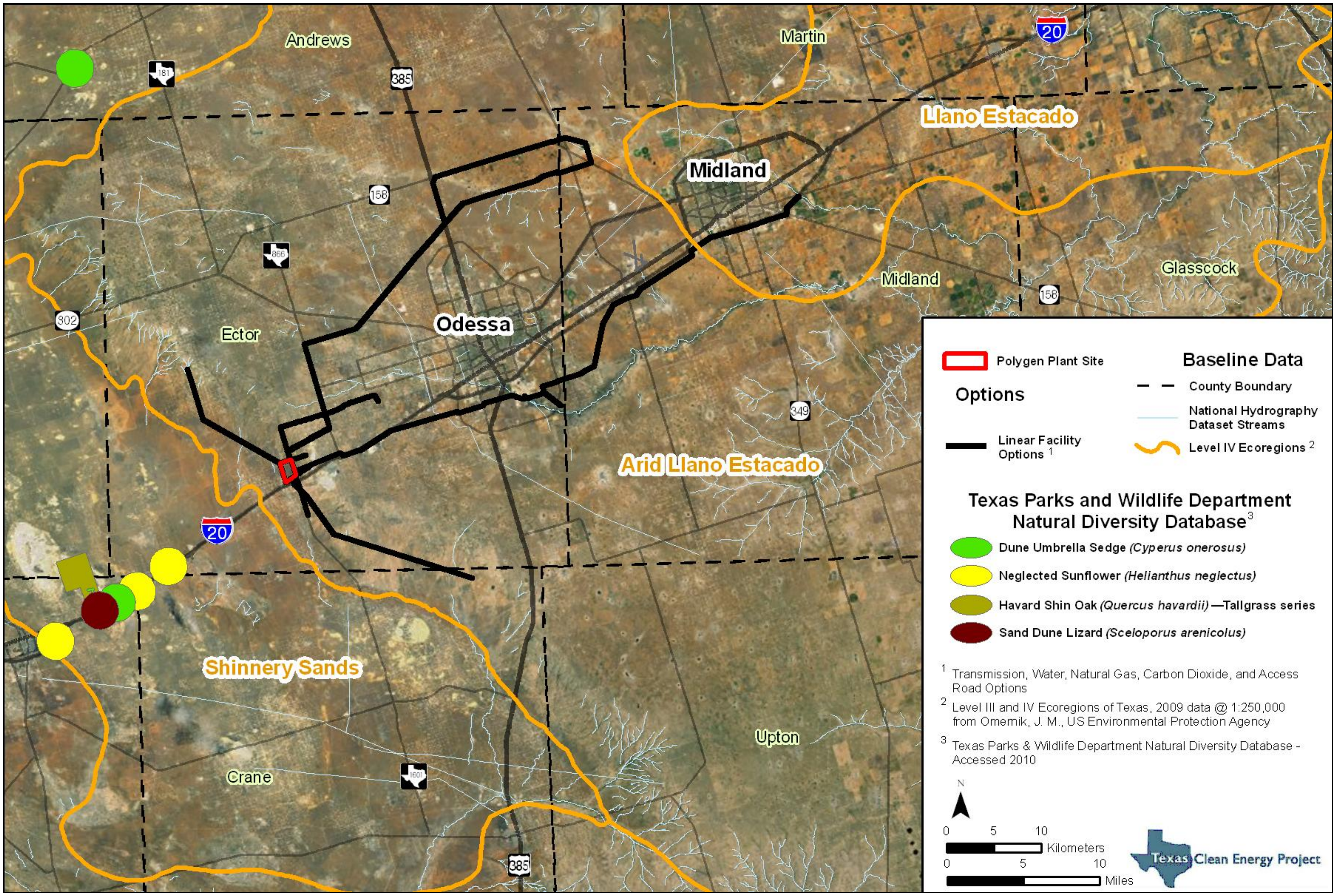

Figure 3.14. Ecoregions and Texas Parks and Wildlife Department Natural Diversity Database locations near the TCEP.

Wildlife

At least 55 species of mammals, 25 species of snakes, 11 species of lizards, 11 species of amphibians, and four species of turtles occur in the Arid Llano Estacado and Llano Estacado subregions (Garrett and Barker 1987; Schmidly 2004; Werler and Dixon 2000). More than 300 species of birds have been documented in the Arid Llano Estacado and Llano Estacado subregions (Hewetson et al. 2006; Midland Naturalists, Inc. 2010).). Because of the presence of suitable habitat in the ROI and the widespread occurrence of these wildlife species and their mobility, it is likely that they would be present in the ROI.

Common mammalian and reptilian species with potential to occur in the ROI include the nine-banded armadillo (*Daspypus novemcinctus*), coyote (*Canis latrans*), black-tailed jackrabbit (*Lepus californicus*), Brazilian free-tailed bat (*Tadarida brasiliensis*), western diamond-backed rattlesnake (*Crotalus atrox*), Texas spotted whiptail lizard (*Aspidoscelis gularis*), and ornate box turtle (*Terrapene ornate*) (Garrett and Barker 1987; Schmidly 2004; Werler and Dixon 2000). Resident avian species potentially occurring year-round in the ROI include Bewick's wren (*Thryomanes bewickii*), European starling (*Sturnus vulgaris*), great-tailed grackle (*Quiscalus mexicanus*), horned lark (*Eremophila alpestris strigata*), house sparrow (*Passer domesticus*), killdeer (*Charadrius vociferous*), mourning dove (*Zenaida macroura*), northern bobwhite (*Colinus virginianus*), northern cardinal (*Cardinalis cardinalis*), northern mockingbird (*Mimus polyglottos*), and western meadowlark (*Sturnella neglecta*) (Hewetson et al. 2006; Lockwood and Freeman 2004; Midland Naturalists, Inc. 2010).

Game mammals with potential to occur in the ROI include mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), and collared peccary (*Pecari tajacus*) (Schmidley 2004). Birds hunted as game include scaled quail (*Callipepla squamata*), Rio Grande turkey (*Meleagris gallopavo intermedia*), and white-winged dove (*Zenaida asiatica*). Feral hogs (*Sus scrofa*), a game species, occur in portions of Ector, Midland, and Crane Counties; this species is a non-native and invasive species that is a conservation threat to native vegetation and wildlife (Taylor 2003).

3.8.4.2 AQUATIC SPECIES

The proposed polygen plant site contains no wetlands, intermittent or perennial waterways, or water bodies that support aquatic species (DOE 2007; SWCA 2010b). The linear facility options intersect three water bodies/wetlands (see Table 3.15). These water features have varying quality of habitat for aquatic species (Table 3.18).

Table 3.18. Aquatic Habitat Characteristics

Water Feature	Linear Facility Option	Seasonality	Habitat Quality	Vegetation	Wildlife
Borrow Pit*	WL1	Ephemeral	Low	Unknown	Amphibians‡ Brazilian free-tailed bats‡ Swallows‡
Monahans Draw Impoundment	WL1	Perennial	Moderate	Broadleaf cattail† Saltcedar† Burningbush†	Amphibians‡ Fish‡ Northern raccoons (*Procyon lotor*) Red-winged blackbirds (*Agelaius phoeniceus*) Swallows Coyotes
Playa Lake*	WL3	Ephemeral	Low	Unknown	Amphibians‡

* Restricted access to property.
† Non-native, invasive, and/or noxious species.
‡ Common wildlife not observed, but presumed to occur due to the habitat present.

WL1 crosses a portion of a borrow pit south of the I-20 frontage road. Two culverts interconnect the borrow pit with a wetland north of the I-20 frontage road; however, DOE observed water in the borrow pit only after rain events, which indicates that the borrow pit is ephemeral and receives runoff from roadways and developments, indicating low-quality habitat for wildlife. Although DOE was unable to access this property to identify plant species, based on observation and the surrounding area, it is likely that this feature provides minimal habitat for wildlife species.

The portion of Monahans Draw that traverses WL1 primarily functions as a wetland due to a downstream impoundment that retains effluent discharge from the GCA Odessa South Facility. The continual water supply attracts wildlife in this arid habitat. Several invasive and noxious plants such as saltcedar are also found in this water feature (see Table 3.18).

During the scoping process, TPWD provided recommendations to minimize impacts to playa lakes in the project area. Playa lakes can support a diversity of wildlife species (e.g., waterfowl), protect water quality, and recharge ground water (Fish et al. 2010; Haukos and Smith 1997). DOE determined that one feature along WL3 appears to have characteristics of a playa lake. Although DOE was unable to assess this water feature because of restricted access, based on review of aerial photography it was determined that this potential playa lake is highly ephemeral. Although the quality of habitat for wildlife is low due to the surrounding land use activities, this playa may provide suitable breeding habitat for some amphibians, such as Couch's spadefoot toad (*Scaphiopus couchii*).

3.8.4.3 MIGRATORY BIRDS

The ROI occurs in the Central Flyway, a major migratory route used by birds traveling between wintering and breeding grounds. This location creates potential for a great number of migratory bird species to pass through and utilize habitat in the ROI during the spring and fall migration periods.

Regular migrants traveling through the ROI typically include the greater yellowlegs (*Tringa melanoleuca*), Forster's tern (*Sterna forsteri*), yellow warbler (*Dendroica petechia*), chipping sparrow (*Spizella passerina*), and clay-colored sparrow (*Spizella pallida*). Common migratory birds with potential to winter in the ROI include the American widgeon (*Anas americana*), common snipe (*Gallinago gallinago*), northern harrier (*Circus cyaneus*), brewer's blackbird (*Euphagus cyanocephalus*), dark-eyed junco (*Junco hyemalis*), lark bunting (*Calamospiza melanocorys*), and vesper sparrow (*Pooecetes gramineus*) (Lockwood and Freeman 2004).

Common migratory birds expected to breed in scrubland habitats similar to those in the ROI include American goldfinch (*Spinus tristis*), brown thrasher (*Toxostoma rufum*), common yellowthroat (*Geothlypis trichas*), dickcissel (*Spiza americana*), grasshopper sparrow (*Ammodramus savannarum*), horned lark, lark sparrow (*Chondestes grammacus*), long-billed curlew (*Numenius americanus*), and western meadowlark.

3.8.4.4 RARE, THREATENED, AND ENDANGERED SPECIES

The USFWS (2010) and TPWD (2010) list 13 threatened and endangered species as occurring, formerly occurring, or having the potential to occur in Ector, Midland, and/or Crane Counties. TPWD lists an additional 13 species as rare.

Based on the results of the TPWD Natural Diversity Database review (see Figure 3.14) and the field reconnaissance conducted by DOE, it was determined that the ROI provides suitable habitat for one state-listed threatened species, the Texas horned lizard (*Phrynosoma cornutum*), and 11 rare species including mammals, reptiles, and migratory birds (Table 3.19). No federally protected species are known to occur or were observed by DOE on or near the proposed polygen plant site or linear facilities (DOE 2007; SWCA 2010b). No designated critical habitat occurs in or adjacent to the proposed polygen plant site or its linear facilities. After review of the *Federally-listed Species Habitat Evaluation for the Texas Clean Energy Project in Ector, Midland, and Crane Counties, Texas* (SWCA 2010b), the USFWS concurred with DOE's assessment that no federally listed species are likely to be adversely affected by the project (see Appendix A).

In its scoping comments, TPWD listed the dune umbrella sedge (*Cyperus onerosus*) as a species of concern, although this species is not listed as threatened or endangered under state or federal law (TPWD 2010). Habitat for this species was not observed in the ROI during field reconnaissance nor does its range extend into the ROI (only into Andrews, Winker, and Ward Counties); thus, this species would not be affected by the TCEP. TPWD also listed Havard Shin Oak (*Quercus havardii*)—Tallgrass series as a natural community that could be impacted by project activities; however, this community was not observed in the ROI during field reconnaissance, nor was it identified in aerial photography. Therefore, this natural community and associated protected species (i.e., the neglected sunflower [*Helianthus neglectus*] and sand dune lizard [*Sceloporus arenicolus*]) are not expected to occur in the ROI and would not be affected by the TCEP.

Table 3.19. State-listed Rare, Threatened, and Endangered Species with Potential to Occur in the Region of Influence

Common Name (scientific name)	Listing Status*	County	Habitat Description	Potential for Occurrence in ROI	Range
Birds					
Baird's sparrow *(Ammodramus bairdii)*[†]	R	Ector Midland Crane	Occurs in shortgrass prairie with scattered low bushes and matted vegetation	Suitable habitat in ROI; very rare or rare migrant that could occur in ROI on occasion	Breeds in northern Great Plains and winters in Trans-Pecos, Mexico, and possibly South Plains; very rare to rare migrant in western half of Texas; few records from High Plains
Ferruginous hawk (*Buteo regalis*)[†]	R	Ector Midland Crane	Occurs in open country, primarily prairie, plains, and grasslands, particularly in areas with prairie dogs	Suitable habitat in ROI	Uncommon to common winter resident in High Plains and Trans-Pecos
Mountain plover (*Charadrius montanus*)[†]	R	Ector Midland Crane	Occurs in shortgrass plains and bare/plowed fields	Suitable habitat in ROI for migrating individuals	Migrant through most of West Texas; localized areas in western two-thirds of Texas as very rare summer resident and winter resident
Prairie falcon (*Falco mexicanus*)[†]	R	Ector Midland Crane	Occurs in open, mountainous areas, plains, and prairies; nests in cliffs	Suitable habitat in ROI	Rare to uncommon migrants and winter residents in the High Plains
Snowy plover (*Charadrius alexandrines*)[†]	R	Ector Midland Crane	Subspecies (Western snowy plover [*C.A. nivosus*]) is also listed as rare; occurs in flat sandy beaches, salt flats, sandy areas with little vegetation, saline lakes, and major rivers	Suitable habitat in ROI for migrants and summer residents	Migrant throughout the High Plains; uncommon summer resident in portions of Midland County and surrounding counties to northeast
Western burrowing owl (*Athene cunicularia hypugaea*)[†]	R	Ector Midland Crane	Occurs in open grasslands, especially prairie, plains, and savanna, sometimes in vacant lots or airports, particularly in areas with prairie dogs	Suitable habitat in ROI, particularly in areas with prairie dogs	Uncommon to common summer resident and uncommon to rare winter resident in western half of state; rare to very rare migrant and winter visitor farther east and south to coastal prairies

Table 3.19. State-listed Rare, Threatened, and Endangered Species with Potential to Occur in the Region of Influence

Common Name (scientific name)	Listing Status*	County	Habitat Description	Potential for Occurrence in ROI	Range
Mammals					
Big free-tailed bat	R	Crane	Prefers roosting in cracks and crevices in high canyon walls, but also known to roost in buildings; rugged, rocky country in both lowlands and highland habitats	No suitable rocky cliffs for roosting, but suitable buildings are near ROI; individuals could fly over ROI, but are not expected to occur	West and South Texas
Black-tailed prairie dog (*Cynomys ludovicianus*)	R	Ector Midland Crane	Lives in large family groups in dry, flat, short grasslands with low, relatively sparse vegetation, including areas overgrazed by cattle	Suitable habitat in ROI	West and western-central Texas
Pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens*)	R	Ector Midland Crane	Occurs in habitats ranging from desert scrub to piñon-juniper woodlands characterized by rocky, broken country; roosts in caves, mines, and occasionally buildings	No caves or mines located near ROI; could roost in buildings or fly over ROI	West Texas
Swift fox (*Vulpes velox*)	R	Ector Midland	Prefers shortgrass prairie, mesa country along borders of valleys, sparsely vegetated habitats on sloping plains, hilltops, and other well-drained areas; adapted to pasture, plowed fields, and fencerows	Potential to occur in ROI; closest record in TPWD Natural Diversity Database is approximately 11 mi (17.7 km) northeast of WL1	West Texas

Table 3.19. State-listed Rare, Threatened, and Endangered Species with Potential to Occur in the Region of Influence

Common Name (scientific name)	Listing Status*	County	Habitat Description	Potential for Occurrence in ROI	Range
Reptiles					
Spot-tailed earless lizard (*Holbrookia lacerata*)	R	Ector Midland Crane	Inhabits moderately open prairie-brushlands with fairly flat areas free of vegetation and other obstructions, including disturbed areas	Suitable habitat in ROI	Central (Edwards Plateau) and south-western Texas
Texas horned lizard	T	Ector Midland Crane	Open, arid and semiarid regions with sparse vegetation, including grass, cactus, scattered brush, or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March to September	Suitable habitat in ROI; individuals observed at the polygen plant site and near WL1 along Monahans Draw	Currently restricted to the western third of Texas

Note: No federally listed species are known to occur in the ROI.
Sources: Bockstanz and Cannatella (2000); Lockwood and Freeman (2004); Poole et al. (2007); Schmidly (2004); TPWD (2010); USFWS (2010).
* TPWD listing designation: T =Threatened; R = Rare.
† Rare species that are also protected under the Migratory Bird Treaty Act.

3.8.5 Environmental Impacts of Summit's Proposed Project

3.8.5.1 TERRESTRIAL SPECIES

Polygen Plant Site

Construction and operation of the polygen plant would result in the permanent loss of up to 300 ac (121.4 ha) of the Mesquite Shrub-Grassland vegetation community and its associated habitat functions for terrestrial species. This habitat is neither rare nor unique in the ROI for the polygen plant. Construction activities could result in direct mortality of those terrestrial wildlife species that are not mobile enough to escape construction equipment. In addition, construction vehicles, equipment, and human traffic could unintentionally disperse seeds of invasive or noxious species, which could encroach into adjacent lands or natural areas. Both plant and wildlife invasive and noxious species can outcompete native species, lower biological diversity, and alter ecosystem function.

Scoping comments inquired about potential impacts to wildlife from the storage and use of coal at the polygen plant site. Inadequately mitigated air emissions and dust can inhibit plant function and growth (Zeiger 2006), which can indirectly impact wildlife through loss and/or degradation of food, shelter, and nesting areas used by wildlife, or result in bioaccumulation of Hg in insects, birds, and mammals (Colman 2007). As described in Chapter 2 and in the air quality section (Section 3.3), coal-handling facilities would be designed to minimize emissions of coal dust, and the TCEP would be designed to remove more than 95 percent of Hg emissions. In compliance with Texas House Bill 460, the TCEP would be required to meet stringent air pollutant emissions limits. Modeling of the air pollutant emissions indicate that ambient air quality for all priority pollutants would be less than the NAAQS primary and secondary standards, which have been developed to protect human health and the environment, and that there would be minimal effects to soils, water, crops, vegetation, and wildlife as a result of the TCEP. Thus, the TCEP would likely have minimal effects on wildlife from the storage and use of coal.

Noise from construction activities at the polygen plant site could result in physiological (e.g., loss of hearing) and behavioral (e.g., communication or nesting) disturbances that could displace or alter the behavior of wildlife. This displacement would be permanent on-site and temporary adjacent to the site until construction is complete or until wildlife could habituate to the noise. Most project construction noise would attenuate to near-background levels within approximately 0.5 mi (0.8 km) (see Section 3.19, Noise and Vibration), indicating that disturbance of wildlife could occur over a maximum of 2,388 ac (966 ha) surrounding the polygen plant site. Temporary interruptions in normal wildlife behavior from construction noise are likely to have minimal impacts on reproductive success, thus resulting in few overall population level effects (AMEC Americas Limited 2005; Richardson et al. 1995). In addition, wildlife in the polygen plant site ROI would not likely notice a substantial noise level increase during regular construction activities due to the existing ambient noise levels from vehicular traffic on I-20 and oil and gas activities (see Section 3.19). Although intermittent high noise-level activities (e.g., steam venting) during construction could have adverse impacts to wildlife, these increases from regular construction noise would be brief and infrequent, indicating that overall impacts from construction noise would be minor.

Although the most acute effects would result from construction noise, less-intense operational noise disturbances would persist for the life of the project. As previously noted, disturbances from I-20 and oil and gas activities currently exist, indicating that wildlife in the ROI are habituated to existing noise disturbances. In addition, wildlife such as deer, rabbits, raptors, and songbirds are known to be resilient and adaptable to the noise levels that would likely occur during TCEP operation (see Section 3.19), based on observations at airport sites (AMEC Americas Limited 2005; Busnel 1978; Ellis et al. 1991 in AMEC Americas Limited 2005). Therefore, most wildlife would not likely be adversely affected by either temporary acute noise from construction or less-intense, long-term noise from operation of the polygen plant.

Linear Facilities

The primary direct impacts to terrestrial species from construction and operation of the linear facilities would be the removal or disturbance of the Mesquite Shrub-Grassland vegetation community and the wildlife species that are associated with it. Vegetation could be permanently removed from 132 to 574 ac (53–232 ha), and could be temporarily removed from or disturbed on an additional 114 to 543 ac (46–220 ha) during construction. The range in vegetation removal is based on the smallest and largest acreage combinations of the linear facility options as identified in Table 3.20. These impact areas from both construction and operational activities are based on the conservative assumption that all areas are currently vegetated; however, there are several developed areas along the linear facilities where vegetation does not occur or where vegetation would not be impacted (e.g., portions of transmission lines).

Table 3.20. Impacts to Terrestrial Habitat from the Linear Facility Options

Linear Facility Option	Temporary/ Construction Impact Area (ac [ha])	Permanent/ Operational Impact Area (ac [ha])	Potential Noise Disturbance Area (ac [ha])*	Total Length (mi [km])
WL1	508.5 (205.8)	256.5 (103.8)	26,650 (10,784.9)	41.2 (66.3)
WL2	113.5 (45.9)	57.2 (23.1)	6,456 (2,612.7)	9.3 (15.0)
WL3	172.4 (69.8)	86.6 (35.0)	9,568 (3,872.0)	14.2 (22.8)
WL4	41.0 (16.6)	23.2 (9.4)	2,184 (883.8)	2.7 (4.3)
TL1	116.6 (47.2)	60.6 (24.5)	6,379 (2,581.5)	9.3 (15.0)
TL2	117.8 (47.7)	65.5 (26.5)	5,950 (2,407.9)	8.6 (13.8)
TL3	31.5 (12.7)	18.0 (7.3)	1,935 (783.1)	2.2 (3.5)
TL4	11.7 (4.7)	8.1 (3.3)	893 (361.4)	0.6 (1.0)
TL5	459.2 (185.8)	236.2 (95.6)	23,973 (9,701.5)	36.8 (59.2)
TL6	455.5 (184.3)	212.0 (85.8)	21,413 (8,665.5)	32.8 (52.8)
CO_2	12.2 (4.9)	6.1 (2.5)	1,151 (465.8)	1.0 (1.6)
NG1	32.9(13.3)	16.5 (6.7)	2,257 (913.4)	2.7 (4.3)
AR1	5.0 (2.0)	2.9 (1.2)	721 (291.8)	0.3 (0.5)
AR2	58.0 (23.5)	35.5 (14.4)	2,882 (1,166.3)	3.7 (6.0)
RR1	13.4 (5.4)	6.7 (2.7)	1,266 (512.3)	1.1 (1.8)

* Area based on 0.5-mi (0.8-km) buffer.

Transmission line construction would require vegetation clearing for installation of the transmission structures and for limited-access road construction. Native vegetation that would not interfere with the safe operation of the transmission lines would remain undisturbed between the transmission line structures. Process water, CO_2, and natural gas pipeline construction would require the clearing of most vegetation in the construction ROW. Following construction, both the construction and operational ROWs would be reseeded with native vegetation. However, because of the need for visual inspection of pipelines, it is likely that ROW maintenance activities along the pipeline ROWs would not include the establishment of woody species such as mesquite. Access road construction would require the clearing of most vegetation in the construction ROW and permanent removal in the operational roadway ROW.

Invasive and noxious plant species could invade disturbed areas during construction and operation of the linear facilities. The relative level of possible impact associated with each option is indicated by the length of the linear facility, as identified in Table 3.20.

Construction noise (e.g., vehicular traffic, construction activities) may temporarily displace wildlife during construction of the linear facilities. However, this impact is expected to be minimal because displaced wildlife would quickly return after construction activities ceased. Furthermore, a number of the linear facilities would be located in areas of existing commercial, industrial, and residential development where comparable noise impacts already occur routinely (see Table 3.27). Table 3.20 shows the maximum area of wildlife habitat anticipated to be affected by noise during construction of each linear option. The area affected is based on the assumption that construction noise would largely attenuate to background levels within 0.5 mi (0.8 km) of linear facilities.

Wildlife fatalities from traffic collisions could also occur during plant construction and operation. The number of wildlife fatalities would likely increase due to the introduction and use of approximately 4.0 mi (6.4 km) of new access roads (AR1 and AR2) as well as the increased use of existing roads. As discussed in Section 3.16, AADT would significantly increase on I-20, FM 866, and FM 1601 during peak construction (18 percent, 193 percent, and 750 percent of current traffic, respectively [see Table 3.48]). However, the increase in AADT on these roads would be more modest during operations (2 percent, 22 percent, and 75 percent of current traffic, respectively [see Table 3.49]). Vehicle speed has a greater impact to the number of wildlife fatalities than the volume of traffic (Case 1978), indicating that wildlife fatalities due to traffic collisions could be minimized with speed regulation.

Bird and bat mortalities from collisions with man-made structures such as transmission lines and towers could occur during operation of the TCEP. Approximately 14 percent of predicted annual avian mortality comes from collisions with transmission lines, which is low when compared to almost 60 percent mortality occurring from collisions with buildings or windows (Erickson et al. 2005). Although bat collisions with transmission lines are known to occur, little is known about the extent of these fatalities (Dedon et al. 1989 in WEST Inc. 2003). In general, any transmission line option would increase the risk of bird and bat mortality due to the introduction of a new hazard in the flyway. The potential for mortality increases with the length of the line, indicating the longest option (TL5) would pose the greatest risk, whereas the shortest transmission line (TL4) would pose the least. In areas where existing transmission lines would parallel TCEP's line (TL1, TL2, TL5, TL6), there would be a greater visual detection, which helps to reduce the potential for bird collisions (Avian Power Line Interaction Committee 2006). There would be anticipated collisions associated with newly constructed lines; however, bird collisions with transmission lines are not considered to be a substantial source of bird mortality (URS Corporation 2005). Furthermore, none of the transmission lines would occur near major flight or feeding corridors, natural drainages, riparian habitats, wetlands, or water bodies, which are considered to be high-risk areas for collisions of birds and bats with transmission lines (Faanes 1987). Thus, all transmission line options would have low impact to wildlife.

3.8.5.2 AQUATIC SPECIES

Polygen Plant Site

As described in the surface water resources section (Section 3.7), no intermittent or perennial waterways or aquatic habitat of any kind are present on the polygen plant site. There would be no off-site waste water discharges and storm water would be diverted to on-site retention ponds. Compliance with TPDES permit requirements and SPCC plans would minimize off-site discharge or erosion that could impact downstream aquatic habitat.

Linear Facilities

Only WL1 and WL3 would have the potential to impact aquatic species due to the removal and disturbance of vegetation and aquatic habitat. Table 3.21 presents the total impacts to aquatic habitat during construction and the permanent disturbance areas following the reclamation of temporary use areas for these linear facility options.

Table 3.21. Impacts to Aquatic Habitat from the Linear Facility Options

Linear Facility Option	Total Temporary/Construction Impacts (ac [ha])	Total Permanent/Operational Impacts (ac [ha])
WL1	1.58 (0.64)	0.81 (0.33)
WL3	0.58 (0.23)	0.30 (0.12)
Total	**2.16 (0.87)**	**1.11 (0.45)**

Indirect impacts from linear facilities would include an increased potential for downstream siltation, risk of fluid spills or leaks, and noise during construction. Adverse effects to the water quality of these features would be minimized as long as erosion and siltation controls are implemented in accordance with EPA and TCEQ requirements.

WL1 would be constructed underneath Monahans Draw and would be constructed using erosion and siltation controls to minimize potential impacts to water quality and aquatic organisms. However, during the two- to three-week construction period, there would be an increased potential for water-quality degradation and impacts to aquatic organisms including amphibians and macroinvertebrates. Because WL1 would be installed underneath Monahans Draw, there would be no operational impacts associated with this pipeline. WL3 is the only linear facility that would directly impact the potential playa lake identified in the ROI (see Table 3.18).

3.8.5.3 MIGRATORY BIRDS

Polygen Plant Site

Consultation with the USFWS and TPWD did not identify any migratory bird populations that would be affected by the project (DOE 2007; SWCA 2010b). Approximately 300 ac (141 ha) of potential migratory bird habitat, including shrubland nesting areas, would be permanently removed by development of the polygen plant site. In addition, introduced species commonly associated with development (e.g., European starlings, house sparrows) could encroach into the ROI and displace or outcompete native bird species (Elphick et al. 2001; Koenig 2003). Human activities such as maintained landscaping and open trash receptacles attract these bird species to the area.

Migratory birds would face similar indirect impacts as described in Section 3.8.5.1, including impacts from noise and other disturbances. Birds could also be attracted to the solar evaporative ponds, if that option is implemented, and suffer adverse impacts from the brine contained in those ponds. Netting placed over the ponds would mitigate that potential impact. However, no rare or unique habitats, water resources, or other features that would be a significant attractant to migratory birds were identified on the polygen plant site. For this reason, no adverse effects would be expected at the population or community level.

Linear Facilities

Habitat loss for migratory birds could occur from the construction and operation of some of the linear facility options. The total acreage of habitat loss would vary by linear facility option (see Table 3.20). In areas adjacent to the linear facilities, disturbance from construction and operational noise could displace migratory birds or negatively affect their reproductive success until they habituate. Aquatic features along the linear facilities, particularly Monahans Draw, are likely an attractant to migratory birds; however, impacts to these features would be temporary (completed within two to three weeks). Although there could be collisions associated with the addition of a transmission line, no rare or unique habitat or attractants (e.g., wetlands, water bodies, or major feeding flight lines) are present along any of the transmission line options. Therefore, construction and operation of the linear facilities would present only minor impacts to migratory birds.

3.8.5.4 RARE, THREATENED, AND ENDANGERED SPECIES

Polygen Plant Site

A permanent loss of 300 ac (121 ha) of Texas horned lizard habitat as well as potential habitat for 11 state-listed rare species would occur due to the construction and operation of the polygen plant site. In addition, fatalities of Texas horned lizards and their prey (red harvester ants [*Pogonomyrmex barbatus*]) and 11 state-listed rare species (see Table 3.19) could occur during construction and operational activities if these species are present on the proposed polygen plant site. These species could face similar indirect impacts as described in Section 3.8.5.1, including impacts from noise and other disturbances.

Impacts from construction and operation of the polygen plant would be more adverse for Texas horned lizards than for more mobile species such as ferruginous hawks or burrowing owls. Rare migrant and resident species that may be present on the polygen plant site have ranges that extend throughout the Arid Llano Estacado and Llano Estacado subregions (see Table 3.19), thus any impacts to these species attributable to the TCEP would have minimal adverse effects to population viability.

Linear Facilities

Habitat loss for the threatened Texas horned lizard and 11 state-listed rare species could occur from the construction and operation of some of the linear facility options. The total acreage of habitat loss would vary by linear facility option (see Table 3.20). Fatalities of Texas horned lizards, their prey (harvester ants), and state-listed rare species could occur during construction of the linear facilities. Impacts to these species during operation of the buried pipelines would be unlikely, and impacts associated with operation of transmission lines would be primarily limited to maintenance activities where vehicles and workers would be in the field, and to bird collisions with power lines. Transmission line options that parallel existing transmission lines are more visually apparent to birds (Avian Power Line Interaction Committee 2006). Furthermore, none of the transmission lines would occur near major flight or feeding corridors, natural drainages, riparian habitats, wetlands, or water bodies, which are considered to be high-risk areas for collisions of birds with transmission lines (Faanes 1987). Thus, the transmission lines would have minimal adverse effect on birds. Overall, potential impacts to Texas horned lizards would be greater than other listed wildlife species, because of their decreased mobility.

3.8.6 Mitigation

Mitigation measures that Summit would implement as part of the construction and operation of the TCEP are described in Section 2.5. Additional mitigation measures that Summit could implement or that DOE could require as a condition of approval to further reduce impacts to biological resources are:

- Planting or seeding areas disturbed by the construction or operation of the TCEP with native vegetation to provide habitat for wildlife.
- Developing a monitoring and control plan; inspecting and cleaning construction equipment; using invasive species–free mulches, topsoil, and seed mixes; planting native species after construction and as landscaping; and using chemical and mechanical eradication of non-native or invasive species if they develop in the ROI to reduce the potential for the introduction or spread of non-native or invasive species (Bureau of Land Management [BLM] 2009; Federal Highway Administration 1999).
- Performing construction activities outside the breeding season for migrating birds, including western burrowing owls and ferruginous hawks.
- Conducting threatened and endangered species surveys in the proposed polygen plant site and along the linear facility corridors to minimize or avoid impacts to these species. Summit will also consult further with TPWD regarding Texas horned lizards prior to construction. TPWD specifically recommends the following mitigation measures be implemented to protect Texas horned lizards:
    - A permitted biologist should conduct Texas horned lizard surveys at the polygen plant site and along the linear facility corridors prior to construction. If found, individual lizards should be relocated to areas outside the construction area.
    - During construction and operation of the linear facilities, Summit should take measures to eradicate the red imported fire ant (*Solenopsis invicta*), a species that outcompetes Texas horned lizard prey species (red harvester ants). Eradication techniques should include spot applications of pesticides rather than broadcast applications of pesticides, which can kill Texas horned lizards and their prey.
    - To the extent practicable, Summit should avoid construction activities within 10 ft (3 m) of red harvester ant colonies along the linear facilities.
- Avoiding playa lakes and other water resources, or restoring temporarily affected water resources to their original condition.
- Constructing new transmission lines or modifying existing transmission lines to recommended industry and federal standards to reduce avian mortality from transmission lines. These could include increasing the visibility of lines with marker balls or similar devices, removing overhead grounding wire, and providing a 60-in (152-cm) separation between energized conductors (Avian Power Line Interaction Committee and USFWS 2005).
- Directing TCEP workers and contractors to drive below certain speeds while driving along the access roads to reduce the risk of wildlife fatalities.

Placing netting over solar evaporation ponds, if Summit implements this option, to minimize the risk of birds landing in them and being exposed to the concentrated brine water.

3.9 Aesthetics

3.9.1 Background

This section identifies and describes the aesthetic resources of the viewed landscape that could be affected by the construction and operation of the polygen plant and linear facilities. This section also presents the environmental impacts of the proposed project and the No Action Alternative. Additional mitigation measures that could be implemented to further reduce potential adverse consequences are presented.

Aesthetic resources include scenic areas, such as state and municipal parks, and viewpoints. In this analysis, aesthetics refers to the pleasing visual characteristics or features of the landscape, and consists of 1) areas containing visual resources, and 2) scenic viewsheds. Landscapes managed by federal, state, and local governments and that have visual resources may be protected for their scenic quality. These areas have been identified as having higher natural aesthetic values. Viewsheds are the landforms, water bodies, man-made structures, and other landscape elements that are seen from a fixed viewpoint. Scenic viewsheds are those landscapes that may have aesthetic value to a community and to residents that view them, or to commuters and other travelers that pass through them.

The night sky is also a component of aesthetics. The quality of the night sky view relates to the quantity of artificial light in the viewshed. Outdoor lighting can affect the view and the enjoyment of a natural, dark night sky where stars, planets, and the moon can be best observed. Light pollution can be created by the upward spill of light from an unshielded light source. Dust, water vapor, and other particles scatter and reflect light directed upward into the atmosphere, creating a phenomenon called skyglow. This light that escapes directly upward into the night sky is a major contributor to the loss of the dark night sky.

3.9.2 Region of Influence

The ROI for aesthetics is the 743-mi^2 (1,924-km^2) viewshed around the polygen plant site (Figure 3.15). This is the area from which the 200-ft-tall (61-m-tall) emissions stack at the polygen plant site could be seen within a 50-mi (80-km) radius.

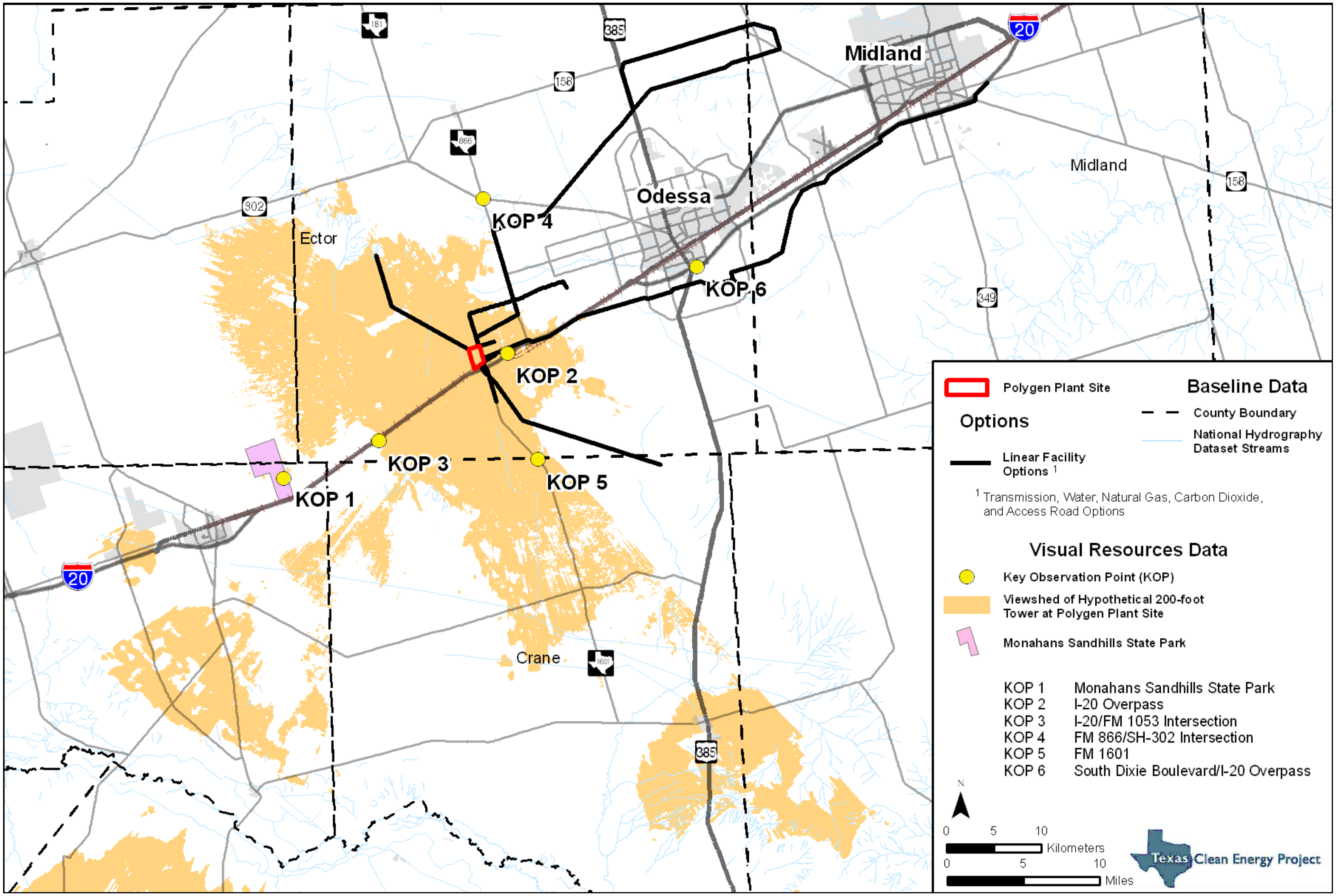

Figure 3.15. Key observation point locations.

3.9.3 Methodology and Indicators

The impacts analysis for aesthetic resources used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. Potential impacts and their indicators are shown in Table 3.22.

Table 3.22. Indicators of Potential Impacts to Aesthetic Resources

Potential Impact	Impact Indicator
Reduction in scenic quality from surface disturbances	Viewing distance to and angle of the project area Length of time project area is in view, as seen from the selected view points Expected viewer sensitivity to changes in the landscape
Reduction in scenic quality from fugitive dust production in disturbed areas	
Reduction in scenic quality from visually disruptive infrastructure (transmission lines) or equipment	
Reduction in night sky scenic quality from skyglow and visual intrusion from night lighting	

The analysis applied to aesthetics for the TCEP is based on the BLM Visual Management System. Using this system, the aesthetics of existing viewsheds and visual resources in and around the area that would be affected by the TCEP (the existing conditions) were compared to what those same viewsheds and resources would look like after TCEP construction. The comparison was conducted from fixed viewpoints known as key observation points (KOPs) (Table 3.23; see Figure 3.15). Typically, KOPs are located along hiking trails and roads or highways, at scenic viewing areas, in parks, and in communities where the project area would be in view.

Table 3.23. Key Observation Points Analyzed

KOP	Name	Location Relative to Proposed Polygen Plant Site (mi [km])	Basis for Selection
KOP 1	Monahans Sandhills State Park	14.8 (23.8) southwest	Is a popular sightseeing destination
KOP 2	I-20 overpass	1.6 (2.4) east	Is the boundary of a topographic break with unobstructed views of proposed polygen plant site
KOP 3	I-20/FM 1053 (Fort Stockton Road) intersection	7.8 (12.6) southwest	Is representative of highway corridor viewshed for eastbound motorists
KOP 4	FM 866/State Highway 302 intersection	9.6 (15.4) north	Has views of landscape along two secondary roads near Odessa
KOP 5	FM 1601	7.5 (12.1) southeast	Shows existing aesthetic conditions along proposed water pipeline ROW alternatives that parallel FM 1601
KOP 6	South Dixie Boulevard/ I-20 overpass	15.2 (24.5) northeast	Shows the viewshed within Odessa city limits

As shown in Table 3.23, DOE identified six KOPs to analyze the potential impacts to aesthetic resources near the proposed polygen plant site and linear facilities. The locations of these KOPs are shown in Figure 3.15. Note that the areas in the figure that depict the 200-ft (61-m) stack visibility area were computer-calculated, based on whether local topography would block a line-of-sight view of the stack. It does not account for Earth curvature, heat shimmer, or atmospheric haze. It also does not account for potential structural blocking of the stack by buildings, roadways, vegetation, or other site-specific features. The purpose of the visibility information is to approximately define where the proposed site might be regionally visible under ideal conditions.

These KOPs were selected as representative views of the affected area and surrounding landscape. They were selected on the basis of factors such as the number of viewers that would see the project area, the length of time that the project area would be in view, the angle of view, the viewing distance to the project area, and viewer sensitivity. Viewer sensitivity is the importance or concern that people place on any changes that might occur to a viewshed or an area with visual resources.

The **Odessa Meteor Crater** is a national natural landmark located 6.5 mi (10.4 km) southeast of the proposed project area. The site includes a visitor center, picnic area, and a short walking path through the meteor crater. Though relatively close to the project area, this site was not used in the analysis of impacts to aesthetics because of its very small size and low visitor use and because the construction and operation of the TCEP would not affect its goal of preserving a unique geologic feature.

During the visual resource field survey, the viewshed to the northwest of the proposed project area was considered for potential analysis and identification of KOPs. However, based on the criteria or indicators used to establish the KOPs, none were identified because of the relative remoteness of the area, the distance from the project area, the few residences or communities in the area, and the relatively low traffic volume along State Highway 302.

Once the KOPs for the TCEP were selected, the scenic resources and existing conditions in and around the project area were described from those selected viewpoints. The descriptions included the landforms and water features, vegetation, landscape colors, roads, and structures that can be seen from each viewpoint. A panoramic series of photographs were taken from each KOP to document the scenic resources (such as parks) and scenic viewsheds that can be seen from each viewpoint.

Once the scenic resources and scenic viewsheds were described and documented at each KOP, a description of the proposed project was used to create a computer-generated visual simulation of what the project would look like from each KOP. This approach shows the scale of the project and the relative placement of potential aesthetics-disturbing project features. The image was then used to determine the degree to which impacts would affect the area's aesthetics, as seen from each KOP. The potential impacts of the project were described using the same terms used for describing the existing conditions: what the landforms, water features, roadways, and other existing structures, vegetation, and landscape colors would look like if the project was constructed. By comparing the aesthetic existing conditions to future conditions (through the use of the simulation), it is possible to gauge the level of scenic resource and scenic viewshed change.

3.9.4 Affected Environment

> The **visual resource management system** consists of a scenic quality evaluation, sensitivity level analysis, and a delineation of distance zones, which are divided into four classes that represent the relative value of the visual resources: Classes I and II are the most valued, Class III represents a moderate value, and Class IV is the lowest value.

Based on the level of existing development in the area, highly visible oil and natural gas extraction pumps, the visibility of roadways and railways, clearly visible surface disturbance along the highway corridor, and the flat landscape lacking obvious scenic contrasts in the KOP viewing areas, the scenic quality surrounding the polygen plant would be comparable to the BLM visual resource management Class IV. This classification applies to landscapes that have relatively low scenic quality, and are managed to allow high levels of change where management activities dominate the view and may be a major focus of viewer attention (BLM 1986). Figure 3.15 shows the locations of the KOPs selected for the TCEP.

3.9.4.1 SCENIC RESOURCES

Key Observation Point 1: Monahans Sandhills State Park

The Monahans Sandhills State Park is approximately 14.8 mi (23.8 km) southwest of the proposed polygen plant site. It consists of more than 3,800 ac (1,538 ha) of sand dunes. Some of the dunes are more than 70 ft (21 m) high, and park visitors who climb to the dune tops have an unobstructed view of the surrounding landscape (Figure 3.16). The park is a popular sightseeing destination, with outdoor activities that include dune surfing, self-guided nature trails, camping, and bird and wildlife viewing. The park topography is diverse, steep, and unstable, and typical of a windblown dune landscape. The park roadways, camping sites, and buildings lie at the base of the dunes, so the surrounding landscape is obscured by the height of the sand dunes.

Figure 3.16. Monahans Sandhills State Park, view facing northeast.

Views from the top of the dunes extend to the horizon and show the dune area continuing across the foreground (within 0.5 mi [0.8 km] of the KOP 1 viewpoint) and a flat landscape in the middle distance (from 0.5 mi [0.8 km] to 5.0 mi [8.0 km] from the viewpoint) and background (beyond 5.0 mi [8.0 km] from the viewpoint). The view in Figure 3.16 is to the northeast, toward the proposed polygen plant site. The predominant colors are tan and beige sand as well as dark and light green vegetation in the dune area and in the middle ground and background. Numerous but faintly visible power transmission lines are present to the northeast and southeast (see Figure 3.16).

The night sky conditions in and surrounding the park are generally unaffected by artificial light sources because of the lack of development in the immediate area. Vehicles parked or moving in the campground create some light, but there are no light poles or beacons along park roadways, nor are there lights in parking lots or visitor use areas to illuminate the roads, signs, access paths and trails, or parking areas.

3.9.4.2 SCENIC VIEWSHEDS

<u>Key Observation Point 2: Interstate 20 Viewshed (west view)</u>

The KOP 2 viewpoint lies along the I-20 shoulder approximately 1.6 mi (2.5 km) to the east of the proposed polygen plant site and the community of Penwell. The outskirts of the town lie just beyond the left edge of the photograph in Figure 3.17. The viewshed includes views of the topographic basin to the west and northwest (from this perspective the polygen plant would be located to the west), and views to the north, west, and south where motorists would see the landscape while travelling west on I-20. The viewpoint was selected because it lies at the boundary of a topographic break, where the landscape changes from flat in the east to a relatively lower elevation to the west. The shallow though rapid elevation change would quickly expose the proposed polygen plant site to unobstructed views by westbound motorists traveling along I-20. Foreground views are of access roads and railway lines, power lines, small commercial structures, and residences along the highway corridor. Middle ground and background views to the north and west show a homogeneous landscape with a sparse scattering of power lines, telecommunications towers, and indistinct structures. The landscape includes sparse lines of trees along secondary roadways in the foreground and middle ground, but views in all directions are unobstructed from this perspective. Landscape colors are various shades of green vegetation, brown areas of surface disturbances and exposed rock along unpaved roads and railroad beds, and miscellaneous bright colors on roadway signs, road shoulders, roadway support structures, and buildings.

Figure 3.17. Westbound viewshed along Interstate 20 near the proposed polygen plant site.[2]

Night sky conditions along the interstate travel corridor are presently affected by commercial and industrial lighting, highway lighting, and motor vehicles. The community of Penwell was not used as a KOP because it did not meet the criteria for KOP selection. Penwell is largely abandoned or vacant, with the exception of a few scattered residences within the community's limits and in proximity to I-20. KOP 2, however, is located very close to this community, is along the freeway, and provides a representative view of what Penwell residents would see. Note that one of the main criterion for selecting KOPs was number of potential viewers, which would be more heavily weighted toward freeway motorist viewers (with approximately 16,000 vehicles per day (vpd) traveling along this major transportation corridor) than the very small residential population in Penwell.

Key Observation Point 3: Interstate 20 Viewshed (East View)

The KOP 3 viewpoint is located at the junction of I-20 and FM 1053. The view is to the northeast toward the proposed project area. The topography is gently inclined but relatively flat, and similar to the surrounding landscape, as shown in Figure 3.18. This perspective is representative of the highway corridor viewshed for motorists traveling eastbound along I-20 toward Odessa and the proposed polygen plant site, and for motorists traveling north along FM 1053 as they approach the FM 1053/I-20 intersection. The viewpoint is approximately 7.8 mi (12.5 km) southwest of the project area, slightly elevated above the highway at the FM 1053 overpass. This point was selected because motorists traveling north along FM 1053 would have lengthy approaching views of the project area, as would eastbound motorists traveling along I-20, and the number of potential viewers along both highways would be large.

[2] The image is a cropped version of the simulation panorama shown in Figure 3.22, and the community of Penwell lies just outside the view, to the left of this photograph.

Figure 3.18. Eastbound viewshed along Interstate 20 at the junction with Farm-to-Market Road 1053.

Foreground and middle ground views are of the highway corridor, railroad embankments, high-voltage transmission lines, road signs, and road lighting poles. Surface disturbances and sparse vegetation growth along the highway corridor have exposed rock and soil. Lines of trees and clumps of shrubs are visible in the foreground. Viewshed colors range from buff and browns where soil and rock have been exposed, to shades of light to dark green where grasses, shrubs, and trees are visible. Background views are obscured by the slight depression of the highway at the viewpoint. No commercial or residential structures are visible.

Night sky conditions are presently affected in this locale by motor vehicles traveling along the interstate and along secondary roads. There are few other light sources.

Key Observation Point 4: Intersection of Farm-to-Market Road 866 and State Highway 302 Viewshed

This intersection lies approximately 9.6 mi (15.5 km) north of the proposed polygen plant site, and was selected because it provides representative views of the landscape along two secondary roadways near Odessa. The view is to the southwest toward the project area. As shown in Figure 3.19, the topography in this viewshed is uniformly flat, and the view is uninterrupted and extends to the horizon. The foreground to background view is of a rural landscape, with some evidence of surface disturbance and development: oil pump jacks are visible in the foreground, and high-voltage power lines, towers, and poles can be seen in the foreground, middle ground, and background. Lines of trees are visible in the middle ground. Landscape colors are limited to shades of green vegetation interspersed with tan and light brown where rock and soil have been exposed by surface disturbances.

Figure 3.19. Farm-to-Market Road 866 and State Highway 302 intersection viewshed.

Night sky conditions are affected by motor vehicles traveling along the road. The roadway is unlit, and there are few artificial light sources along the roadway corridor.

Key Observation Point 5: Farm-to-Market Road 1601 Viewshed

The KOP 5 viewpoint along FM 1601 was selected because it shows existing aesthetic conditions near a proposed waterline (WL3). This viewpoint is located approximately 7.5 mi (12 km) southeast of the proposed polygen plant site, and the view is east toward the proposed waterline routes. As shown in Figure 3.20, the topography is relatively flat to undulating in the foreground and middle ground, with very low ridges visible in the background. The view is uninterrupted and extends to the horizon. The predominant features in the viewshed are dense growths of scrubby trees and shrubs in the foreground and middle ground that, with the undulating landscape, tend to obscure the ground surface. Colors range from light to dark green vegetation with occasional patches and streaks of light brown where exposed soil is visible. Power transmission towers are visible in the background, as are indistinct views of buildings and other structures.

Figure 3.20. Farm-to-Market Road 1601 viewshed.

Night sky conditions are affected by motor vehicles traveling along the road. The roadway is unlit, and there are few artificial light sources along the roadway corridor.

Key Observation Point 6: South Dixie Boulevard and Interstate 20 Overpass Viewshed

The KOP 6 viewpoint, in the city of Odessa, lies approximately 15.2 mi (24.5 km) northeast of the proposed project area, and was selected to show the viewshed from within the city limits. The view is to the west, toward the proposed polygen plant site, along I-20. As shown in Figure 3.21, the view is dominated by typical residential, commercial, and industrial development along a major interstate travel corridor as it passes through a population center. The topography is flat, with views extending to the horizon. The viewshed foreground includes the interstate roadway and infrastructure, small commercial and business buildings, secondary roads, residences, power transmission lines, and urban landscaping. Middle ground views are partially obscured by the foreground structures but include communications antennae, power lines, and large commercial and industrial structures. Background views are obscured by the intervening structures in the middle and foreground. The landscape is highly developed, and form and color is extremely diverse.

Figure 3.21. Odessa viewshed.

Night sky conditions in this viewshed are presently affected by interstate and secondary roadway lighting and motor vehicle lighting. In Odessa, there are many light sources caused by dense commercial, industrial, and residential development.

3.9.5 Environmental Impacts of Summit's Proposed Project

Based on project design schematics and structural height information, DOE created a simulation of the polygen plant site, which is shown in Figure 3.22 (as seen from KOP 2). Based on preliminary polygen plant design schematics (Summit 2010a), the simulation depicts the emissions stack at 200 ft (61 m). The coal piles are estimated to be 105 ft (32 m) in height; the turbine enclosure and gasifier are 175 ft (53 m) and 165 ft (50 m), respectively. At present, the precise layout of smaller-scale polygen plant features (e.g., pipes, road alignments) are unknown and are not depicted in the simulation.

This simulation was used to analyze impacts to aesthetics from each of the KOPs described above. The proposed polygen plant site simulation was viewed from each of the KOPs (using GIS software to locate the point of view at each KOP). It was determined that KOP 2 and KOP 5 would be close enough or have unobstructed views of the polygen plant: from KOP 2 the polygen plant would be approximately 1.5 mi (2.4 km) distant; from KOP 5 the polygen plant would be approximately 7.5 mi (12 km) distant, but would have a clear line-of-sight (Figure 3.23). The other KOPs, representing the perspective of viewers traveling along the major regional roadways, residing in Odessa, or recreating at the state park, would lie at distances or have intervening topography, structures, or vegetation such that the polygen plant site would not be clearly discernible during the daytime.

Figure 3.22. Polygen plant site simulation viewed from Key Observation Point 2. The Interstate 20 shoulder and the community of Penwell are visible at the far left side of the panorama.

Figure 3.23. Polygen plant site simulation viewed from Key Observation Point 5. This view is a north-facing continuation of the view shown in Figure 3.20.

3.9.5.1 IMPACTS TO KEY OBSERVATION POINTS 1, 3, 4, AND 6

An analysis of the KOPs in relation to the polygen plant simulation show that viewing distances, intervening topography, or intervening structures would prevent the site from being clearly viewed by the public at KOPs 1, 3, 4, and 6. The simulation analyses show that under ideal conditions (i.e., very low atmospheric haze, a lack of heat shimmer, and dips in topography), the tops of the polygen plant stacks would be visible; however, these features would not be obviously visible to the casual viewer nor would they attract viewer attention because of the polygen plant's brief visibility and the small portion of the plant exposed to potential view. Thus, the impacts to daylight aesthetics from project construction would be either none or minor depending on local lighting conditions and atmospheric haze.

The proposed transmission line structures would have direct impacts to aesthetics because they would be visible from major travel routes and would create new vertical form contrasts on the landscape. However, the impacts would be reduced because 1) large, cross-country transmission lines are presently visible in the region and adjacent to the proposed project area, 2) constructing another transmission line would be consistent with the level of development in the Odessa area, and 3) existing power lines in the region would prevent the new lines from being a focus of viewer attention.

The impacts of constructing water pipelines would be adverse but minor in the short term because heavy construction equipment would be visible during ROW vegetation and soil removal, trenching, pipeline laying, and pipeline burial. There would be no long-term impacts to aesthetics because the pipeline would be buried, construction-disturbed areas in the ROW would be recontoured and revegetated, and intervening topography and vegetation would prevent casual view of the ROW, as seen from FM 1601.

3.9.5.2 IMPACTS TO KEY OBSERVATION POINT 2

An analysis of the simulated polygen plant in relation to the analysis KOPs show that KOP 2 is the only viewpoint location where the polygen plant would be clearly in view. As mentioned above, this KOP is located along I-20 at a point where the local topography dips down to form the shallow valley, within which the polygen plant would be constructed. From this perspective, the polygen plant would lie in the middle ground, approximately 1.5 mi (2.4 km) from the viewpoint. The tall polygen plant structures, coal piles, and cooling tower would create obvious form, line, and color contrasts with the surrounding, uniformly flat landscape. This level of visible development would be consistent with the BLM management Class IV described above. In the short term, visually intrusive heavy construction equipment and construction vehicles would create color and form contrasts. Exposed soil in construction areas, staging areas, parking lots, and construction materials storage yards would create line and color contrasts. Windblown dust (fugitive dust) from dry, exposed soil in the site would briefly create localized haze during periods of major earth working that would reduce long-distance viewing. The impacts to aesthetics would be moderate, direct, and adverse because the size of the site and its proximity to the observation point would attract viewer attention and be a focus of view, for both westbound and eastbound motorists.

Long-term impacts would be similar to short-term impacts but to a greater degree: strong form, color, and line contrasts would be created that would attract the attention of the casual viewer. The height and size of the polygen plant structures, cooling tower, and coal storage piles would create moderate adverse direct impacts to aesthetics because of the strong form, color, and line contrasts with the surrounding landscape. Building colors and piles of black coal would strongly contrast with the green landscape, and building heights would contrast with the flat landscape. During the operational phase of the polygen plant, water vapor emitted from the cooling tower would increase the degree of contrasts with the surrounding landscape by creating a form and color-contrasting plume.

3.9.5.3 IMPACTS TO KEY OBSERVATION POINT 5

From the perspective of this KOP, the analysis of the simulated polygen plant shows that the structure would be partially visible in the background to motorists traveling north on FM 1601, and would become increasingly visible in the middle ground and foreground as motorists approach the I-20 interchange and Penwell. In the short term, ground-level construction activities and vehicles would be obscured by viewing distance, topography, I-20, and vegetation and would have no direct impacts to aesthetics. Above ground-level, construction activities would become increasingly visible from this viewpoint as the taller polygen plant buildings and stacks reached maximum height and were enclosed. The visible, aboveground portions of the polygen plant would create bold, angular, and clearly defined form, color, and line contrasts with the surrounding landscape and background sky. From this perspective, the structure would appear as a silhouette, creating strong linear edges against a blue sky. These contrasts would create direct, moderately adverse impacts to aesthetics that would likely attract the attention of the casual viewer and be a focus of view at this distance. The viewer's focus of view would become sharper and would begin to be dominated by the visible, aboveground portions of the plant as motorists approached Penwell and I-20.

Operations impacts would be similar to construction impacts, except that water vapor plumes emitted from the cooling tower would create additional color and form contrasts with the surrounding landscape. The contrasts would create direct, moderately strong, adverse impacts to aesthetics because the polygen plant would increasingly attract the attention of motorists traveling north toward Penwell and I-20, become a focus of attention, and begin to dominate the view as travelers approached the polygen plant site.

3.9.5.4 IMPACTS TO NIGHT SKY CONDITIONS

The construction and operation of the polygen plant would have direct, adverse impacts to night sky conditions because of the installation of high-intensity lighting in and around the site, and from nighttime flaring. During construction, lighting would be installed at the site for safety, to protect against trespassing, and to enable night-time construction. Light reflected upward would create light pollution and skyglow, which would be visible regionally. Plant lighting would likely be visible to travelers and residents at distances of up to 8 mi (12.8 km) (DOE 2007), but the night lighting impacts would be greatest for residents nearest the proposed polygen plant.

During TCEP operation, high-intensity lighting to maintain security and safety and to provide sufficient lighting for nighttime operation of the polygen plant would have adverse impacts on night sky viewing conditions. Exhaust stack flaring would contribute to light pollution and skyglow because, though the flares would be enclosed in the stack, light produced by flaring combustion would be directed upward and out of the 200-ft-high (61-m-high) emissions stacks. Additionally, adverse night sky impacts would be caused by Federal Aviation Administration (FAA)-required strobe lighting on the stack tops. This lighting would ensure and maintain safe night flying conditions around the site, but would contribute to skyglow and light pollution because the lighting would be unshielded and outward-directed.

3.9.6 Mitigation

Mitigation measures that Summit would implement as part of the construction and operation of the TCEP are described in Table 2.8 of Chapter 2. Additional mitigation measures that Summit could implement or that DOE could require as a condition of approval to further reduce impacts to aesthetic landscape contrasts are as follows:

- Applying dust control in areas where construction exposes soils
- Minimizing vegetation removal and soil exposure to reduce color contrasts
- Painting the facilities an appropriate color to reduce form, color, and line contrasts with the surrounding landscape (colors should be approximately two shades darker than the surrounding landscape.

- Minimizing building heights to reduce form contrasts

Mitigation measures that Summit could implement to reduce potential light pollution and the adverse impacts on night sky viewing are as follows:

- Using outdoor security and site lighting that is low in height, shielded so that the light is not directed skyward, and of minimal brilliance to illuminate the intended area and meet the intended purpose at that location (e.g., parking lots, signs, walkways, and safety and work areas)
- Using lamps that minimize the potential for light pollution, such as yellow lights rather than white lights (yellow light scatters less in the atmosphere).
- Using red strobes rather than white ones for FAA lighting because they are less visually intrusive but still meet aviation safety standards.

3.10 Cultural Resources

3.10.1 Background

This section identifies and describes the cultural resources that could be affected by the construction and operation of the polygen plant and linear facilities. This section also presents the environmental impacts of the proposed project and the No Action Alternative. Additional mitigation measures that could be implemented to further reduce potential adverse consequences are presented.

Cultural resources include historic, archeological, and paleontological resources. The term also includes Traditional Cultural Properties that have religious and cultural importance to a distinct cultural group, such as a Native American tribe or Native Hawaiian group. The National Historic Preservation Act of 1966 requires that federal agencies take into account the effect that a federal undertaking may have on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places (NRHP) (16 U.S.C. § 470f). NRHP eligibility criteria include elements significant to American history, architecture, archaeology, and culture as found in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association (36 C.F.R. § 60.4(a–d)). Traditional Cultural Properties may be eligible for inclusion in the NRHP.

Paleontological resources are geological in nature but are generally included in an analysis of impacts to cultural resources.

3.10.2 Region of Influence

Any historic properties identified in the area of potential effects must be evaluated to determine if the resource is on the NRHP or if it possesses characteristics that would make it eligible for inclusion in the NRHP. The area of potential effects consists of the geographic area or areas within which the undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist (36 C.F.R. § 800.16(d)). For the TCEP, the area of potential effects consists of the total disturbance area in the polygen plant site property and along the length of the linear facilities and access roads. In addition, the area of potential effects incorporates any historic structures located within a 0.5-mi (0.8-km) radius of the proposed polygen plant site. The 0.5-mi (0.8-km) radius was selected for this project based on the project's scope and potential to affect significant resources, should they be located. For purposes of analysis in this EIS, the ROI is the same as the area of potential effects and the term ROI is used for consistency with the other sections in Chapter 3.

3.10.3 Methodology and Indicators

The impacts analysis for cultural resources used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. Potential impacts and their indicators are shown in Table 3.24.

Table 3.24. Indicators of Potential Impacts to Cultural Resources

Potential Impact	Impact Indicator
Physical disturbance that could affect known cultural resources that are eligible for the NRHP	Number of known cultural resources (NRHP-eligible and NRHP-ineligible sites)
Physical disturbance to previously undocumented cultural resources or human remains from construction activities	Acres of surface disturbance
Increase in access to areas previously not accessible by road could result in inadvertent damage, looting, or vandalism to cultural resources	Numbers of known cultural resources (NRHP-eligible sites) Identification of Traditional Cultural Properties through Native American consultation

A background study of cultural resources was conducted for the proposed polygen plant site in 2010 (Peyton 2010). As part of this study, archaeologists examined maps and site files at the Texas Archeological Research Laboratory and searched the Texas Historical Commission's Texas Archeological Sites Atlas. These sources provided information on the nature and location of previously conducted archaeological surveys, previously recorded cultural resource sites, locations of NRHP properties, sites designated as State Archeological Landmarks, Official Texas Historical Markers, Registered Texas Historic Landmarks, cemeteries, and local neighborhood surveys. Archaeologists also reviewed the studies conducted in 2006 by the FG Alliance for the polygen plant site (FG Alliance 2006). This FutureGen study included background and archival data for the area and recommendations for future survey work on the property.

Because any ground-disturbing construction activity for the TCEP could alter or disturb previously undocumented cultural resources, archaeologists conducted a sample survey within the 600-ac (243-ha) polygen plant site in July 2010, excavating shovel test pits every 328 ft (100 m) in a grid-like pattern to determine whether any cultural resources might be present in previously unsurveyed areas. The sample survey included a search for cultural resources visible on the ground surface and exposed soils. Land access to the linear facilities was not available at the time of survey. A survey was also conducted to inventory all historic-age structures in the ROI. Similar survey efforts were not extended to the linear facilities due primarily to land access restrictions and the preliminary nature of proposed route alignments. To help locate sites where historic-age structures (i.e., older than 1960) once existed and to evaluate the potential indirect impacts to existing historical structures, archaeologists used soil maps, topographic maps, and city survey maps, some of which date to the middle to late nineteenth century. Historical aerial photographs were also examined.

Information from the historical map and photograph research was used to create an inventory of historic-age structures in the ROI. The inventory list was then verified during field efforts. This study also investigated the extent to which the proposed plant might be visible from existing historical structures, and whether there was potential for a historic district in the area. All fieldwork was confined to public roads and/or specific areas where the survey team had permission to access the property. Local residents were also interviewed when encountered.

For the associated linear facilities, data from background research efforts, soil and geology research, and field reconnaissance efforts were used to help identify areas with the highest potential for undiscovered cultural resources, and to plan for future investigations accordingly. Although a field investigation was conducted along public roads, full sample surveys were not conducted along the linear facility options because most of the alignments have not been finalized and no land access was granted. Once the alignments have been identified, areas with high or medium archaeological potential would be surveyed before construction begins.

3.10.4 Affected Environment

The TCEP lies on the far southwestern edge of the Southern Plains archeological region (Hofman 1989:1–2), bordering the Trans-Pecos archeological region to the west. The four main eras of human chronology for the Southern Plains region are the Paleoindian (10,000+ to 6000 B.C), Archaic (6000 B.C. to 500 A.D.), Late Prehistoric (500 to late 1500s A.D.), and Historic (sixteenth century to present).

The cultural resources background archival research revealed that most of the previous archeological work consisted of linear surveys conducted on behalf of various state and federal agencies, including TxDOT, TWDB, BLM, EPA, and the U.S. Army Corps of Engineers. Although several of these previous surveys intersect with one or more of the proposed linear facilities, none provide a substantial amount of information about the prehistoric or historical context of the project area. Archival research conducted for the FutureGen EIS in 2006 produced similar results, indicating that little to no archaeological investigations had been conducted recently near the project area (FG Alliance 2006).

There are no documented Traditional Cultural Properties and no cemeteries in the ROI for the proposed TCEP. Additionally, there are no documented paleontological resources or National Natural Landmarks in the project area.

3.10.4.1 POLYGEN PLANT SITE

The archaeological survey of the proposed polygen plant site conducted as part of DOE's 2010 cultural resources study resulted in the documentation of one new archaeological site (referred to as 41EC21, shown in Figure 3.24). This site is a historic-era industrial site related to oil-drilling activity in the early to mid-twentieth century. The site is located in the southwestern portion of the proposed polygen plant site and consists of two concrete pump jack foundations and an associated historical debris scatter. Due to the poor structural integrity of the two pump-jack foundations and the amount of industrial development in and around the site that has altered the landscape's character, 41EC21 is not considered eligible for listing in the NRHP.

The historical structures survey noted the presence of 14 residences, industrial facilities, commercial businesses, and oil-and-gas-related features in the ROI. These structures are described in Table 3.25 and their locations are noted in Figure 3.24. All of the development in the ROI, both modern and historical, was directly tied to oil and gas exploration and production.

Table 3.25. Built Environment Inventory in the Region of Influence

Name	Inventory Number	Type	Age	Location	NRHP Status	Description
The Joker Coffee Shop	1	Building	circa 1955	North side of the I-20 service road; west of Avenue C	Ineligible	The café is constructed with concrete block, has a flat roof and sits on a concrete slab foundation. The overall styling of the building is typical of 1950s roadside architecture, with hints of high-style modernism mixed with more modest vernacular construction techniques.
Rhodes Welding Complex	2	Building	1928, 1950, and 1952	North side of the I-20 service road; east of Avenue C	Potentially Eligible	The Rhode Welding Complex consists of three buildings, built from 1928–1952.
Lubrication complex	3	Building	circa 1935	North side of I-20, on east side of Avenue C	Ineligible	The circa 1935 complex consists of three standing buildings and a collapsed building.
Industrial shop	4	Building	circa 1935	South of Avenue G; east of lubrication complex (Inventory No. 3)	Ineligible	The shop may have been part of a larger complex of buildings at the location but is now the only standing building on the lot. The small shop building is typical of early to mid-twentieth century industrial architecture.
Wooden-framed house	5	Building	circa 1940	Intersection of Avenue H and Avenue D	Ineligible	The circa 1940 minimal traditional house has an L-shaped layout and is located to the southeast of the Avenues D and H intersection.
Asbestos-clad house	6	Building	circa 1945	Avenue H; across from wooden-framed house (Inventory No. 5)	Ineligible	The circa 1945 house is in the minimal traditional style.
Service station	7	Building	circa 1958	I-20 service road, south side of highway	Ineligible	The small station dates from the late 1950s or the early 1960s and has subtle touches of Googie architectural styling that dominated roadside architecture during the mid-twentieth century.
Service station complex	8	Building	circa 1965	I-20 service road, south side of highway	Ineligible	The complex housed a restaurant, service station, and fuel pumps and was built with the clean lines of simple modernist styling, lacking any decorative features.

Table 3.25. Built Environment Inventory in the Region of Influence

Name	Inventory Number	Type	Age	Location	NRHP Status	Description
Small service building	9	Building	circa 1945	Avenue C (east side) on south side of I-20	Ineligible	The circa 1945 service building is small, wooden-framed, and has a front-gabled roof with exposed rafter tails.
Penwell Post Office	10	Building	circa 1965	Avenue C (east side) on south side of I-20	Ineligible	The post office is constructed from concrete block, sits on a concrete slab foundation, and has a front-gabled roof clad in composite shingles.
House	11	Building	circa 1950	Avenue C (east side) on south side of I-20	Ineligible	The circa 1950s house has a side-gabled roof clad in asphalt shingles. Construction is wooden-framed and the house appears to be clad in asbestos siding and brick. The house is located on the south side of I-20, along Avenue C.
Rhodes House	12	Building	circa 1951	Northwest corner of Penwell, Avenue A	Ineligible	The house, built in 1951, appears to be a combination of ranch and minimal traditional styling, with a low-pitched side-gabled roof, a dominant external brick chimney, and a gabled entry porch spanning much of the front façade.
Mid-century office building	13	Building	circa 1958	South side of I-20 along service road	Ineligible	The small pink concrete block building is located along the I-20 service road on the west side of Penwell and faces north toward the highway. The building dates from circa 1958 and has a flat roof with a small entry porch supported by square posts.
Tank storage yard	14	Site and structures	circa 1925 for tanks	South side of I-20 along service road	Ineligible	The storage yard is located south of I-20, along the service road and just east of the service station (Inventory No. 7). The yard appears to be a storage area for old oil derricks and tanks. The yard is littered with historic-age wooden tanks and other machinery. The wooden tanks are of varying sizes, are constructed of vertical wooden boards and bound by metal banding.

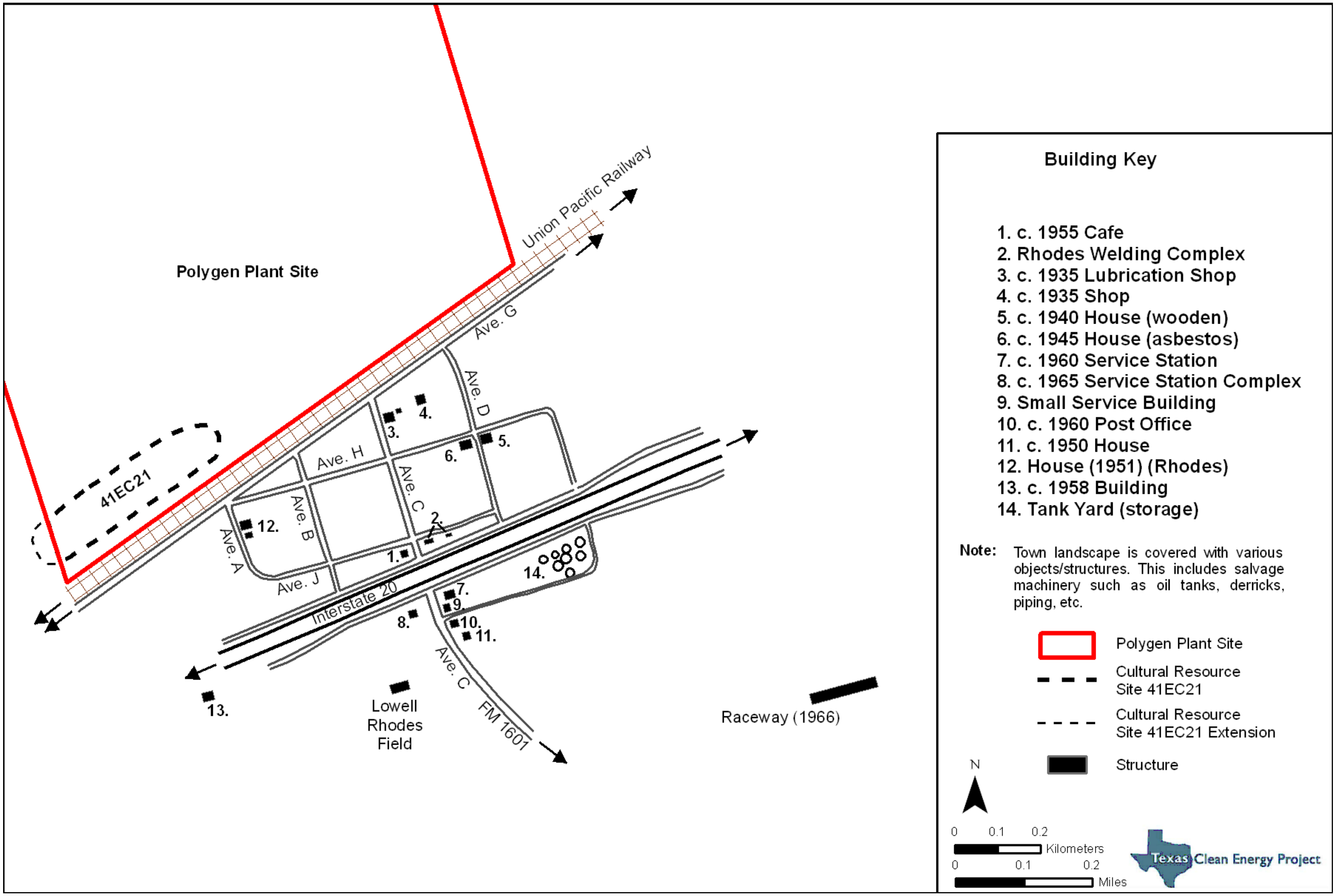

Figure 3.24. Location of historical structures documented in the region of influence.

Of the 14 historic structures in the ROI, 13 are ineligible for the NRHP. These 13 structures retain their integrity of location only. The integrity of design, materials, workmanship, and feeling have all been compromised by severe deterioration, changes in the surrounding environment due to widespread abandonment of the community, and the shift of land use from residential/commercial to an industrial storage yard and debris dump. Additionally, the construction of I-20 in the 1950s contributed to the disruption of the community's integrity by overlaying the highway corridor directly on the town's southernmost grid blocks.

One historical structure, the Rhodes Welding Complex, is potentially eligible for inclusion in the NRHP. The complex is located on the westbound frontage road of I-20 at the corner of Avenue C. It consists of two metal buildings, which are used as welding shops, and a concrete masonry unit building that functions as an office. The Rhodes Welding Company began operation before the community of Penwell was officially laid out in 1929. The original building (circa 1928) was located along the old highway/rail corridor on the north side of town. When that highway was decommissioned and the new interstate corridor moved automobile traffic to the southern side of Penwell in the 1950s, Rhodes Welding moved their shops to the I-20 frontage road and constructed two additional buildings (a larger metal shop building and an office). All three buildings can be seen on a 1963 aerial photograph of Penwell in their present configuration.

The complex as a whole retains all aspects of integrity. The individual buildings also retain all aspects of integrity, with the exception of the 1928 metal shop, which was moved from its original location and attached to the larger welding shop (structure No. 2, see Figure 3.24). Because the Rhodes Welding Complex represents a pattern of events that made a significant contribution to the development of a community, it is recommended as eligible for listing in the NRHP.

The Penwell historical marker is located west of the project area, approximately 0.9 mi (1.5 km) northwest of the intersection of I-20 and FM 1601. This marker was erected in 1965 and notes the birthplace of the Ector County oil boom following the construction of large oil wells on Robert Penn's land (Texas Archeological Sites Atlas 2010).

3.10.4.2 LINEAR FACILITIES

With the exception of WL1, there are no previously recorded NRHP-eligible sites along or within 1.0 mi (1.6 km) of the corridors for the proposed linear facilities. For WL1, there are four previously recorded archeological sites located along or within 1.0 mi (1.6 km) of the proposed corridor:

- A sparse prehistoric lithic scatter
- An Archaic-era seasonal campsite
- A possible Comanche open shelter/seasonal campsite with a hearth feature
- A prehistoric open campsite

None of these sites are recommended as eligible for the NRHP for a variety of reasons, including poorly preserved site deposits or lack of significant artifacts or features. In particular, the sparse prehistoric lithic scatter has been impacted by ROW construction and the field investigation conducted in July 2010 found no evidence of the site.

The Odessa Meteor Craters historical marker is located adjacent to the proposed WL1 corridor. These craters were created approximately 20,000 years ago from a shower of nickel-iron meteorites, and cover an area of approximately 2 mi^2 (5 km^2). None of the craters are located within the proposed corridors.

3.10.5 Environmental Impacts of Summit's Proposed Project

3.10.5.1 POLYGEN PLANT SITE

The construction and operation of the proposed TCEP would adversely affect the historic-era pump jack foundations and associated debris scatter that is located on and just outside of the proposed polygen plant site. However, as noted above, this site is not eligible for the NRHP because of its poor structural integrity and the amount of industrial development that has altered the character of the surrounding landscape. Although some local residents reported finding evidence of prehistoric sites affiliated with Native American culture as well as Anglo-American railroad settlement northeast of the project area, DOE's survey efforts determined that no Native American or historical railroad settlement sites are located on the polygen plant site.

For the historic-age structures in the ROI, only the Rhodes Welding Complex is potentially eligible for inclusion in the NRHP. The Rhodes Welding Complex viewshed was assessed to determine if the proposed TCEP would diminish the property's integrity as related to the NRHP. Overall, the viewshed around the complex has degraded as the town has changed from a thriving oil and gas community to a nearly abandoned and overgrown landscape dominated by dilapidated structures and industrial debris. Although the proposed plant could be seen from the Rhodes Welding Complex, the view to the north would be somewhat obscured by a row of large hardwood trees, the steep railroad grade, and various industrial debris including derricks, piping, and machinery. The interstate highway and overpass immediately south of the complex completely obstructs the view facing south. To the east and west are overgrown lots and several dilapidated structures.

The proposed plant, although different in scale, would be consistent with newer oil and gas industry structures in the area such that it would not present an entirely new element to the landscape. Although the proposed plant would be an imposing fixture in the viewshed of the Rhodes Welding Complex, the existing viewshed has already been considerably diminished as a result of the construction of the interstate highway, overpass, and railroad grade; the changes and degradation of the surrounding community; and shifts in local land use from community to an industrial debris dump. Thus, the proposed TCEP would not diminish the characteristics that make the Rhodes Welding Complex eligible for inclusion in the NRHP.

DOE's 2010 cultural resources report, including the archeological survey and historical structures survey, was submitted to the Texas Historical Commission (which serves as the SHPO for Texas) for review and comment. The report, submitted on September 3, 2010, detailed the results of the survey efforts and made recommendations for further work, which are summarized below. The Texas Historical Commission/SHPO provided a written response on October 14, 2010. In that response, the Commission concluded that no historic properties would be affected by the construction and operation of the TCEP and concurred with the recommendations in the cultural resources report.

3.10.5.2 LINEAR FACILITIES

As described above, the construction of WL1 could affect four previously recorded archaeological sites. None are eligible for inclusion in the NHRP because they are poorly preserved or lack of significant artifacts or features. One of the sites has been impacted by ROW construction and the field investigation conducted in July 2010 found no evidence of the site. No other cultural resources have been documented within the corridors of the other linear facilities associated with the proposed TCEP.

The field investigation determined that despite the absence of NRHP-eligible sites or other documented cultural resources, construction of any of the proposed linear facilities has the potential to affect previously undocumented cultural resources. Areas with the highest potential for intact prehistoric sites are those nearest Monahans Draw and its unnamed tributaries. Areas with low potential for harboring intact, significant cultural resources are those portions of the linear facilities that parallel existing roadways or pipeline and transmission line ROWs. These segments of the linear features are primarily located northeast of the proposed polygen plant site and along I-20. The remaining segments of the proposed linear features traverse open land, and have a moderate probability for harboring cultural resources. This is due primarily to the prevalence of oil and gas development throughout the region, which has taken a heavy toll on the landscape.

A cultural resources survey of the TCEP linear facilities would be conducted after the alignments had been finalized and prior to construction, in compliance with recommendations provided by the Texas Historical Commission on September 10, 2010. Although the probability is considered low, should any cultural resources or human remains be discovered during the pre-construction surveys for the linear facilities, the Texas Historical Commission/SHPO would be immediately contacted and consulted.

Operational impacts associated with ongoing maintenance and repair of the linear facilities could result in additional ground disturbance and physical impacts to presently unknown cultural resources. Increased access to areas previously not accessible by road could result in impacts to presently unknown cultural resources from inadvertent damage, looting, or vandalism.

3.10.5.3 NATIVE AMERICAN RESOURCES

There are no documented Traditional Cultural Properties in the proposed TCEP ROI. During the preparation of this EIS, requests for consultation letters were sent to representatives of federally recognized Native American tribes with potential interests in Crane, Ector, and Midland Counties to solicit information regarding the locations of any undocumented Traditional Cultural Properties or other culturally sensitive areas (see Appendix A for copies of the consultation letters).

The Ysleta Del Sur Pueblo of Texas responded to the consultation request letter, stating that they only wish to be contacted if human remains are discovered during the construction or operation of the TCEP. The Comanche Nation requested a copy of the draft EIS statement in order to officially comment on the proposed project.

The construction and operation of the TCEP could result in increased access to areas previously not accessible by roads. However, no known Traditional Cultural Properties are located in the proposed TCEP ROI, and impacts associated with TCEP construction and operation are not anticipated.

3.10.6 Mitigation

Mitigation measures that Summit would implement as part of the construction and operation of the TCEP are described in Section 2.5. Additional mitigation measures that Summit could implement or that DOE could require as a condition of approval to further reduce impacts to cultural resources are:

- Conducting pre-construction surveys and altering the site plot plan or linear corridors if undocumented cultural resources are found.
- Developing a discovery plan that would be implemented in the unlikely event that cultural resources (including human remains or burial features) are discovered at any point during construction, operation, or ongoing maintenance of the proposed TCEP. This plan should be developed in consultation with the Texas Historical Commission/SHPO and should include the immediate cessation of all ground-disturbing activities and further consultation with the Texas Historical Commission/SHPO to determine the appropriate course of action.

3.11 Land Use

3.11.1 Background

This section identifies and describes the existing land uses that could be affected by the construction and operation of the polygen plant and linear facilities. It describes existing land uses in the project area, potential impacts of the proposed project on land uses (particularly residential, industrial, and commercial) in and near the proposed polygen plant site and linear facilities, potential impacts from the proposed project on the ability to access nearby lands, and consistency with comprehensive land use plans and regulations. The section also presents the environmental impacts of the proposed project and the No Action Alternative. Additional mitigation measures that could be implemented to further reduce potential adverse consequences are presented.

A proposed project can result in new land uses that may conflict with existing land uses on lands near it. In some cases, land use plans and/or regulations define the types of land uses that are compatible and not compatible with other land uses. New land uses may have direct or indirect impacts on other existing land uses.

3.11.2 Region of Influence

The land use ROI for the TCEP consists of the 600-ac (243-ha) polygen plant site and the area within 2.0 mi (3.2 km) of the site's boundaries. This distance from the proposed site was chosen as the area in which existing land use could be affected by plant construction or operations and to account for potential indirect impacts from increased vehicle traffic, impediments to access, and impacts to existing land uses that would extend beyond the project area. The land use ROI for the linear facilities consists of the applicable linear facility and construction-footprint buffer areas, which are located 100 ft (30 m) from the centerline of each linear facility.

3.11.3 Methodology and Indicators

The impacts analysis for land use used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. Potential impacts and their indicators are shown in Table 3.26.

Table 3.26. Indicators of Potential Impacts on Land Uses

Potential Impact	Impact Indicator
Changes to existing and/or planned residential development/dwelling	Physical restrictions to existing and/or planned development as a result of construction or operation of the TCEP
Changes to existing commercial or industrial land use	
Changes to public and/or private land	Physical restrictions to public and/or private land as a result of fencing or other physical or legal barriers necessary for project construction or operation
Changes in land uses prescribed in existing land use plans	Conflicts with or limitations on land uses prescribed in existing land use plans
Impacts to air space	Conflicts with FAA regulations

DOE reviewed existing and future land use data collected from agency and local governmental land use plans and conducted a GIS overlay comparison of compatible and noncompatible uses to illustrate indicators of what land uses will be most affected by the TCEP. In addition, federal, state and county regulatory land use requirements were also reviewed.

3.11.4 Affected Environment

This section describes the land use conditions that could be affected by the construction and operation of the proposed polygen plant and associated linear facilities.

3.11.4.1 POLYGEN PLANT SITE

This section describes existing land uses, land ownership, land use plans, public access and recreation areas, and airspace designations that could be affected by the construction and operation of the proposed polygen plant.

Existing Land Uses

Prior to its current use for oil and gas production, the area in which the proposed polygen plant site is located was historically used for cattle ranching. Oil was discovered in this area in 1929 and, by the 1980s, oil and gas activities had replaced cattle grazing as the area's dominant land use. Over 200 permitted or developed oil and gas wells, three crude oil pipeline systems, one natural gas pipeline system, and one refined products pipeline system are found in the land use ROI. Many of the wells, however, are no longer in production. RRC records indicate that six permitted or developed natural gas and oil wells exist on the proposed polygen plant site (RRC 2010) (Figure 3.25). However, individuals familiar with the site indicated that only one oil well and one gas well remained active by 2006 (DOE 2007). Pipelines also cross the proposed polygen plant site, and although there are several existing pipelines, the only active pipelines include one crude oil pipeline system, one natural gas pipeline system, and one condensate pipeline system (Figure 3.25). Although there are no water wells on the proposed polygen plant site, TWDB records identified two documented water wells in the ROI (DOE 2007).

No residences or businesses are located in the proposed polygen plant site. The nearby community of Penwell (immediately south of the site) and the UPRR line that borders the polygen plant site were established after the discovery of oil. Seven occupied (and habitable) residences in Penwell remain (Figure 3.26). Three are located immediately north of I-20 and south of the proposed polygen plant site, and four are located south of I-20 along FM 1601. Several oil and gas extraction-related businesses still operate in and around Penwell outside of the proposed polygen plant site.

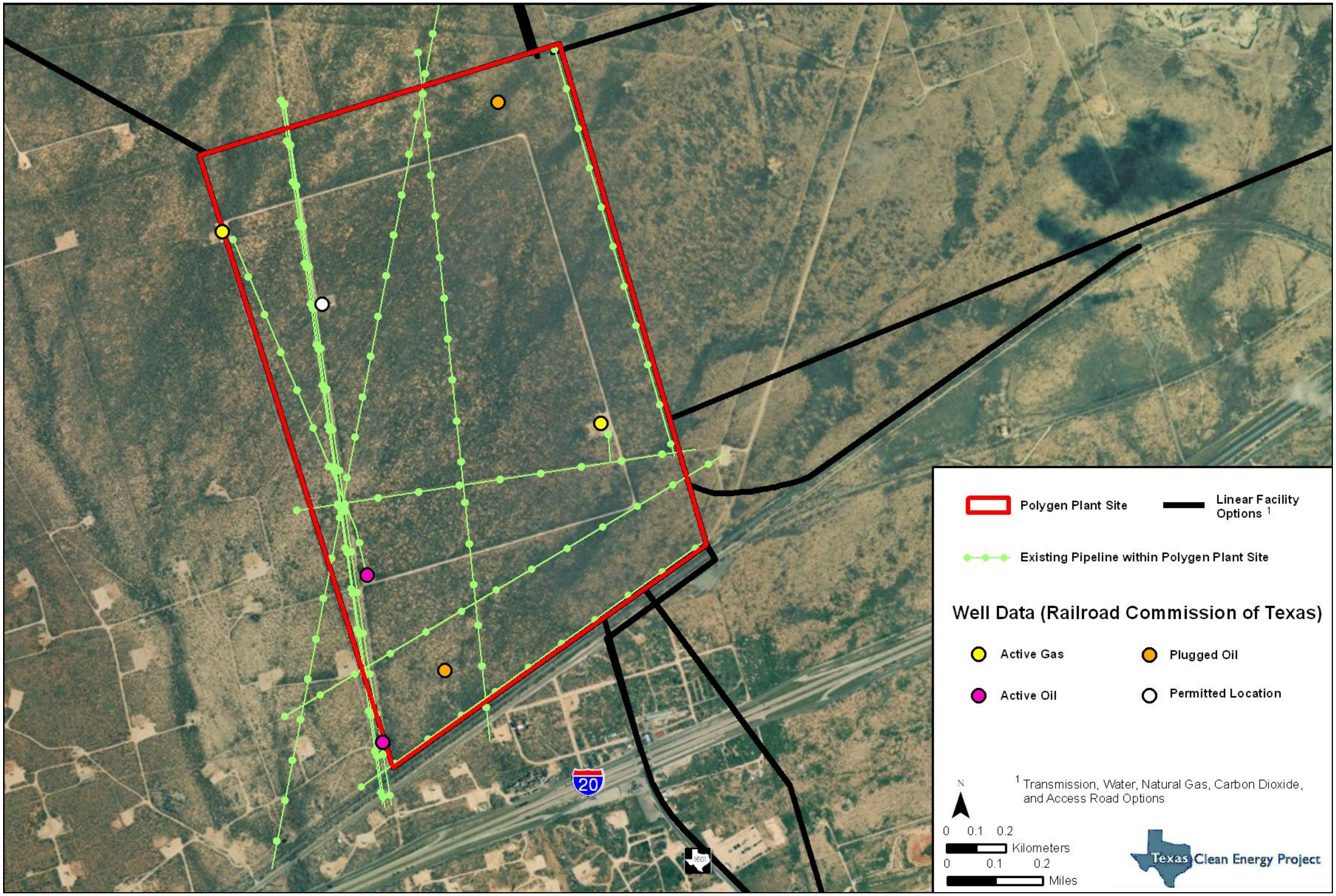

Figure 3.25. Existing wells and pipelines in the polygen plant site.

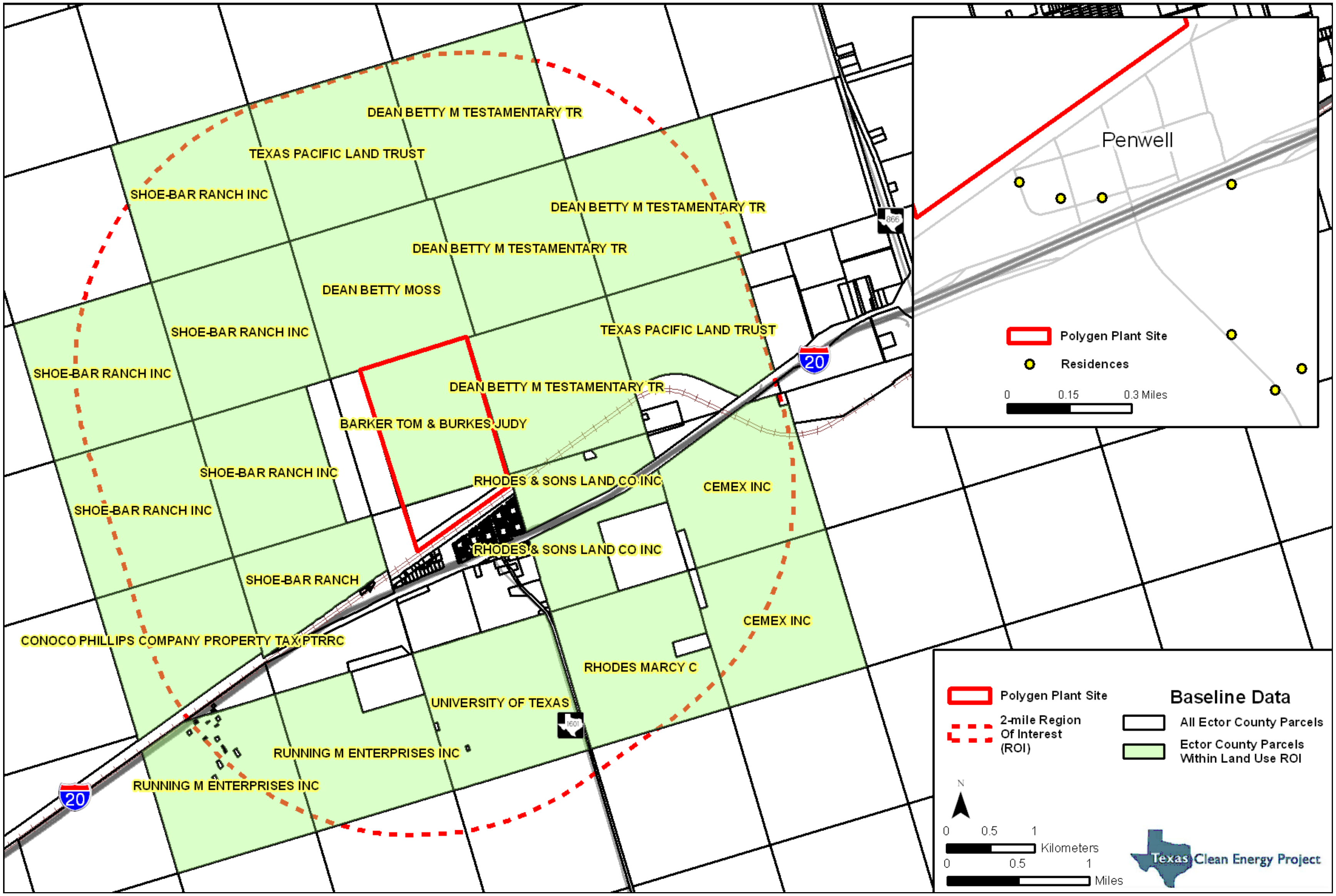

Figure 3.26. Large parcels in the polygen plant site region of influence.

Land Ownership

The proposed polygen plant site is owned by Summit. In the land use ROI, there are 22 large parcels of land owned by the Texas Pacific Land Trust, Ector County Sheriff's Department, Rhodes and Sons Land Company, Quell Petroleum Services, and the University of Texas, among others (see Figure 3.26). More than 200 other property owners have smaller holdings in the ROI, including private residences. Various utility and oil and gas companies have easements for access to subsurface oil and gas resources on the proposed plant site and surrounding lands.

Land Use Plans and Regulations

The proposed polygen plant site is located in unincorporated Ector County. The county has no land use plan, zoning, or development standards that are applicable to the proposed plant site.

Public Access Areas and Recreation

There are no recreational areas on the proposed plant site. The Penwell Knights Raceway, an active public drag strip, is located along FM 1601 on the south side of I-20, approximately 0.8 mi (1.3 km) southeast of the proposed plant site.

Airspace

There are no military airspaces designated above the ROI.

3.11.4.2 LINEAR FACILITIES

This section describes existing land uses, existing land use plans, and public access and recreation areas that could be affected by the construction and operation of the linear facilities associated with the TCEP.

Existing Land Uses

The corridors in which the TCEP linear facilities would be located generally pass through land that is rural and sparsely populated. Most of the land use in these areas is related to oil and gas extraction, and ranching. Other land uses include support services for the oil and gas industry (such as drilling and equipment storage, petrochemical manufacturing and storage) and some clusters of residences. Figure 3.27 identifies the locations of the residential areas along the linear facilities. Table 3.27 identifies the areas that contain residences as well as existing transportation and utility (electrical transmission and distribution lines and pipelines) ROWs that the linear facility options would cross.

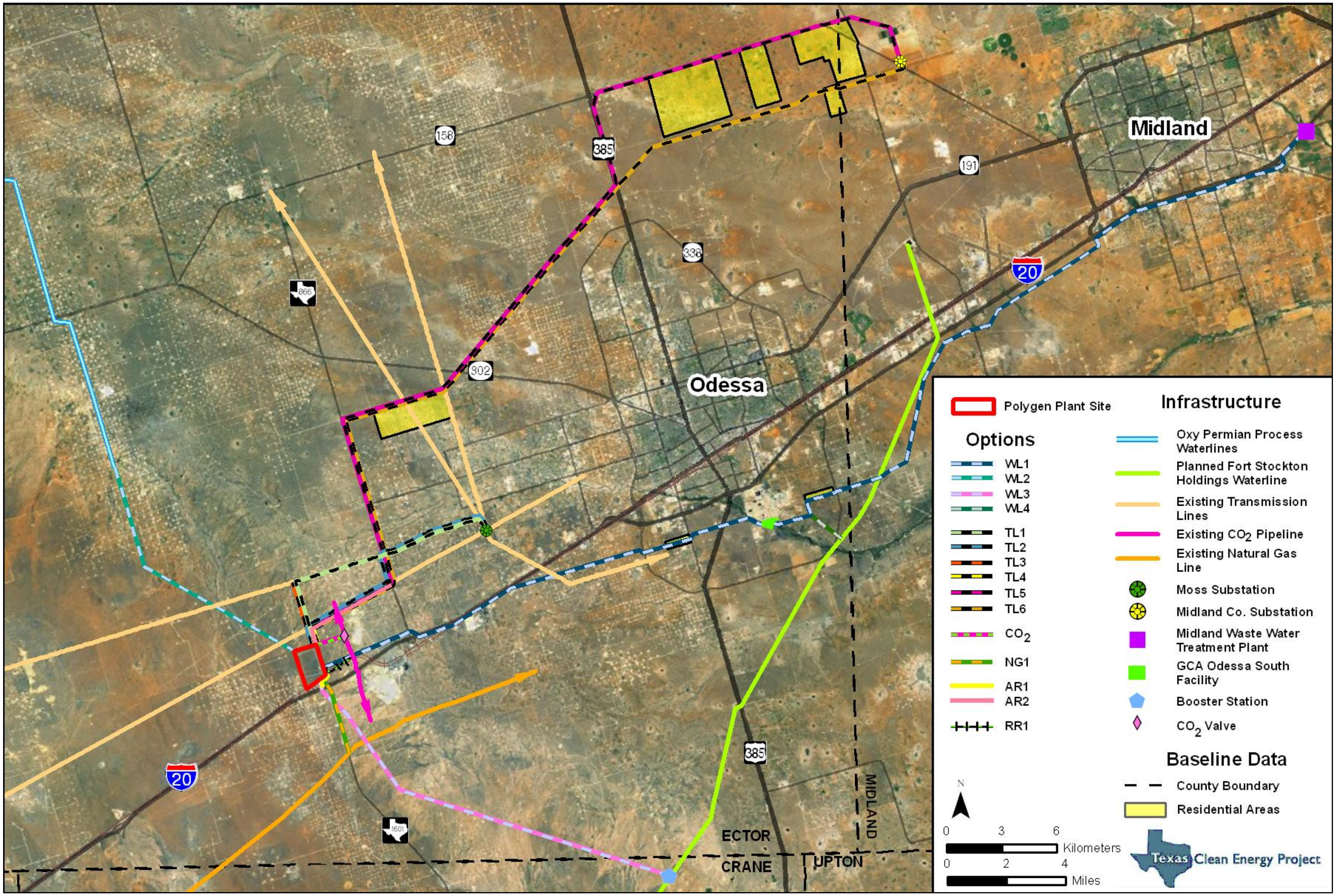

Figure 3.27. Residential areas along the linear facilities.

Table 3.27. Existing Land Uses, other than Oil and Gas Activity, along TCEP's Linear Facilities

Linear Facility Option	Type of Land Use Crossed	Distance and Direction from Polygen Plant Site (mi [km])	Total Length (mi [km])	ROW Use/Occupancy (if applicable)
WL1	Transportation ROW	3.0 (4.8) east	1.1 (1.8)	I-20 eastbound frontage road
	Transportation ROW	3.5 (5.6) east	2.4 (3.9)	UPRR
	Transportation ROW	12.0 (19.3)east	1.0 (1.6)	West Bell Street
	Residential area	12.0 (19.3) east	1.0 (1.6)	Scattered residences north and south of ROI
	Utility ROW	15.0 (24.1) east	1.9 (3.1)	Collector pipelines
	Utility ROW	16.0 (25.7) east	1.1 (1.8)	138-kV transmission line
	Transportation ROW	16.0 (25.7) east	0.5 (0.8)	FM 3503
	Residential area	17.0 (27.4) east	1.0 (1.6)	Clustered residences north of Hamett Drive
	Utility ROW	28.0 (45.1) east	4.3 (6.9)	138-kV transmission line
	Transportation ROW	30.0 (48.3) east	1.6 (2.6)	I-20 Eastbound Frontage Road
	Transportation ROW	33.0 (53.1) east	1.5 (2.4)	CR 110 and 111
	Transportation ROW	41.0 (66.0) east	1.1 (1.8)	I-20 eastbound frontage road
WL3	Transportation ROW	0.8 (1.3) south	0. 9 (1.4)	FM 1601
WL4*	Utility ROW	16.0 (25.7) east	1.1 (1.8)	138-kV transmission line
TL1	Utility ROW	2.2 (3.5) north	7.1 (11.4)	138-kV transmission line
TL2	Utility ROW	0.6 (1.0) north	3.1 (5.0)	138-kV transmission line
	Transportation ROW	3.5 (5.6) northeast	1.0 (1.6)	FM 866
	Transportation ROW	3.8 (6.1) northeast	3.9 (6.3)	138-kV transmission line
TL5†	Transportation ROW	7.5 (12.1) northeast	4.8 (7.7)	FM 866
	Transportation ROW	9.7 (15.6) northeast	2.4 (3.9)	West Yukon Road
	Residential area	9.7 (15.6) northeast	2.0 (3.2)	Scattered residences south of West Yukon Road
	Utility ROW	18.0 (29.0) northeast	8.9 (14.3)	345- and 138-kV transmission line
	Transportation ROW	20.6 (33.1) northeast	3.2 (5.1)	U.S. Highway 385
	Transportation ROW	22.0 (35.4) northeast	7.9 (12.7)	State Highway 158
	Residential area	27.0 (43.4) northeast	1.9 (3.1)	Scattered residences south of State Highway 158
TL6†	Transportation ROW	7.5 (12.1) northeast	4.9 (7.9)	FM 866
	Transportation ROW	9.7 (15.6) northeast	2.4 (3.9)	West Yukon Road
	Residential area	9.7 (15.6) northeast	2.0 (3.2)	South of West Yukon Road
	Utility ROW	16.0 (25.7) northeast	16.3 (26.2)	345- and 138-kV transmission line
	Transportation ROW	24.0 (38.6) northeast	1.0 (1.6)	East Cottonwood Road
	Residential area	25.0 (40.2) northeast	1.6 (2.6)	Scattered residences adjacent to CR 40
	Utility ROW	26.0 (41.8) northeast	2.2 (3.5)	345- and 138-kV transmission line
NG1	Transportation ROW	0.9 (1.4) south	1.7 (2.7)	FM 1601

Note: Only linear facilities that intersect with non–oil and gas land uses are discussed in this table.
* Includes WL1 from the polygen plant site to GCA Odessa South Facility.
† Also includes all of TL2.

Land Use Plans and Regulations

With the exceptions identified below, all of the TCEP linear facilities would be located in unincorporated Ector County. The county has no land use plan, zoning regulations, or development standards that would be applicable to the linear facilities. Portions of WL1 and WL4 would pass through areas in the city of Odessa that are zoned as Future Development and Heavy Industry and would need to comply with the Odessa Zoning Ordinance (City of Odessa 2006). WL1 would also cross through the city of Midland in areas zoned Single-family Dwelling, Business Park, Commercial, Local Retail, and Mobile Home and would need to be consistent with the *Midland Master Plan 2025* (City of Midland 2005).

Public Access and Recreation Areas

The Penwell Knights Raceway is the only public access and recreation area in the ROI. It is accessed from I-20 via the north I-20 frontage road and FM 1601. NG1 and WL3 would be located adjacent to the entrance to raceway.

3.11.5 Environmental Impacts of Summit's Proposed Project

This section describes the potential environmental impacts of the construction and operation of the proposed polygen plant and associated linear facilities on land use in the ROI.

3.11.5.1 POLYGEN PLANT SITE

This section describes the potential impacts of the proposed polygen plant on existing land uses and land ownership, the extent to which the plant would be consistent with existing land use plans, and the potential impacts of the proposed plant on public access and recreation areas and airspace.

Existing Land Uses

There are no existing residential dwellings or planned residential developments in the proposed polygen plant site. During construction, noise and visual impacts associated with construction-related activities (particularly traffic) would occur near several of the residences in Penwell that are south of the polygen plant. However, project construction would not affect the current use of these properties, and construction impacts would be similar to those currently experienced from nearby oil and gas activities and I-20 traffic. Access to some residences could be temporarily delayed by construction traffic, as discussed in Section 3.16, Transportation. Impacts during the operational phase of the TCEP to existing residents would be similar to those currently experienced from nearby oil and gas activities and I-20 traffic.

The primary use of the polygen plant site would change from oil and gas extraction to energy and chemical production. The TCEP would be an industrial type of energy-related use that would be consistent with the land uses in the ROI. Existing oil and gas extraction on the polygen plant site could continue, although access would need to be coordinated with Summit. Oil and gas exploration and production on lands in the ROI but outside of the polygen plant site would not be affected. There are no public lands in the land use ROI, and access to I-20 would not be compromised by the project.

Land Ownership

The ownership of land in the ROI would not change as a result of the construction or operation of the proposed TCEP.

Consistency with Comprehensive Land use Plans and Regulations

As previously mentioned, the proposed polygen site is located in unincorporated Ector County. The county does not have a land use plan and has not assigned land use zones to lands in its jurisdiction. Therefore, the polygen plant would not be inconsistent with any Ector County land use plans for the project area.

Public Access and Recreation Areas

No impacts to the majority of public access areas and recreation would result from the construction and operation of the plant. The Penwell Knights Raceway Park, the only public access and recreational area within the ROI, operates on Friday nights and Saturdays. Construction-related traffic using AR1 to access the polygen plant site could result in traffic delays for patrons accessing the raceway. These potential delays could be mitigated through scheduling and close coordination with the raceway operators.

Airspace

In accordance with FAA regulations, signal lights would be required atop the plant cooling towers and other structures that are higher than 200 ft (61 m). No other impacts to airspace would be expected.

3.11.5.2 LINEAR FACILITIES

This section describes the potential impacts of the proposed TCEP linear facilities on existing land uses, the extent to which those facilities would be consistent with existing land use plans, and the potential impacts of the proposed linear facilities on public access and recreation areas.

Existing Land Uses

Construction of the linear facilities would have temporary impacts on some adjacent lands. The construction ROW would be used for activities such as trenching, equipment movement, and materials laydown (see Table 2.2). Construction work would consist of activities such as land clearing, trenching, pipe installation, backfilling, compacting, and hydrostatic testing for leakage, cleanup, and restoration. Where appropriate, street and driveway pavements would be cut and temporarily covered during pipeline construction to maintain access. All regulated road and rail-line crossings would be accomplished using directional drilling technology, which allows for site-specific locations of the pipeline to be buried beneath lands without disturbing the surface directly above the pipeline. The ability to use some lands for their existing uses (oil and gas development, utility and road ROWs, and cattle grazing) would be temporarily affected during construction but would not be inhibited during operations.

Most of the lands that the process waterlines, natural gas pipeline, transmission lines, and CO_2 pipeline would pass through are primarily used for oil and gas extraction and ranching. The TCEP linear facilities would be located in existing ROWs where possible, which would reduce potential land use impacts. The linear facilities (except for the transmission lines) would be buried and would have little to no impact to the ability to use adjacent lands. The TCEP transmission line routes would follow existing transmission lines and other linear facilities and would be located in or next to existing ROWs when possible. Table 3.28 shows the acreage of land that would be required for the linear facilities ROWs.

Table 3.28. Linear Facility Rights-of-way Acreage Requirements

Linear Facility Option	Acreage Requirement (ac [ha])
WL1	252.4 (102.1)
WL2	56.3 (22.8)
WL3	86.6 (35.0)
WL4	18.1 (7.3)
TL1	60.6 (24.5)
TL2	65.5 (26.5)
TL3	18.0 (7.3)
TL4	8.1 (3.3)
TL5	236.2 (95.6)
TL6	212.0 (85.8)
CO_2	6.1 (2.5)
NG1	16.5 (6.7)
AR1	4.0 (1.6)
AR2	35.5 (14.4)
RR1	6.7 (2.7)

Note: Represents the permanent (operational) ROWs, not temporary (construction) ROWs.

No new residential developments are planned near the proposed TCEP linear facilities. However, several of the linear features would pass through or be adjacent to existing residential areas (see Figure 3.27). WL1 would pass within 400 ft (122 m) of two residential areas in unincorporated Ector County. One area is located approximately 12 mi (19 km) east of the proposed polygen plant site and the other is approximately 17 mi (27 km) east. The residences in both areas are along approximately 2 mi (3.2 km) of the proposed WL1 corridor. Because the waterline would be buried, the residences would not be impacted by the WL1 pipeline and ROW.

TL5 would also pass within 200 ft (61 m) of two residential areas. The areas begin approximately 9.7 mi (15.6 km) and 27 mi (43.5 km) northeast of the proposed plant site, and both areas have residences along approximately 2.0 mi (3.2 km) of the proposed TL5 corridor. TL5 would not impact the use of these residential areas, although the transmission line could be seen from these areas.

TL6 would also be routed within 200 ft (61 m) of two different residential areas. The residential area closest to the proposed polygen plant site (9.7 mi [15.6 km] northeast) is the same area near which TL5 would pass. The second area is approximately 25 mi (40 km) to the northeast of the proposed plant site and would be located along approximately 1.6 mi (2.5 km) of scattered residences. The presence of the transmission line under TL6 would not impact the use of these residences, although it could be seen from them.

Consistency with Comprehensive Land Use Plans and Regulations

WL1 and WL4 are the only linear facilities that would pass through lands that are subject to land use controls (zoning). WL1 and WL4 would travel through the city of Odessa in areas with zoning district designations of Future Development and Heavy Industry. Approximately 1,200 ft (366 m) of WL1 would travel through the Future Development zoning district, and its permanent ROW would total approximately 1.2 ac (0.5 ha). WL4 would pass through approximately 1,000 ft (305 m) of the Heavy Industry zoning district and would require approximately 1 ac (0.4 ha) for its permanent ROW. Permitted uses in these two zoning districts include local utility lines (such as waterlines), sewage pumping stations, natural gas lines, and high voltage electrical transmission lines. Thus, it is expected that WL1 and WL4 would be permitted uses.

WL1 would also pass through approximately 2.0 mi (3.2 km) of the city of Midland. Table 3.29 shows the number of miles this option would cross in each zoning district and the acreage required for permanent ROW.

Table 3.29. Waterline Option 1, Zoning District Crossings, and Acreage Required for Right-of-way

	Extent in Zoning District (mi [km])	ROW Area (ac [ha])
Business park	1.6 (2.5)	9.7 (3.4)
Commercial	0.5 (0.8)	3.0 (1.2)
Light industrial	0.8 (1.3)	4.8 (2.0)
Local retail	2.5 (4.0)	15.5 (6.3)
Mobile home	0.8 (1.3)	4.8 (1.9)
Single-family dwelling	0.7 (1.0)	4.2 (1.7)

The proposed corridor for WL1 contains an existing pipeline ROW that also could be used for the WL1 pipeline. The location, construction, and operation of water pipelines are not specifically covered in the *Midland Master Plan 2025* zoning classifications. It is assumed that water pipelines would be consistent with the six zoning districts that WL1 would pass through, because utilities and infrastructure are recognized in the master plan as necessary for businesses and residents.

Public Access and Recreation Areas

Access to the Penwell Knights Raceway Park could be affected by construction of NG1 and/or WL3. These options would not cross the drag strip, but would cross the public access to the park. However, because the park only operates on Friday nights and Saturdays, coordination of construction activities with the operators of the park could mitigate any potential impacts. There are no other public access or recreation areas along the linear corridors.

3.11.6 Mitigation

Mitigation measures that Summit would implement as part of the construction and operation of the TCEP are described in Section 2.5. Additional mitigation measures that Summit could implement or that DOE could require as a condition of approval to further reduce impacts to land use are:

- Using erosion and siltation controls to manage the effects of construction and ground-disturbing activities
- Implementing practices to reduce traffic volumes

Other mitigation measures noted in Sections 3.19, Noise and Vibration; 3.15, Utility Systems; and 3.16, Transportation would also assist in maintaining compatibility with existing land use designations.

3.12 Socioeconomics

3.12.1 Background

This section identifies and describes the existing socioeconomic conditions that could be affected by the construction and operation of the polygen plant and linear facilities. The potential impacts of the proposed TCEP on socioeconomic conditions such as population levels, housing requirements, and economic output in the region are addressed. This section also presents the environmental impacts of the proposed project and the No Action Alternative.

3.12.2 Region of Influence

The ROI for the socioeconomic analysis is Ector, Midland, Crane, and Ward Counties, which cover approximately 3,426 mi^2 (8,873 km^2) in West Texas. These are the counties in which the proposed polygen plant and associated linear facilities would be located and in which DOE expects almost all construction and operations workers would live. The prominent cities in the ROI are Odessa in Ector County and Midland in Midland County. Although Penwell is close to the proposed project area, socioeconomic data for the town are unavailable.

3.12.3 Methodology and Indicators

The socioeconomic analysis used the following federal, state, and local data sources:

- U.S. Census Bureau
- U.S. Department of Commerce, Bureau of Economic Analysis
- U.S. Department of Labor, Bureau of Labor Statistics (BLS)
- Texas State Data Center
- Texas Office of the State Demographer
- Real Estate Center at Texas A&M University
- IMPLAN data (created by the Minnesota IMPLAN Group)

To analyze potential economic impacts in the ROI, DOE used IMPLAN (Version 3.0). IMPLAN is an economic modeling tool that can create a detailed social accounting picture and a predictive multiplier model for a regional economy. The IMPLAN database contains county, state, and federal economic statistics that can be used to measure the effect on a regional or local economy of a given change or event in the economy's activity. Economic modeling considers a regional economy, which for the TCEP consists of Ector, Midland, Crane, and Ward Counties.

The impacts analysis for social and economic resources used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. Potential impacts and their indicators are shown in Table 3.30.

Table 3.30. Indicators of Potential Impacts to Social and Economic Conditions

Potential Impact	Impact Indicator
Demographic changes in population levels because additional construction and operations workers would be required for the project	Change in population from changes in employment
Housing availability changes for construction and operations workers	Change in demand on housing supply (substantial population increase leads to changes in housing supply needs [insufficient housing supply or increased vacancies])
Economic changes in employment, area income taxes, and economic output in the region	Change in revenue benefits from taxes (increase in employment leads to increase in housing demand, addition of plant leads to increased royalty tax revenue, or increase/decrease in economic output

3.12.4 Affected Environment

3.12.4.1 DEMOGRAPHICS

Population data were obtained from the U.S. Census Bureau and the Texas State Data Center and Office of the State Demographer. Table 3.31 summarizes historical and projected population values in the ROI with comparative figures for the state of Texas.

Table 3.31. Historical and Projected Population in the Region of Influence

Location	Population		Total Percent Change in Population	Projected Population				Increase (%)
	2000*	**2009†**	**2000–2009**	**2010**	**2020†**	**2030†**	**2040†**	**2010–2040**
Texas	20,851,820	24,538,335	17.7	25,373,947	28,005,740	31,830,575	35,761,165	40.9
Ector County	121,123	132,153	9.1	132,817	143,926	153,884	163,093	22.3
Odessa	90,943	99,507	9.4	132,817	143,926	153,884	163,093	22.8
Midland County	116,009	130,203	12.2	129,715	133,633	140,138	145,132	22.3
Midland	94,996	107,248	12.9	129,715	133,633	140,138	145,132	11.9
Crane County	3,996	4,084	2.2	4,299	4,723	4,757	4,710	9.6
Ward County	10,909	10,693	-2.0	9,914	12,083	12,174	12,100	22.0
ROI Total	**252,037**	**277,133**		**276,745**	**294,365**	**310,953**	**325,035**	**17.4**

*Data from U.S. Census Bureau (2000).

†Data from Texas State Data Center and Office of the State Demographer (2010).

These data indicate population growth of 17.7 percent in Texas from 2000 to 2009, and projections for the state between 2010 and 2040 show a population growth rate of 40.9 percent.

Between 2000 and 2009, Ector County grew by 9.1 percent and is anticipated to continue growing approximately 22.3 percent between 2010 and 2040. Odessa shows a similar pattern, having increased its population by 9.4 percent between 2000 and 2009. Anticipated growth for Odessa between 2010 and 2040 is 22.8 percent. Between 2000 and 2009, Midland experienced the most growth overall at 12.9 percent, and additional growth between 2010 and 2040 is expected to be approximately 11.9 percent. Crane County had the slowest population growth between 2000 and 2009 at 2.2 percent and is anticipated to increase by 9.6 percent between 2010 and 2040. Ward County had negative growth between 2000 and 2009 at -2.0 percent; however, population projections show steady growth between 2010 and 2040 at 22 percent.

3.12.4.2 HOUSING

According to 2005–2009 census data estimates, which are based on average estimates of data collected between January 2005 and December 2009, Ector and Midland Counties had an occupancy rate higher than the state at 90.4 percent and 93.0 percent, respectively (Table 3.32). The median home value was $109,600 in Midland County, $67,700 in Ector County, $48,200 in Crane County, and $41,300 in Ward County.

Table 3.32. Total Housing Units and Occupancy Rate, 2005–2009

Location	Total Housing Units	Occupied	Occupied (%)	Vacant	Vacant (%)	Median Home Value ($)
Texas	9,407,692	8,269,046	87.9	1,138,646	12.1	118,900
Ector County	51,519	46,561	90.4	4,958	9.6	67,700
Odessa	39,387	35,609	90.4	3,778	9.6	76,500
Midland County	50,142	46,629	93.0	3,513	7.0	109,600
Midland	41,523	38,931	93.8	2,592	6.2	113,700
Crane County	1,657	1,489	89.9	168	10.1	48,200
Ward County	4,909	3,897	79.4	1,012	20.6	41,300

Source: U.S. Census Bureau (2010).

According to the Real Estate Center at Texas A&M University, in 2009 the average occupancy rate for apartment units was 96.7 percent in Midland and 97.1 percent in Odessa. There were approximately 2,600 hotel rooms in the Midland metropolitan area with an occupancy rate of 54.4 percent. For the same year, Odessa had approximately 2,100 hotel rooms with an occupancy rate of 50.4 percent (Texas A&M University 2010a, 2010b).

3.12.4.3 ECONOMICS

Economic factors discussed below are gross domestic product (GDP), industry employment, and taxes and revenues.

Gross Domestic Product for the Region of Influence

Table 3.33 summarizes existing GDP by industry in the ROI, which was used to compare changes in GDP in the ROI as a result of the project. GDP is the contribution of each private industry and government to the ROI's output. GDP, or value added, is equal to the gross output (which consists of sales or receipts and other operating income, commodity taxes, and inventory change) minus its intermediate inputs (which consist of energy, raw materials, semifinished goods, and services that are purchased from domestic industries or from foreign sources). It can also be measured as the sum of incomes related to production, such as wages and salary accruals and gross operating surplus (IMPLAN 2008). GDP is presented in undiscounted 2008 dollar terms, rounded to the nearest thousand.

As shown in Table 3.33, total GDP for the ROI in 2008 was $17.73 billion. The top industries were dominated by the oil and gas sectors, with extraction of oil and natural gas accounting for 30.7 percent of GDP for the ROI, followed by support activities for oil and gas operations (10.7 percent) and drilling oil and gas wells (10.6 percent).

Table 3.33. Gross Domestic Product by County for the Region of Influence: Top Ten Industries

Sector	Ector	Midland	Crane	Ward	ROI Total
Food services and drinking places	$145,628,392	$150,139,319	$2,101,086	$4,927,858	$302,795,655
Rental activity for owner-occupied dwellings	$314,652,400	$546,245,752	$8,213,391	$24,751,434	$893,862,977
Motor vehicle parts manufacturing	$9,967,138	$2,829,420	$2,217,558	$5,049,028	$20,063,144
Drilling oil and gas wells	$503,392,374	$885,284,063	$53,724,099	$46,893,299	$1,489,293,835
Extraction of oil and natural gas	$441,22,832	$3,757,353,280	$79,245,936	457,850,887	$4,294,450,103
Support activities for oil and gas operations	$561,628,696	$786,419,038	$38,223,060	$108,643,881	$1,494,914,675
Transport by pipeline	$29,373,331	$79,724,038	$3,985,746	$3,010,985	$116,094,100
Transport by truck	$96,693,910	$84,189,794	$2,703,205	$15,427,528	$199,014,437
Offices of physicians, dentists, and other health practitioners	$140,345,838	$135,751,702	$554,204	$2,936,943	$279,588,687
Construction of other new nonresidential commercial and health care structures	$174,040,085	$81,916,423	$759,210	$5,825,042	$262,540,760
Commercial and industrial machinery, and equipment rental and leasing	$182,603,440	$95,042,707	$553,615	$12,194,445	$290,394,207
Real estate establishments	$80,308,156	$168,268,051	$42,634	$2,178,470	$250,797,311
Architectural, engineering, and related services	$47,945,641	$180,304,355	$141,407	$7,665,059	$236,056,462
Wholesale trade business	$656,838,225	$579,170,252	$4,142,961	$12,615,413	$1,252,766,851
Employment and payroll only (state and local government, education)	$342,643,444	$216,515,222	$10,315,503	$29,907,600	$599,381,769
Employment and payroll only (state and local government, noneducation)	$136,216,728	$206,088,732	$6,719,528	$16,175,402	$365,200,390
Electric power generation, transmission, and distribution	$30,210,582	$32,353,358	$0	$18,365,378	$80,929,318
Total County GDP	**$3,452,488,380**	**$7,987,595,506**	**$213,643,143**	**$774,418,652**	**$12,428,144,681**

Source: IMPLAN (2008).
Note: Total county GDP includes other sectors not described in the table. Shaded sectors rank in the top ten industries for each county

Industry Employment

To determine how the TCEP could alter existing employment numbers, DOE considered current industry employment in prominent industries in the ROI. Industry employment is based on the BLS Covered Employment and Wages, as reported by IMPLAN (IMPLAN 2008). Generally these data include jobs for people who worked during, or received pay for, the reporting period. Excluded from employment data are self-employed, sole proprietors, domestic workers, and unpaid family workers. Table 3.34 lists employment by industry in the ROI in 2008; shaded cells indicate the top five employment sectors for each county. Food services and drinking place jobs dominate the ROI, representing 7.2 percent of ROI employment. State and local government (education) (6.5 percent) and support activities for oil and gas activities are in the top five for every county in the ROI (6.3 percent).

Table 3.34. Region of Influence Employment, By Industry (number of jobs)

Sector	County				ROI Total
	Ector	Midland	Crane	Ward	
Total full and part-time employment	72,595.51	82,835.01	1,689.82	4,278.80	161,399.14
State and local government (education)	5,876.82	3,869.05	182.23	584	10,512.1
State and local government (noneducation)	2,423.62	3,638.71	159.49	333.2	6,555.02
Food services and drinking places	5,839.22	5,424.82	84.03	227.4	11,575.47
Wholesale trade business	5,133.92	4,227.02	38.58	99	9,498.52
Support activities for oil and gas operations	4,079.06	5,169.98	219.02	728.5	10,196.56
Drilling oil and gas wells	1,411.91	2,220.61	99.81	101.9	3,834.23
Extraction of oil and gas	966.17	5,929.53	200.34	163.3	7,259.34
Retail stores (food and beverage)	1,069.84	1,050.97	53.4	100.6	2,274.81
Architectural, engineering, and related services	598.5	2,872.7	1.9	142.9	3,616
Transport by truck	1,262.2	989.6	38.5	137	2,427.3
Motor vehicle parts manufacturing	145.8	86.2	27	106.3	365.3

Source: IMPLAN (2008).

Note: Shaded sectors rank in the top five employment sectors for each county.

According to the BLS, in October 2010 the unemployment rate was 8.1 percent in the state of Texas, 7.4 percent in the city of Odessa, and 5.1 percent in the city of Midland (BLS 2010a). In May 2009, the state average hourly wage was $19.76 with an average annual wage of $41,100 (BLS 2010b). In the construction industry, the average hourly wage of workers was $17.12 with an average annual wage of $35,610 (BLS 2010b).

Taxes and Revenues

There is no individual income tax in Texas; the state does levy sales, luxury, estate, and corporate income taxes. Only those revenues that are reported by the state or federal government (e.g., income and sales taxes.) were considered for this analysis. Revenue information was gathered at the county level.

Sales taxes apply to the retail sale of personal property or services in the state. Texas levies a 6.25 percent general sales (transaction privilege) tax on consumers, which is just above the national average of 5.4 percent.

Property taxes are levied by school districts, cities, counties, and special districts in Texas. Table 3.35 illustrates the total property tax rate for each county and revenues received for the 2009 calendar year. Total revenue collected from property taxes in 2009 for the ROI was $78.99 million.

Table 3.35. 2009 County Property Tax Rates and Revenues

Jurisdiction	Total 2009 Tax Rate	Revenue ($)
Ector County	0.358000	34,108,383
Midland County	0.211805	24,620,026
Crane County	0.312580	6,646,236
Ward County	0.789900	13,618,287
ROI Total		**78,992,932**

Source: Texas Comptroller of Public Accounts (2009a).

According to the State Comptroller's Office, property taxes in the region are paid into one of three county government general funds: the general fund, the farm-to-market roads and flood control fund, and the road and bridge fund. Table 3.36 shows the tax rates and revenue paid into the three funds in 2008 for each county.

Table 3.36. 2008 County General Fund, Farm-to-Market Roads and Flood, and Bridge Revenues

Jurisdiction	General Fund Tax Rate (%)	General Fund Revenue ($)	Farm-to-Market Tax Rate (%)	Farm-to-Market Control Revenue ($)	Road and Bridge Tax Rate (%)	Road and Bridge Revenue ($)	Total ($)
Ector County	3.5	34,267,631	0.0	0	0.0	0.0	34,267,631
Midland County	2.1	23,489,746	0.0	0	0.0	0.0	23,489,746
Crane County	2.8	6,537,898	0.3	719,126	0.0	0.0	7,257,024
Ward County	6.3	12,043,109	0.3	566,225	0.0	0.0	12,609,334
ROI Total		**76,338,384**		**1,285,351**		**0.0**	**77,623,735**

Source: Texas Comptroller of Public Accounts (2008).

As shown in Table 3.36, Ector County collected $34.26 million in property taxes in 2008, Midland County collected $23.49 million, Crane County collected $7.26 million, and Ward County collected $12.61 million.

3.12.5 Environmental Impacts of Summit's Proposed Project

3.12.5.1 DEMOGRAPHICS

During the construction phase of the project (2011–2013), an annual average of 200 workers would be needed in 2011, with a peak of 300 workers; an annual average of 700 in 2012, with a peak of 1,050 workers; and an annual average of 1,000 in 2013, with a peak of 1,500 workers. According to the IMPLAN model used to estimate economic impacts to the ROI from construction of the TCEP, almost all of the workers needed for construction would currently live in the ROI. Therefore, during the construction phase, there would be no impacts to existing population levels.

During the operations phase (with a lifespan of at least 30 years and possibly up to 50 years), 150 workers would be needed on an annual basis. For the purpose of this analysis, it is assumed that TCEP workers would be equally distributed throughout three primary industries: 50 workers in electricity production, 50 workers in urea manufacturing, and 50 workers in CO_2 manufacturing. According to the IMPLAN model used to estimate economic impacts to the ROI from the operation of the TCEP, approximately 26.8 percent (13 workers) of the electricity production workforce would live in the ROI. The remaining 73.2 percent of workers (37 workers) would be highly skilled workers who were not necessarily available from the workforce in the ROI. These workers would likely commute or relocate to the ROI from areas outside the ROI. Assuming that all 37 workers relocated to the ROI with an average family size of four, this would result in a 0.05 percent increase in overall population. The IMPLAN model also estimated that all of the workers needed for the urea manufacturing and CO_2 manufacturing processes would live in the ROI, resulting in no impacts to existing population levels.

3.12.5.2 HOUSING

During the construction phase, it is expected that all workers would live in the ROI and continue residing in their existing homes. For this reason, no impacts to housing would be expected during construction.

During the operations phase, 37 new workers from outside the ROI would be expected to fill highly skilled positions. These workers would either commute from their current residences (assumed to be outside the ROI) or relocate to the area. Assuming that all of the workers relocated to the ROI, the existing housing supply shown in Table 3.32 would be adequate to support this increase. Because housing is expected to be available, impacts to existing home prices as a result of potential relocations would be negligible.

3.12.5.3 ECONOMICS

Impacts to economic factors, which include GDP, industry employment, and taxes and revenues, are discussed below. To remain consistent with data presented in 3.12.3.3, IMPLAN estimates using 2008 dollars were calculated.

Gross Domestic Product for the Region of Influence

GDP is the measure of economic contribution of an industry to the regional economy, or the net of the intermediate goods and services used. Indirect GDP consists of value added by other industries that would be used to support the TCEP, such as construction materials to build the polygen plant. Induced value added would occur through the respending of income received by the TCEP into the local and regional economies (IMPLAN 2008).

As shown in Table 3.37, total GDP for the construction of the project in 2011 would be $24.15 million, representing a 0.1 percent increase in GDP for the ROI in 2008. In 2012, total GDP would be $84.53 million, increasing the GDP for the ROI by 0.5 percent. In the final year of construction in 2013, total GDP would be $120.75 million, representing a 0.7 percent increase in the ROI.

Table 3.37. Total TCEP Gross Domestic Product per Year

Year	Direct GDP ($)	Indirect GDP ($)	Induced GDP ($)	Total GDP ($)
2011 construction	15,098,475	4,356,725	4,696,404	24,151,604
2012 construction	52,844,665	15,248,538	16,437,411	84,530,614
2013 construction	75,492,378	21,783,626	23,482,017	120,758,021
Annual operation	15,529,632	20,848,191	5,406,630	41,784,453

Source: IMPLAN (2008).

During the operations phase, the total GDP per year would be $41.78 million (an increase of 0.2 percent to the ROI). Because the life of the project would be between 30 and 50 years, total GDP from the TCEP would be long term and beneficial for the region.

Given the proximity of Penwell to the polygen plant, it is possible that the project could have a favorable impact to the town's economy. However, this is largely dependent on the location of the main operational entrance and whether it will run through the town (Crutcher 2010). If the entrance is through Penwell, it is possible that a convenience store or restaurant may be constructed (Crutcher 2010).

Industry Employment

Total employment would vary by year. In 2011, an annual average of 200 workers would be needed, 700 in 2012, and 1,000 in 2013. For the purpose of this analysis, the annual average number of annual workers from the ROI was used to run an IMPLAN model to assess economic impacts during construction.

As previously stated, the IMPLAN model estimated that all construction workers would reside in the ROI. During the operations phase, the IMPLAN model estimated that, of the 150 workers needed for TCEP operations, 37 electrical production workers would need to be highly skilled. The model also predicted that these highly skilled workers would not be available from the workforce in the ROI. Thus, it is assumed that these highly skilled workers would reside outside the ROI and would have no positive economic impact in the ROI. The other 113 workers needed for electricity production and urea and CO_2 production would live in the ROI and thus would have a positive economic impact in the ROI (Table 3.38).

Table 3.38. Total Employment per Year

Year	Number of Workers	Indirect Employment	Induced Employment	Total Employment
2011 construction	200.0	43.6	64.2	307.8
2012 construction	700.0	152.7	224.9	1,077.6
2013 construction	1,000	218.1	321.2	1,539.3
Annual operation	113.4	132.1	74.0	319.5

Source: IMPLAN (2008).

Although the overall impacts would be beneficial, total employment from each phase of construction and the operation phase would have a negligible effect on total employment in the ROI. During the operations phase, additional employment would account for less than a 0.07 percent increase in employment. The construction and operation phases of the TCEP would have a negligible effect on income levels in the ROI.

Taxes and Revenues

Numbers presented below include estimated household tax and corporation tax by year and phase. Household tax is associated with the estimated sales tax paid by households (IMPLAN 2008). Corporation tax is associated with the production of the goods and services, the generation of incomes by production, the subsequent distribution and redistribution of incomes among institutional units, and the use of incomes for purposes of consumption or saving (IMPLAN 2008). As shown in Table 3.39, total revenue from state and local taxes for the construction phase would be $0.19 million in 2011, $0.68 million in 2012, $0.97 million in 2013, and $0.36 million during the operations phase. For 30 years of operation, total revenue from taxes could be $10.8 million. This would have beneficial and long-term impacts to the region as revenue would be redistributed to counties, which in turn would allocate and redistribute revenue to local communities.

In 2009, House Bill 469 was enacted to provide an annual exemption for state franchise tax (up to a cumulative limit of $100 million) for the first three projects that qualify as "clean energy projects," primarily by using coal for fuel, capturing 70 percent or more of carbon emissions, and using the captured CO_2 for EOR if the EOR operation is certified by the Texas Bureau of Economic Geology as meeting requirements for CO_2 MVA. If a project proponent elects to receive this franchise tax exemption and qualifies for it, it must pay the Texas Bureau of Economic Geology a total of $8 million or some agreed other amount to devise, implement, and monitor compliance with the MVA program. The franchise tax would otherwise equal 0.5 percent of the gross receipts of sales of products by the clean energy project. The same legislation exempts from sales tax any equipment used for the capture, compression, and transportation of equipment used for CO_2/EOR.

The proposed TCEP may be eligible for the state franchise exemption. In addition, the proposed project includes some equipment that would be included in the sales tax exemption. Further, the TCEP would be eligible for accelerated depreciation under normal tax law principles to the extent it is considered primarily a chemical plant by virtue of its production of urea and captured CO_2.

In terms of local taxes, Summit would apply for customary local property and other tax exemptions, which, if granted by local authorities, would be temporary in nature (typically limited by statute to 10 years of abatement).

Table 3.39. State and Local Taxes

Phase	Households ($)	Corporation ($)	Total ($)
2011 construction	128,270	66,525	194,795
2012 construction	448,945	232,838	681,783
2013 construction	641,350	332,626	973,976
Annual operation	147,673	212,301	359,974

Source: IMPLAN (2008).

As shown in Table 3.40, a total of $0.99 million in indirect state and local business taxes would be generated in the TCEP construction phase in 2011, a 0.07 percent overall increase in indirect regional taxes. In 2012, revenue generated through indirect business tax would be $3.46 million (0.2 percent increase in overall indirect regional taxes), $4.94 million in 2013 (0.3 percent increase), and $3.53 million for each year of operations (0.2 percent increase).

Table 3.40. State and Local Indirect Business Taxes

Phase	State and Local ($)
2011 construction	989,234
2012 construction	3,462,318
2013 construction	4,946,169
Annual operation	3,532,786

Source: IMPLAN (2008).

3.12.6 Mitigation

Mitigation measures that Summit would implement as part of the construction and operation of the TCEP are described in Table 2.8 of Chapter 2. Impacts to socioeconomic resources as a result of the proposed TCEP would be minor and, in general, beneficial. For that reason, additional mitigation measures for socioeconomic resources not were developed.

3.13 Environmental Justice

3.13.1 Background

This section identifies and describes the potential for environmental justice impacts to result from the construction and operation of the polygen plant and linear facilities. Environmental justice is defined as the fair treatment and meaningful involvement of all people—regardless of race, ethnicity, or income level—in environmental decision making. Environmental justice programs promote the protection of human health and the environment, empowerment by means of public participation, and the dissemination of relevant information to inform and educate affected communities. The section also presents the environmental impacts of the proposed project and the No Action Alternative.

Executive Order 12898 (February 11, 1994) and its accompanying memorandum require that "each federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations" (Council on Environmental Quality 1997).

3.13.2 Region of Influence

The ROI for the environmental justice analysis is Ector, Midland, Crane, and Ward Counties. These are the counties in which the proposed polygen plant and associated linear facilities would be located and in which DOE expects almost all construction and operations workers would live. The same ROI was used for the socioeconomic impacts analysis.

3.13.3 Methodology and Indicators

The methodology for this analysis included assessing the presence and percentage of minority populations and/or low-income populations in the ROI and determining whether those communities would experience disproportionately high and adverse impacts as a result of the TCEP. U.S. Census Bureau data for 2000 at the census tract level were used to determine presence of these populations in the ROI. Once available, 2010 U.S. Census Bureau data will be used to determine potential impacts to environmental justice populations. Figure 3.28 shows the areas and census tracts used in the analysis.

Environmental justice populations may exist in definable communities, or they may be dispersed among other populations but in higher concentrations than in either the county or state as a whole. When assessing whether a proposed action would have disproportionately high and adverse impacts, one part of the analysis focuses on whether the project's impacts would be greater in areas having higher concentrations of minority members or low-income people. Criteria to assess environmental justice issues are outlined below.

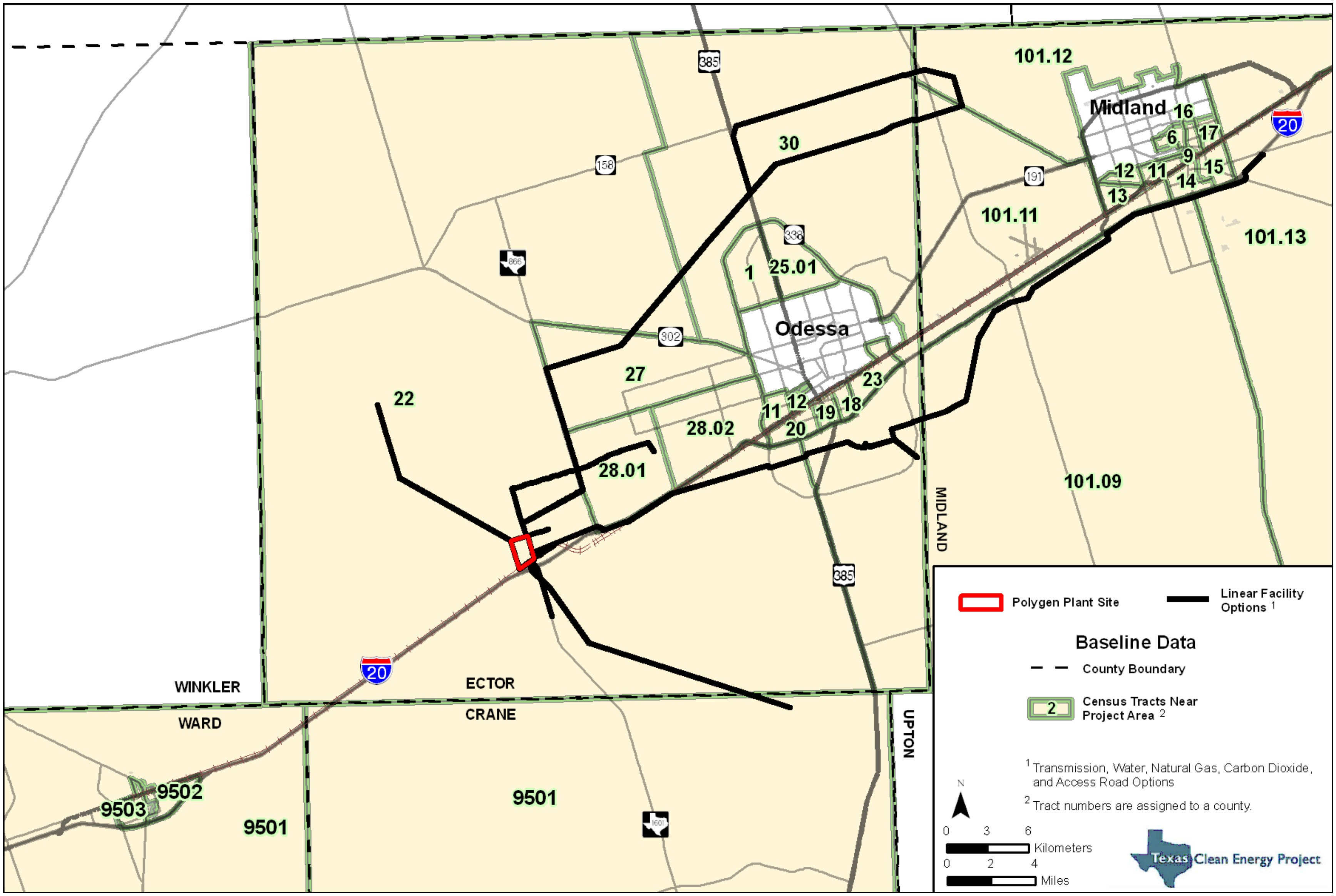

Figure 3.28. Census tracts in the region of influence.

Definition of Minority Populations

Minority populations are defined as follows:

- Minority: Individual(s) classified by Office of Management and Budget Directive No. 15 as Black/African American, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, and other nonwhite persons.
- A minority population exists where either
    - the minority population of the affected area exceeds 50 percent; or
    - the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.

A minority population also exists if there is more than one minority group present and the minority percentage, as calculated by aggregating all minority persons, meets one of the above-stated thresholds.

Definition of Low-income Population

Low-income populations in an affected area are populations below the annual, statistical poverty thresholds from the U.S. Census Bureau's current population reports on income and poverty. Families and persons are classified by the U.S. Census Bureau as "below poverty level" if their total family income or unrelated individual income is less than the poverty threshold specified for the applicable family size, age of householder, and number of related children under 18 that are present. A low-income population exists where either

- the low-income population of the affected area exceeds 50 percent; or
- the low-income population percentage of the affected area is meaningfully greater than the low-income population percentage in the general population or other appropriate unit of geographic analysis.

Disproportionately High and Adverse Human Health and Environmental Effects

Under Executive Order 12898, when determining whether human health effects are disproportionately high and adverse, agencies must consider the following three factors to the extent practicable:

- Whether the health effects, which may be measured in risks and rates, are significant, unacceptable, or above generally accepted norms (adverse health effects may include bodily impairment, infirmity, illness, or death).
- Whether the risk or rate of hazard exposure by a minority population or low-income population to an environmental hazard is significant and appreciably exceeds or is likely to appreciably exceed the risk or rate to the general population or other appropriate comparison group.
- Whether health effects occur in a minority or low-income population affected by cumulative or multiple adverse exposures from environmental hazards.

Similarly, when determining whether environmental effects are disproportionately high and adverse, agencies are to consider the following three factors to the extent practicable:

- Whether there is or would be an impact to the natural or physical environment that significantly and adversely affects a minority population, low-income population, or Indian tribe. Such effects may include ecological, cultural, human health, economic, or social impacts on minority communities, low-income communities, or Indian tribes when those impacts are interrelated to impacts on the natural or physical environment;
- Whether environmental effects are significant and are or may have an adverse impact to minority populations, low-income populations, or Indian tribes that appreciably exceeds or is likely to appreciably exceed those on the general population or other appropriate comparison group; and
- Whether the environmental effects occur or would occur in a minority population, low-income population, or Indian tribe affected by cumulative or multiple adverse exposures from environmental hazards.

The impacts analysis for environmental justice used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. Indicators for the environmental justice analysis are summarized in Table 3.41.

Table 3.41. Indicators of Potential Environmental Justice Impacts

Potential Impact	Impact Indicator
Disproportionate impacts to low-income or minority populations (federal agencies are required to address environmental justice when implementing their respective programs).	Identification of populations considered low income and/or minority in the ROI and that would be adversely affected by the proposed TCEP. Distribution of adverse effects on the above populations.

3.13.4 Affected Environment

3.13.4.1 MINORITY AND/OR LOW-INCOME POPULATIONS IN THE REGION OF INFLUENCE

Minority Communities

There are six census tracts in Ector County (census tracts 11, 12, 19, 20, 22, and 28.01), three census tracts in Midland County (14, 16, and 17), and one census tract in Ward County (9503) in which the minority population exceeds 50 percent. In addition to those census tracts, there are four census tracts in Ector County, six census tracts in Midland County, one census tract in Crane County, and two census tracts in Ward County in which the minority populations exceed the state's minority population of 32 percent. The minority populations are primarily Hispanic or Latino.

Low-income Populations

According to the Current Population Report of 2000, the national poverty rate in 2000 was 11.3 percent (U.S. Census Bureau 2000). In the ROI, all of the census tracts in Ector County, seven census tracts in Midland County (9, 11, 14, 15, 16, 17, and 101.09), one census tract in Crane County (9501), and all of the census tracts in Ward County had at least 50 percent of the population identified as individuals or families living below the national poverty level.

3.13.5 Environmental Impacts of Summit's Proposed Project

This section discusses the potential for disproportionately high and adverse impacts on minority or low-income populations as a result of the construction or operation of the TCEP. Twenty-three of the 26 census tracts in the ROI are minority and/or low-income communities. Eleven of those are located in Ector County (1, 11, 12, 18, 19, 20, 22, 27, 28.01, 28.02, and 30), nine in Midland County (9, 11, 12, 13, 14, 15, 16, 17, and 101.9), one in Crane County (9501), and all three in Ward County (9501, 9502, and 9503).

In terms of air quality, project emissions during construction and operation would not contribute to exceedances of NAAQS and would not be expected to cause significant air quality or human health impacts (Section 3.3.6). No long-term impacts to surface water or ground water from the construction or operation of the TCEP would occur, as discussed in Chapters 3.6 and 3.7, respectively. Construction activities would cause a temporary decrease in the level of service (LOS) on FM 866 because construction activities would use this road for access to the project area (see Section 3.16). Although some decrease in LOS would likely occur as a result of construction of the polygen plant, this decrease would not constitute a disproportionately high and adverse impact. Construction activities would produce increased noise levels from commuter and construction-vehicle traffic, construction-equipment operation, and steam-venting during polygen plant startup (see Section 3.19.4); however, these increased noise levels would not have disproportionately high and adverse effects on minority or low-income communities.

No disproportionately high and adverse impacts as a result of the TCEP's operations would occur to low-income or minority populations. Short-term beneficial impacts could include an increase in employment opportunities and potentially higher wages or supplemental income through jobs created during plant construction.

Both the construction and operation phases of the TCEP would disproportionately affect minority and or low-income communities in regard to housing availability and cost, utility rates, or safety issues associated with increased traffic.

3.13.6 Mitigation

Mitigation measures that Summit would implement as part of the construction and operation of the TCEP are described in Table 2.8 of Chapter 2. No additional mitigation measures specific to environmental justice would be necessary for the proposed project.

3.14 Community Services

3.14.1 Background

This section describes the existing community services (law enforcement, emergency response, health services, schools, and recreation) and anticipated impacts to those services as a result of construction and operation of the TCEP.

3.14.2 Region of Influence

The ROI for community services is Ector, Midland, Crane, and Ward Counties. These are the counties in which the proposed polygen plant and associated linear facilities would be located and in which DOE expects almost all construction and operations workers would live. The same ROI was used for the socioeconomic impacts analysis.

3.14.3 Methodology and Indicators

DOE used data from county websites and the TPWD website to analyze the potential impacts of the proposed TCEP on local community resources. The impacts analysis for community services used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. Potential impacts and their indicators are shown in Table 3.42.

Table 3.42. Indicators of Potential Impacts to Community Services

Potential Impact	**Impact Indicator**
Demands on or effective access to law enforcement, local and regional emergency response entities, and health services; conflict with local and regional plans for law enforcement, emergency response services, and health services	Increase in population as measured against calculated population that existing infrastructure and workforce resources could support
Enrollment in local school system, or conflict with local and regional plans for school system capacity and enrollment	Increase or decrease in school enrollment as measured against calculated capacity of local school system
Impacts to existing recreational areas and facilities such as trail networks or local and regional recreational areas and facilities	Increase or decrease of miles of trail or number of acres in recreational areas Changes in recreational experiences due to noise, light, or air pollution impacts Changes in recreational experience due to visual impacts.
Population changes due to TCEP construction or operation could affect local and regional recreational areas, facilities, and/or trails, such as the Monahans Sandhills State Park	Increase or decrease in visitor use days for recreational areas, facilities, and/or trails

3.14.4 Affected Environment

3.14.4.1 LAW ENFORCEMENT

The Ector County Sheriff's Department, Odessa Police Department, and Midland Police Department provide law enforcement in Ector County. The Sheriff's Department has 201 employees, of which 90 are sworn peace officers (Ector County Sheriff's Office 2010). The Odessa Police Department consists of 170 sworn personnel and 59 civilian personnel. The City of Midland's Police Department has 172 law enforcement officers. Based on 2009 population data, there are approximately 0.5 law enforcement officers per thousand Ector County residents.

The Midland County Sheriff's Department provides law enforcement in Midland County. The Sheriff's Department has 15 patrol deputies (Midland County Sheriff's Office 2010). There are approximately 0.1 officers per thousand Midland County residents.

The Crane County Sheriff's Department and the Crane Police Department provide law enforcement in Crane County. The Sheriff's Department has nine law enforcement officers (Crane County Sheriff's Office 2010), and the Crane Police Department has five law enforcement officers (Crane Police Department 2010). There are approximately 2.2 officers per thousand Crane County residents.

The Ward County Sheriff's Department and the Monahans Police Department provide law enforcement for Ward County. The Sheriff's Department has 17 law enforcement officers, three of whom are reserves (Ward County Sheriff's Office 2010). The Monahans Police Department has 11 officers (City of Monahans 2010). There are approximately 0.001 law enforcement officers per thousand Ward County residents.

3.14.4.2 EMERGENCY RESPONSE SERVICES

In Texas, the Councils of Government are associations of local county governments that work together to solve regional issues and planning needs. Emergency response and fire protection, in particular, are managed by the Councils of Government. All counties in the ROI are members of the Permian Basin Regional Planning Commission's 9-1-1 Program, which also serves 10 other member counties. The 9-1-1 Program is responsible for 911 emergency management throughout the commission's boundaries. The program is used to dispatch ambulances and fire, rescue, and emergency medical personnel from various locations throughout its member counties. There are numerous emergency medical and ambulance services in the ROI, mostly located in Ector and Midland Counties where there are larger and more concentrated populations.

3.14.4.3 FIRE PROTECTION

The Odessa Fire Department provides emergency response support to the city of Odessa and Ector County. The Odessa Fire Department has 165 employees, of which 150 are full-time firefighters. Fire services are provided to Midland County through the Midland Fire Department, which consists of 187 personnel. The Greenwood and Northeast Midland County volunteer departments also serve the area (Fire Department Directory 2010). There is one fire station in Crane County, which is used by the Crane Volunteer Fire Department (Fire Department Directory 2010).

3.14.4.4 HAZARDOUS MATERIALS EMERGENCY RESPONSE

All of the counties in the ROI have hazardous materials units. These units respond and perform functions to handle and control actual or potential leaks or spills of hazardous substances (OSHA 2010).

3.14.4.5 HEALTH SERVICES

There are seven hospitals in the ROI. Three hospitals are in Ector County: Odessa Regional Medical Hospital, Odessa Memorial Hospital, and Medical Center Hospital. Odessa Regional Medical Hospital has 230 beds, Odessa Memorial Hospital has 44, and the Medical Center Hospital has 277 (HealthGrades 2010; Hospital-Data 2010a; Odessa Regional Medical Center 2010). The Midland County Hospital District operates the Midland Memorial Hospital, which has 321 beds (Hospital-Data 2010b). The Crane County Hospital District and Crane County Rural Health Clinic serve the residents of Crane County with 28 beds (Hospital-Data 2010c). Lastly, Ward County has one hospital, the Ward Memorial Hospital, which has 49 beds (Hospital-Data 2010d).

3.14.4.6 SCHOOLS

School districts in the ROI are the Ector County Independent School District (ISD) in Ector County, the Greenwood ISD and Midland ISD in Midland County, the Crane ISD in Crane County, and the Monahans-Wickett-Pyote ISD, Pyote ISD, Grandfalls-Royalty ISD, and Pecos-Barstow-Toyah ISD in Ward County. Table 3.43 provides a summary of each district's educational statistics.

Table 3.43. 2009–2010 School Enrollment

County	District	Enrollment in 2009	Number of Schools
Ector	Ector County ISD	27,435	2 early education centers 25 elementary schools 6 junior high schools 2 high schools **Total: 35 schools**
	Private schools	n/a	0 schools
Midland	Greenwood ISD	1,652	1 primary school 1 intermediate school 1 middle school 1 high school **Total: 4 schools**
	Midland ISD	21,466	26 elementary schools 12 secondary schools **Total: 38 schools**
	Private schools	n/a	7 schools
Crane	Crane ISD	1,006	1 elementary school 1 middle school 1 high school **Total: 3 schools**

Table 3.43. 2009–2010 School Enrollment

County	District	Enrollment in 2009	Number of Schools
	Private schools	n/a	n/a
Ward	Monahans-Wickett-Pyote ISD	1,983	2 elementary schools 2 middle schools 2 high schools **Total: 6 schools**
	Grandfalls-Royalty ISD	123	Prekindergarten to grade 12 **Total: 1 school**
	Pecos-Barstow-Toyah ISD	2,198	1 kindergarten 2 elementary schools 1 middle school 1 high school **Total: 4 schools**

Source: Texas Education Agency (2010).
Note: n/a = not available.

As shown in Table 3.43, Ector County ISD has the highest enrollment in the ROI at 27,435 students followed by Midland ISD with 21,466 students, and Grandfalls-Royalty ISD in Ward County has the lowest at 123 (Texas Education Agency 2010).

3.14.4.7 RECREATION

In the ROI, there are 80 county and city parks that offer recreational opportunities to nearby residents. In Ector County, there are 30 parks that are located in Odessa and one located in Douro. There are 49 county parks in Midland County and one county park in Crane County.

The closest recreation area to the proposed polygen plant site is the Penwell Knights Raceway, an active public drag strip located along FM 1601 on the south side of I-20, approximately 0.8 mi (1.3 km) southeast of the proposed plant site in Ector County. The 3,840-ac (1,554-ha) Monahans Sandhills State Park is located approximately 15 mi (24 km) from the proposed polygen plant site in Ward and Winkler Counties. Recreational activities in the park include camping, hiking, and sand surfing. Monahans Sandhills State Park hosts approximately 25,000 visitors per year and provides recreational infrastructure such as developed campsites, a mile-long hiking trail, shaded picnic areas, and an interpretive visitor's center.

3.14.5 Environmental Impacts of Summit's Proposed Project

3.14.5.1 LAW ENFORCEMENT

DOE assumes that all workers for the construction phase of the TCEP would already reside in the ROI. For the operations phase, DOE assumes that most of the workers would be from the ROI and those who were not would commute or relocate to the ROI. Thus, construction and operation of the

TCEP would result in a very small increase in population (0.05 percent) over current levels; for this reason, no impacts to the capacity of local law enforcement would occur.

3.14.5.2 EMERGENCY RESPONSE SERVICES

It is estimated that during the three-year construction period of the TCEP, there would be 91.65 recordable nonfatal incidents and no (0.19) fatalities (see Section 3.18). During operations, it is estimated that there would be 5.25 nonfatal recordable incidents occurring annually and no (0.01) fatalities. Based on the number of emergency response agencies throughout the ROI, and in particular in Ector County, the proposed polygen plant and linear facilities would be adequately served in an emergency during the construction and operations phases of the project. In addition, a very small increase in the existing population as a result of potential workers relocating to the ROI for the TCEP operation phase would have a negligible impact to demand for these services.

As a result of the TCEP, there would be an increase in traffic to and from the proposed site due to commuters for both the construction and operation phases, as well as the transport of potable water and construction materials during the construction phase. There would be an increase in traffic volume, and as a result, potential delays in emergency response time could occur ranging from three to five minutes (see Section 3.18).

3.14.5.3 FIRE PROTECTION

Although incidents that require fire protection services could occur during the construction or operation of the proposed polygen plant, the TCEP would have its own on-site fire protection capability. Any of the local fire departments would also be able to assist in a fire emergency if needed. The very small potential increase in population due to worker relocation to the ROI for the TCEP operation phase would have a negligible impact to demand for fire protection services.

3.14.5.4 HAZARDOUS MATERIALS EMERGENCY RESPONSE

The TCEP would also have its own on-site hazardous materials emergency response capability. Any incidents that may occur at the proposed polygen site would not increase the demand of existing hazardous materials units in the area. Hazardous materials units from counties in the ROI would be able to assist in an emergency if needed.

3.14.5.5 HEALTH SERVICES

Hospitals close to the proposed polygen site include Odessa Regional Medical Hospital, Odessa Memorial Hospital, Medical Center Hospital, and Midland Memorial Hospital. Should injuries occur as a result of the TCEP during the construction or operation phases, there would be enough beds and availability of medical facilities to assist in an emergency. The very small increase in population expected as a result of TCEP operations would not affect the capacity of health services in the ROI.

3.14.5.6 SCHOOLS

As noted above, all construction workers would reside in the ROI. DOE also assumes that most operations workers would reside in the ROI and that a few would commute from areas outside the ROI or relocate to an area in the ROI. However, any increases to the existing population resulting from TCEP operations would be negligible. For this reason, only a very small increase in school enrollment would be expected in the ROI, and no increased burden on the school systems is anticipated.

3.14.5.7 RECREATION

Any increase in the population of the ROI as a result of the TCEP would be negligible; therefore, population-related impacts to recreation (including nearby city, county, and state parks, as well as the Penwell Knights Raceway) are not anticipated. Due to the distance of Monahans Sandhills State Park from the polygen plant site and the expectation of no project-induced changes in local or ROI population, the recreational experience is not expected to be affected.

3.14.6 Mitigation

Mitigation measures that Summit would implement as part of the construction and operation of the TCEP are described in Table 2.8 of Chapter 2. Because no impacts would occur, no additional mitigation measures specific to community services would be necessary.

3.15 Utility Systems

3.15.1 Background

This section identifies utility systems that may be affected by construction and operation of the proposed polygen plant and related linear facilities. It addresses the ability of the existing utility infrastructure to meet the needs of the proposed TCEP without interrupting services provided to existing users. The section also addresses the potential for construction-related impacts to existing utility infrastructure.

3.15.2 Region of Influence

The ROI for utility systems consists of 1) the existing infrastructure that provides process and potable water, sanitary waste water treatment, electricity, CO_2, and natural gas to nearby existing users and that would provide service to the proposed project; and 2) the pipelines, transmission lines, and other utility lines that lie within or cross the proposed polygen plant site or linear facilities. This existing infrastructure is or would be located in Ector, Midland, Crane and Ward Counties.

Utility systems for potable water are not addressed because potable water would be supplied by truck. Similarly, utility systems for fire suppression are not addressed because such requirements would be met by process water stored on-site, and industrial and sanitary waste water systems are not addressed because such wastes would be managed on-site.

3.15.3 Methodology and Indicators

DOE compared the expected TCEP utility needs to the existing utility infrastructure capacity to determine if the proposed project would strain any of the existing systems. DOE also identified the presence of utility infrastructure that could be affected by project construction using aerial photography, pre-existing studies, Public Utility Commission of Texas regulations and data, and TCEP conceptual design reports. The pre-existing studies include the Environmental Information Volume and EIS documents prepared for the FutureGen EIS (DOE 2007).

The impacts analysis for utility systems used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. Potential impacts and their indicators are shown in Table 3.44.

Table 3.44. Indicators of Potential Impacts to Utility Systems

Potential Impact	Impact Indicator
Potential uses that could exceed current capacity of utility systems, that would require system upgrades, or that would affect other utility users	Capacity quantities
Temporary failure/impacts to utilities due to direct contact with existing infrastructure during construction	Acreage areas associated with construction only

All routing options for the process water and transmission line linear facilities and the natural gas and CO_2 pipelines were considered.

3.15.4 Affected Environment

The proposed project area is located in a rural area where land use has historically been and currently is dominated by oil and gas activities and cattle ranching. Some existing utility systems in the ROI have been in place for many years. More recently, newer systems have been constructed in response to continued development in the region. Combined, these utility systems serve the needs of the Odessa–Midland area, as well as oil and gas operations throughout West Texas.

3.15.4.1 PROCESS WATER

Existing water sources in West Texas are used for a variety of activities related to oil and gas activities and agriculture and livestock use. No water pipelines are currently located on the proposed polygen plant site.

Process water required for the TCEP, as illustrated on Figure 2.7 in Chapter 2, could come from the following three potential sources:

- The primary water source would be treated effluent from the GCA Odessa South facility. Much of the water provided by GCA would be made up of waste water received at the GCA Odessa South Facility from the City of Midland Wastewater Treatment Plant. This water source, which would be used by WL1, would make beneficial use of treated effluent and would not use any other surface or ground water sources.
- WL2 would receive brackish ground water from the existing Oxy Permian company.
- WL3 and WL4 would receive slightly brackish ground water from the proposed FSH water mainline, which is proposed to be built from Fort Stockton to the Odessa–Midland area.

Existing conditions for each water supply system are described below.

The City of Midland Wastewater Treatment Plant currently provides primary treatment to the city's effluent prior to land application on agricultural fields. The treatment plant treats approximately 10 million gal (37.8 million L) per day on average (Womack 2010). The current maximum capacity of the waste water treatment plant is 21 million gal (79 million L) per day (City of Midland 2011). Treated effluent is currently pumped to city-owned agricultural lands approximately 15 mi (24 km) away and is applied through several center-pivot irrigation systems to hayfields on two farms, the Plant Farm and the Spraberry Farm. The city pays for the fields to be cultivated and the hay to be harvested (Summit 2010c). The effluent farm is currently permitted to handle up to 20 million gal (75 million L) per day of waste water (City of Midland 2011).

The GCA Odessa South Facility uses an activated sludge treatment process to treat both municipal sewage from the city of Odessa (approximately 2.0 million gal [7.5 million L] per day) and industrial waste water (GCA 2010). GCA's current capacity (as limited by its discharge permit) is 7.0 million gal (26.5 million L) per day; on average, the plant treats 2.0 million gal (7.5 million L) per day (Summit 2010c). GCA has a minimum required discharge rate of approximately 2.0 million gal (7.5 million L) per day into Monahans Draw. GCA currently has no water reuse customers; all treated effluent is currently discharged into Monahans Draw. The Oxy Permian water supply system is a network of pipelines providing ground water from a well field near the town of Kermit, Texas, for EOR water flood projects in the Permian Basin. Ground water from this source, the Capitan Reef Complex Aquifer, is brackish and would require additional treatment prior to use for the TCEP. In the 1960s, this aquifer was capable of producing at a rate of 25.2 million gal (95.4 million L) per day; however, with the significant reduction in demand for water flood make-up water in the oilfields of West Texas, heavy demand no longer exists (Smith 2010).

Currently in the developmental stage, the main FSH waterline project has been proposed to provide drinking water to the cities of Midland and Odessa. The TCEP could use approximately 10 percent of the total water that would be available through the FSH water mainline, if it were built. The FSH water source would be ground water from the Edwards-Trinity (High Plains) Aquifer located near the city of Fort Stockton, which is approximately 66 mi (106 km) southwest of the proposed TCEP area. FSH is permitted to pump up to 14 billion gal (54 billion L) or 44,100 ac-ft per year (Thornhill Group, Inc. 2008). The water that would be used by the TCEP is currently used for irrigation and would come from the water that is already being used for irrigation. This source would also require additional treatment prior to use for the TCEP.

3.15.4.2 TRANSMISSION LINES

There are no transmission lines located on the proposed polygen plant site. Power produced by the TCEP could go to the following two potential market sources:

- ERCOT, which manages the flow of electric power to 22 million Texas customers, including the Odessa–Midland area. ERCOT is one of nine regional electric reliability councils under North American Electric Reliability Corporation authority.
- SPP, which is a regional transmission organization that provides service to more than 370,000 mi^2 (595,457 km^2), including portions of Texas. SPP is also one of nine regional electric reliability councils under North American Electric Reliability Corporation authority.

The need for upgrades to the existing transmission grid to handle the additional power from the TCEP will be determined by interconnection studies currently be conducted.

Information regarding the capacity of the existing transmission systems to carry the power from the TCEP is not currently available and is the subject of ongoing transmission line routing and compatibility studies.

Oncor is the primary transmission and utility distribution company in the ERCOT market. TL1 through TL4 would interconnect with existing Oncor transmission lines located 9.3 mi (15.0 km), 8.6 mi (13.8 km), 2.2 mi (3.5 km), or 0.6 mi (1.1 km) away from the proposed polygen plant site, respectively. Competitive Renewable Energy Zones for the development of wind power have been designated in areas of Texas's ERCOT system. Under TL4, the proposed TCEP would interconnect with a 138-kV line located approximately 0.6 mi (1.1 km) north of the proposed plant site. Because this existing transmission line has been designated as a Competitive Renewable Energy Zones support transmission line (Public Utility Commission of Texas 2010), the compatibility of TL4 with Competitive Renewable Energy Zones–supported transmission lines is currently being evaluated as part of the transmission line routing and compatibility studies being conducted by Oncor.

Transmission lines maintained by Southwestern Public Service Company (a subsidiary of Xcel Energy) that offer connection to the SPP market are located 36.8 mi (59.2 km) and 32.8 mi (52.8 km), respectively, from the proposed polygen plant site (TL5 and TL6, respectively).

3.15.4.3 NATURAL GAS PIPELINE

No natural gas pipelines are currently located on the proposed polygen plant site (only connector and spur are present [oil pipelines occur on the proposed polygen plant site]). An existing 24-in (60-cm) natural gas pipeline owned and operated by ONEOK WesTex is located approximately 2.7 mi (4.3 km) south of the proposed polygen plant site; it would be the tie-in point for a natural gas lateral to supply the polygen plant.

The ONEOK WesTex system consists of approximately 2,380 mi (3,830 km) of pipeline of various sizes up to 24 in (60 cm) in diameter. The system operates at pressures up to 1,200 lbs (544 kg) per in^2 gauge and has a peak day capacity of 750 million ft^3 (70 million m^3) per day. The pipeline is connected to major natural gas–producing areas in the Texas Panhandle, Waha Hub, and Permian Basin (ONEOK 2010). The existing ONEOK pipeline has the capacity to supply the needed volume of natural gas required for the project (Randall 2010).

3.15.4.4 CARBON DIOXIDE PIPELINE

No CO_2 pipelines are currently located on the proposed polygen plant site. An existing 24-in (60-cm) CO_2 pipeline owned by Kinder Morgan runs north–south approximately 1.0 mi (1.6 km) east of the proposed polygen plant site. The pipeline is currently operating at a pressure of approximately 2,000 lbs (907 kg) per in^2 with a maximum operating pressure for this section of the pipeline at 2,300 lbs (1,043 kg) per in^2 (Hattenbach 2011). This pipeline begins in northeast New Mexico at Bravo Dome, where there are more than 300 CO_2 wells, and travels south to Texas to support various oil and gas operations throughout the Permian Basin (Kinder Morgan 2010b). As the largest transporter and marketer of CO_2, Kinder Morgan owns interests in CO_2 pipelines that deliver more than 1.5 billion ft^3 (139 million m^3) per day to the Permian Basin, Utah, and Oklahoma (Kinder Morgan 2010b). As part of the TCEP, a CO_2 connector pipeline would be constructed between the polygen plant site and the existing Kinder Morgan CO_2 pipeline. The existing Kinder Morgan CO_2 pipeline has the capacity to accept all of the CO_2 produced by the project (Hattenbach 2011), although injection of additional CO_2 would require Kinder Morgan to balance the inputs and outtakes along the system (Hattenbach 2011).

3.15.5 Environmental Impacts of Summit's Proposed Project

3.15.5.1 CONSTRUCTION

Existing utilities would not be adversely impacted by construction activities at the polygen plant site. No known transmission lines, natural gas transmission pipelines, cables, or sanitary sewer lines or waterlines occur on the proposed polygen plant site; however, several oil and gas collector pipelines and two active wells are present on-site. Summit would work with the owners of the active collector pipelines and active wells to relocate these facilities, as necessary, to avoid interference with the construction and operation of the proposed project.

Existing utilities infrastructure could inadvertently be damaged or have service disrupted during construction of the linear facilities. The ROWs for the linear facilities would include intersections with existing potable water and sewer lines, overhead or buried transmission lines, gas utility lines, fiber optic cables, and other utility system facilities. The potential for inadvertent damage or service disruption during construction would vary based on proposed construction methods and proximity of the proposed linear facility to existing utility systems, but would be greatest during trenching activities.

All linear facility ROWs would be of sufficient width and access to allow for the safe construction of project-related transmission lines and pipelines without interfering with existing utilities. Construction would include controls and prudent construction procedures (e.g., the identification and marking of all existing utility infrastructure in the work areas) to further reduce impacts to existing utilities. Prior to construction, the construction contractor would perform reconnaissance surveys and would record, delineate, and flag the locations of all utility lines in the proposed linear facility ROWs. During construction, controls such as hand digging of trenches in select areas would decrease the potential for construction equipment, particularly trenching equipment, to sever or damage existing underground lines.

Table 3.45 provides a summary of the construction method for each proposed linear facility option, as well as its estimated length and the number of pipelines and transportation ROWs that could be intersected.

Table 3.45. Proposed TCEP Linear Facilities Intersections to Existing Utility Systems

TCEP Linear Facility	Construction Method	Distance (mi [km])	Number of Known Pipeline ROW Crossings*	Number of Transportation ROW Crossings
Process waterline options	Machine trenching would be used in areas that do not intersect existing utility lines.	WL1: 41.2 (66.3) WL2: 9.3 (15.0) WL3: 14.2 (22.8) WL4: 2.7 (4.3)	WL1: 40 WL2: 11 WL3: 13 WL4: 2	WL1: 9 WL2: 9 WL3: 2 WL4: 2
Transmission lines options	No trenching would be required for the overhead power lines. Individual support towers would require small excavations for the foundations of towers.	TL1: 9.3 (15.1) TL2: 8.6 (13.8) TL3: 2.2 (3.5) TL4: 0.6 (1.0) TL5: 36.8 (59.2) TL6: 32.8 (52.8)	TL1: 15 TL2: 13 TL3: 4 TL4: 2 TL5: 44 TL6: 41	TL1: 3 TL2: 3 TL3: 0 TL4: 0 TL5: 12 TL6: 14
CO_2 pipeline	Same as process water supply pipeline.	1.02 (1.6)	4	3
Natural gas pipeline	Same as process water supply pipeline.	2.7 (4.3)	5	0

Table 3.45. Proposed TCEP Linear Facilities Intersections to Existing Utility Systems

TCEP Linear Facility	Construction Method	Distance (mi [km])	Number of Known Pipeline ROW Crossings*	Number of Transportation ROW Crossings
Access road/rail spur	Entirely in proposed ROW. AR1 follows an existing transportation ROW; AR2 and RR1 would require new ROWs. Roads would be constructed per county standards and would be paved. Construction would include cut and fill.	AR1: 0.03 (0.05) AR2: 3.7 (6.0)	AR1: 3 AR2: 14	AR1: 0 AR2: 1

*Based on proposed linear facility temporary ROW width of 100 ft (30 m).

Because electric power transmission lines are suspended over the land surface, there would be fewer impacts to existing utility systems, even with the required construction for the support towers. Existing utility systems would be taken into account during planning of the alignments.

3.15.5.2 OPERATIONS

Polygen Plant Site

Existing utilities would not be adversely impacted by operation activities at the polygen plant site. The brine concentrator and filter press option may require the greatest use of electricity, depending on the choice of equipment, as waste heat from the power plant could be used to crystallize the salts. The solar evaporation ponds would require the least use of electricity. The wet cooling tower option would have a lower electricity demand than the dry cooling tower option. Additionally, the wet cooling tower option may potentially require a larger water supply pipeline than currently proposed under the various waterline options.

Process Water Options

Waterline Option 1

Under this option, treated sanitary effluent from the City of Midland Wastewater Treatment Plant would be piped to the GCA Odessa South Facility and ultimately to the polygen plant.

Impacts to the City of Midland Wastewater Treatment Plant

Discussions with the City of Midland indicate that there is an adequate available volume of effluent to supply the total process water needs for the proposed project without impacting the City of Midland Wastewater Treatment Plant (CH2M Hill 2010). The city currently disposes of treated effluent through application on city-owned effluent farms. It is currently unclear if the city would continue to reserve a portion of treated effluent for this practice, although both the treatment plant and the two effluent farms have considerable more capacity than is currently being used (see Section 3.15.4.1). Providing Midland's treated effluent to the TCEP would permit the city to continue to operate without a discharge permit and potentially reduce or eliminate the costs of maintaining the agricultural activities associated with current effluent disposal.

Impacts to the GCA Odessa South Facility

The GCA Odessa South Facility has a treatment capacity of 7.0 million gal (26.5 million L) per day and is currently treating 2.0 million gal (7.5 million L) per day, which includes a required discharge of 2.0 million gal (7.5 million L) per day into Monahans Draw. The specific quantity of effluent to be transferred from Midland to the GCA is currently being negotiated by those two entities. The City of Midland has expressed an intention to provide at least an amount that would allow GCA to fully supply the TCEP while not decreasing the current discharge rates into Monahans Draw (Ganze 2011). The process water would come from one of two approaches: 1) a combination of treated effluent from the GCA Odessa South Facility and untreated effluent from the City of Midland Wastewater Treatment Plant, which would be piped to and treated at the GCA Odessa South Facility; or 2) entirely from the City of Midland Wastewater Treatment Plant, which also would be piped to and treated at the GCA Odessa South Facility before being piped to the polygen plant site. Either approach would provide an adequate volume of treated effluent to supply the maximum TCEP water usage demand of 5.5 million gal (20.8 million L) per day while maintaining the current discharge to Monahans Draw of 2.0 million gal (7.5 million L) per day including during drought conditions (Ganze 2011).

Under WL1, all of the process water demands for the TCEP would be supplied by municipal reuse water; no other surface or ground water sources would be used. The GCA Odessa South Facility would be able to make use of more of its full treatment capacity at the Odessa South Facility.

Waterline Option 2

Under this option, water would be piped to the polygen plant from the existing Oxy Permian pipeline system where it would be treated on-site. This option would have no impacts on existing water treatment utility systems.

Oxy Permian has determined it can meet its current water needs while supplying 5.0 million gal (18.9 million L) per day of water to the TCEP with no significant upgrades to their system (Smith 2010). Therefore, there would be no impacts to the system under average or maximum TCEP water usage conditions.

Waterline Option 3

Under this option, water would be supplied from the proposed FSH water mainline. The TCEP would require approximately 10 percent of the expected capacity of the FSH waterline (Brock 2011). Under this option, FSH water would be treated on-site; therefore, this option would have no impacts on existing water treatment utility systems.

Waterline Option 4

Under this option, water from FSH would be piped to the GCA Odessa South Facility for treatment and then piped to the polygen plant. Supplementing GCA process water supply with only enough FSH water to meet the TCEP's needs would result in the same impacts to the GCA Odessa South Facility described for WL1.

Transmission Line Options

TCEP operations would result in approximately 213 MW of electricity entering the power grid, which would provide needed electricity supply to the existing utility system.

Electric Reliability Council of Texas Grid

Summit is working with Oncor to develop an interconnection agreement for the TCEP. A detailed interconnection study is being prepared by Oncor, which will identify any required system improvements necessary to support the interconnection of the TCEP with the existing electric transmission grid (preferred TL4 option). TL4 would require the construction of approximately 0.6 mi (0.9 km) of a 138-kV transmission line and a switching station at the intersection with the existing transmission line. Power provided by the TCEP would help ERCOT's projected load growth. Although the interconnection study has not been finalized, some improvements to the grid may be necessary. The extent of the grid improvements would be refined when the interconnection study is complete.

The interconnection study will provide a preliminary identification of any thermal or voltage limit violations resulting from the interconnection, a preliminary identification of network upgrades required to deliver the proposed generation to ERCOT loads. The interconnection study will assess the current and projected future power flow dynamics of the ERCOT system both with and without the TCEP. The interconnection study will include the most recent information for load, generation additions, transmission additions, interchange, and other pertinent data necessary for analysis.

As part of the interconnection study, ERCOT will determine what upgrades would be required to deliver the output of the project to SPP load customers. Potential infrastructure upgrades may include new and/or upgraded switch stations, upgraded substation at the point of interconnection, upgrading conductors and/or structures on existing transmission lines, and other system infrastructure.

The use of Oncor's transmission line could have indirect impacts to Competitive Renewable Energy Zones projects if the Oncor line does not have additional capacity. Additionally, transmission line projects currently in planning phases could be completed by the time the proposed TCEP is constructed, which would improve the utility system's ability to efficiently move wind and solar-generated electric power to market even further (Oncor 2010). If the planned improvements are completed, no impacts to Competitive Renewable Energy Zones would be expected.

Southwest Power Pool Grid

SPP is currently conducting a similar interconnection study to determine what impacts interconnecting the TCEP under TL5 and TL6 would have on the existing SPP transmission system infrastructure. The interconnection study will evaluate impacts of the TCEP on the overall stability of the existing SPP grid and what system upgrades may be required as a result.

The purpose of the interconnection study is to identify solutions to resolve power flow, stability, and short circuit impacts potentially resulting from the interconnection of the TCEP. In addition, the interconnection study will identify the necessary facilities required to interconnect the new generating plant to the SPP transmission system. The interconnection will also provide estimates of the cost and in-service schedules for these items. The identification of limitations or required network upgrades and an assessment of current and future power flow dynamics would also occur similar to the ONCOR interconnection study.

Natural Gas Pipeline

The TCEP requirement of 2 trillion Btu annually represents approximately 1 percent of the current annual available capacity of the ONEOK WesTex system; thus, no impacts would occur to this system for the operation. If the TCEP were to use natural gas for full electricity dispatch, it would require 17.5 trillion Btu annually. This represents approximately 7 percent of the available current ONEOK WesTex system capacity.

Carbon Dioxide Pipeline

The existing Kinder Morgan CO_2 pipeline has sufficient capacity and line distribution to accept and transport the TCEP's CO_2 to potential customers while simultaneously meeting the needs of existing users (Hattenbach 2011). Therefore, no impacts to the existing CO_2 system would occur.

3.15.6 Mitigation

Mitigation measures that Summit would implement as part of the construction and operation of the TCEP, including various controls and measures, are described in Table 2.8 in Chapter 2. Because no impacts to existing utility systems would occur, no additional mitigation measures have been developed.

3.16 Transportation

3.16.1 Background

This section discusses the existing roadway and railway infrastructure that would be used during construction and operation of the polygen plant and associated linear facilities. This analysis focuses on the potential short- and long-term impacts that may occur along existing interstate highways, maintained state and county roadways, municipal roadways, and railway lines in the ROI. Based on a traffic analysis conducted as part of the FutureGen EIS (a similar energy project that would have used the polygen plant site and the FM 1601 access route), DOE expects that traffic impacts as a result of the TCEP would be minor. For this reason, a full traffic analysis was not conducted as part of transportation analysis contained in this EIS.

3.16.2 Region of Influence

The ROI for the transportation analysis consists of the primary roads most likely to be used for worker commute and delivery of materials; that is, I-20, FM 866 and FM 1601, as well their exit ramps, frontage roads, or any cross streets that would be used or modified to facilitate that transport.

3.16.3 Methodology and Indicators

The impacts analysis for transportation used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. Potential impacts and their indicators are shown in Table 3.46.

Table 3.46. Indicators of Potential Impacts to Transportation

Potential Impact	Impact Indicator
Change in daily traffic volume and LOS	Volume of roadway traffic and LOS rating along existing travel ways during construction and operation of the TCEP
Change in daily railroad car volume	Volume of railway traffic along existing travel ways during construction and operation of the TCEP

Roadway LOS is a measure of the capacity road segments and intersections to manage existing vehicle traffic volume. It is determined by consideration of a variety of factors, including the average speed of all vehicles and percent time spent following slower vehicles (that is, the time that vehicles spend in platoons behind slow vehicles due to inability to pass) (TxDOT 2009a).

There are six LOS categories, designated with letters ranging from A to F, with A representing the best driving conditions (free flow, little delay) and F as the worst (congestion, long delays) (Transportation Research Board 2000). LOS A, B, or C are typically considered good operating conditions in which minor or tolerable delays of service are experienced by motorists (Transportation Research Board 2000). An adverse impact would be created if traffic generated by a proposed project increased road traffic enough to degrade the LOS to levels below good operating conditions (i.e., LOS D or worse) or cause increased traffic delays and congestion.

The number of vehicles that travel along a route in a 24-hour period is the average daily traffic, which is not adjusted for trucks or seasonal variations. The AADT includes adjustments for seasonal, weekly, daily, and hourly variations and is calculated as the number of vehicles traveling along a roadway in a year, divided by 365 days.

To assess potential TCEP impacts to the local railways, the change in daily railroad car volume during both construction and operation of the polygen plant was compared to existing conditions. The ability of the existing rail infrastructure to accommodate the increased railroad car volume was assessed. An adverse impact to railroad traffic would be created by any changes to railroad traffic that would cause delays or exceed capacity along the existing railways in region or affect traffic in the region.

3.16.4 Affected Environment

3.16.4.1 ROADWAY SYSTEM

<u>Existing Operating Conditions</u>

Highways and roadways in the ROI would be used to transport materials and workers involved in TCEP construction and operations. Based on TxDOT criteria, these roads are classified as principal arterials, minor arterials, collector roads, and local roads and streets. Principal arterials include federal interstate highways and major state highways whose function is high traffic movement and mobility with limited access. Minor arterials are roadways that connect to or interconnect principal arterials. These roads provide moderate mobility with limited access. Collectors are roads that connect local roads to arterials. They have moderate mobility and moderate access. Local roads and streets are roads that permit access to property and have high access, but limited mobility (TxDOT 2009a).

The primary access roadway to the polygen plant site would be the I-20 corridor, which runs east–west. I-20 has four travel lanes, two in each direction, a posted speed limit of 70 mi (113 km) per hour, and is designated as a Class 1 rural freeway (a principal arterial) by the U.S. Department of Transportation.

FM 1601 and FM 866 would serve as access roads connecting the polygen plant site to I-20. FM 1601 is a two-lane collector road with a posted speed limit of 55 mi (89 km) per hour. This road transects the community of Penwell in a north–south direction. North of I-20, FM 1601 terminates at CR 1216 (Avenue G), located at the southern boundary of the polygen plant site, less than 0.5 mi (0.8 km) from I-20. The intersection is controlled with a stop sign for FM 1601 traffic. To the south, FM 1601 runs under the interstate and continues southward for approximately 25 mi (40 km) until it intersects with State Highway 329. Two-way frontage roads, located on the north and south sides of I-20, allow access to Penwell and FM 1601 from the interstate using two entrance and two exit ramps, with the two exit ramps labeled Exit 101 (Figure 3.29). Traffic is controlled with four-way stop signs where the frontage roads intersect FM 1601.

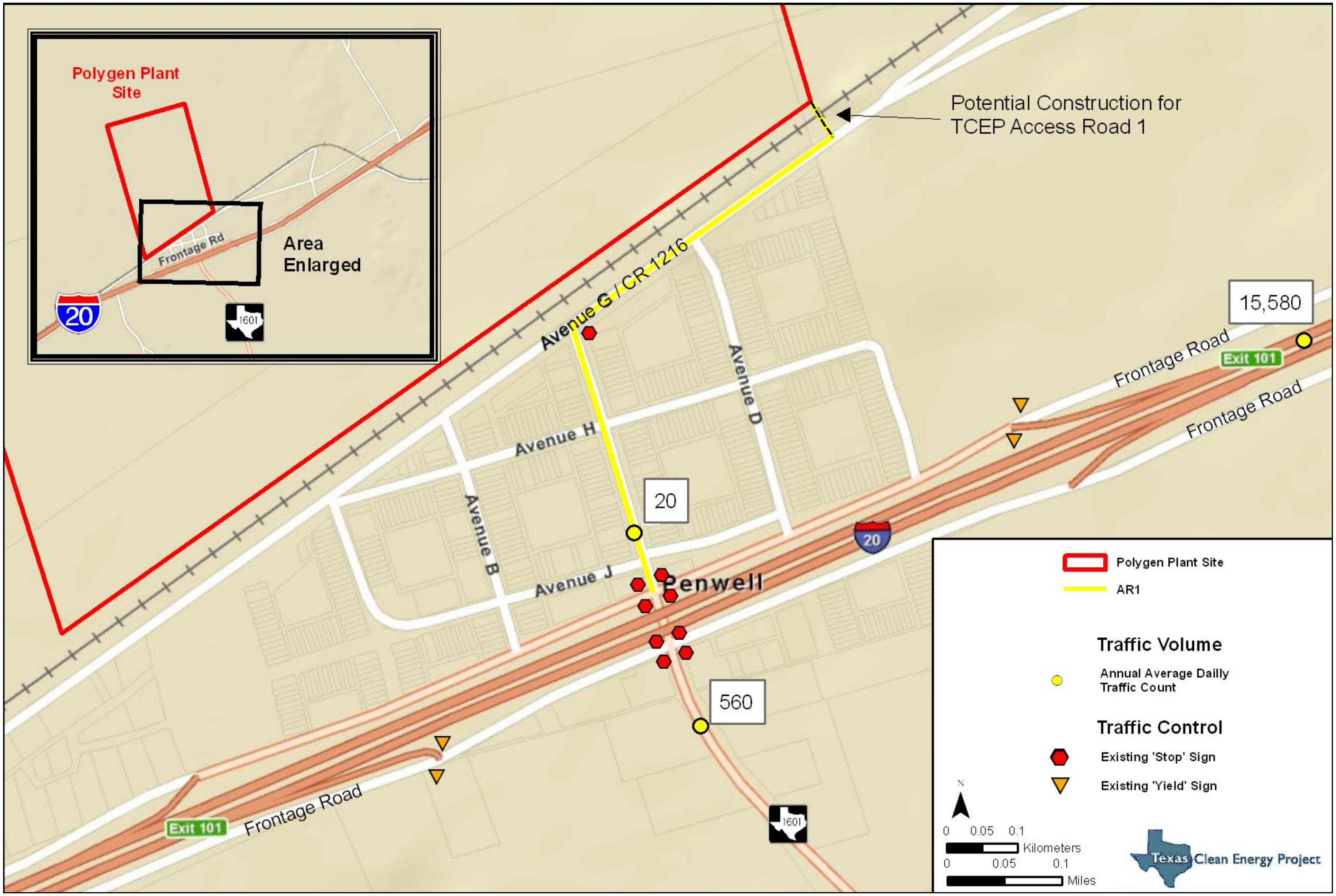

Figure 3.29. Interstate 20 exit, frontage roads, and intersection with Farm-to-Market 1601.

FM 866 is a two-lane collector road with a posted speed limit of 70 mi (113 km) per hour and is located approximately 3.0 mi (4.8 km) to the east of Penwell. FM 866 also runs in a north–south direction. North of I-20, FM 866 terminates at State Highway 158, approximately 16 mi (25 km) from the interstate and near the town of Goldsmith. To the south, FM 866 passes under I-20 and terminates in less than 1.9 mi (1.6 km) at West Murphy Street. Two-way frontage roads, located on the north and south sides of I-20, allow access to FM 866 using two entrance and two exit ramps, with the two exit ramps labeled Exit 104 (Figure 3.30). Frontage road traffic is controlled with two-way stop signs where the frontage roads intersect FM 866.

Traffic Volumes

In 2008, the AADT along I-20 was 16,100 vpd just east of the I-20 and FM 1601 interchange, and 16,700 vpd just east of the I-20 and FM 866 interchange (TxDOT 2009b). Unpublished data provided by TxDOT indicate that the AADT at the Penwell site has since dropped to 15,580 vpd (Carr 2010).

Urban traffic maps published in 2008 report an AADT of 20 vpd on FM 1601 just north of I-20 and 560 vpd south of I-20. An AADT of 200 vpd was reported on CR 1216 (Avenue G) just east of Penwell (TxDOT 2008).

The 2007 published AADT on FM 866 was 1,300 vpd, just north of both I-20 and the north side frontage road and exit ramp (TxDOT 2008). To the south of I-20 and the south side exits and frontage roads, the AADT decreases to 630 vpd. Unpublished data provided by TxDOT indicate that the AADT at northern site has since increased to 1,500 vpd (Carr 2010).

Based on the most current available traffic data, I-20, FM 1601, and FM 866 all operate at LOS A. LOS A describes traffic flow as free-flow traffic when motorists can travel at or above the posted speed limit and they have maneuverability between lanes.

Table 3.47 depicts total traffic volume and LOS for four sites closest to the TCEP proposed access roads.

Table 3.47. Annual Average Daily Traffic Volumes and Level of Service

Roadway	AADT (vpd)	LOS
I-20 east, at Penwell	15,580	A
I-20, east of FM 866 exit	16,700	A
FM 1601 north	20	A
FM 866 north	1,500	A

Sources: TxDOT (2008) and Carr (2010).

3.16.4.2 RAIL SYSTEM

The UPRR would serve the TCEP. The UPRR ROW borders the southern boundary of the polygen plant site and also forms the northern boundary of Penwell. In general, the UPRR line links major West Coast and Gulf Coast ports, as well as serving Mexico, Canada, and the U.S. East Coast through Chicago, St. Louis, Memphis, and New Orleans (Union Pacific Corporation 2010a).

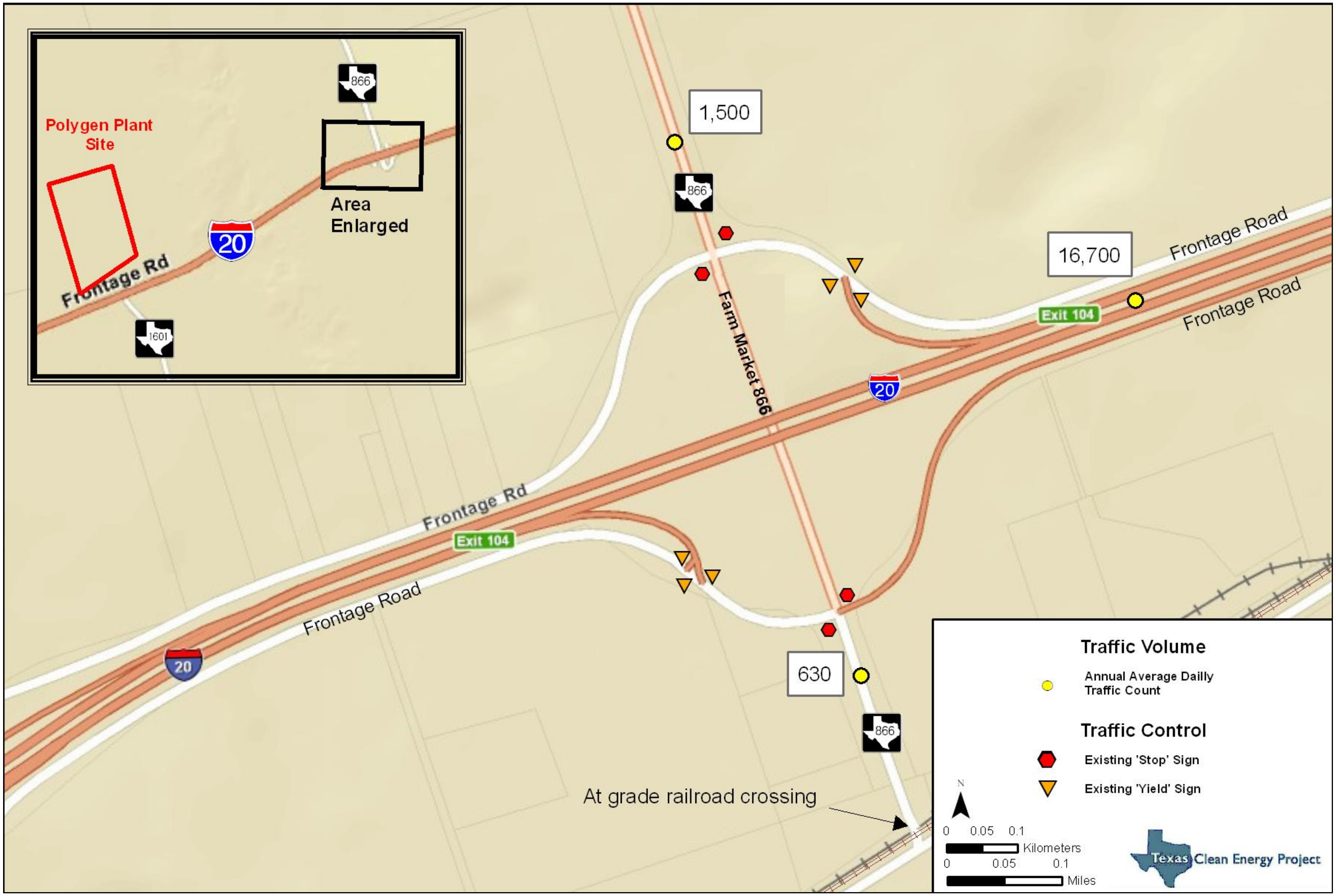

Figure 3.30. Interstate 20 exit, frontage roads, and intersection with Farm-to-Market 866.

Annually, UPRR transports over 200 million tn (181 t) in coal from the Powder River Basin in Wyoming and from other coal fields in Utah, Colorado, and southern Illinois to electric power plants across the nation, West Coast and Gulf Coast ports, and facilities on the Mississippi and Ohio Rivers and Great Lakes (Union Pacific Corporation 2010b). Powder River Basin coal is currently used in power plants located in La Grange, Sudan, Amarillo, Mount Pleasant, Fort Ben County, and Jewitt, Texas. UPRR trains of Powder River Basin coal bound for Texas destinations typically travel on rail lines passing through Wyoming, Nebraska, Kansas, and Oklahoma before reaching Fort Worth, Texas, after which trains are routed to their respective destinations (UPC 2009).

Approximately 1.5 million freight rail tn (1.3 million t) were moved through the Odessa District (a 12-county area covering Andrews, Crane, Ector, Loving, Martin, Midland, Pecos, Reeves, Terrell, Upton, Ward and Winkler Counties) in 2004, with a projected increase of 177 percent by 2025 (HNTB Corporation and TxDOT 2008). The UPRR line is the only Class I railroad (defined as one that carries large freight) and track service providing long distance and interstate fright shipments in the Odessa District, and owns approximately half of the mainline tracks in the district (HNTB Corporation and TxDOT 2008). UPRR is aware of the rail transport needs of TCEP and has included them in its company forecasts (Union Pacific Corporation 2009).

UPRR operates trains through the Odessa area 24 hours per day for the entire year (FG Alliance 2006). Near the polygen plant site, the UPRR rail line operates as a single-track mainline with 17 trains per day, seven days a week (i.e., 119 trains per week) all year (Schelbitzki 2010). There is no scheduled passenger train operation in the Odessa District (HNTB Corporation and TxDOT 2008). On the portion of the UPRR line between the polygen plant and the city of Odessa, there are 25 at-grade crossings. At-grade rail-highway crossings represent a traffic risk and can cause motor traffic delays or contribute to motor traffic bottlenecks depending on location.

3.16.5 Environmental Impacts of the Proposed Project

3.16.5.1 IMPACTS TO ROADWAY TRANSPORTATION

For purposes of this analysis, it was assumed that I-20, connecting to FM 866 at Exit 104, would function as the primary roadway access to the polygen plant (AR2) and that most workers and materials would be coming from the Odessa–Midland area. FM 1601 would function as an alternative route for emergency access (AR1); entrance to the polygen plant site by this route would be regulated by a locked gate. Summit has indicated that the maximum daily vehicular use of the FM 1601 access gate is expected to be approximately 5 percent of total TCEP traffic during construction and operations. All truck traffic would use FM 866.

Construction

Summit estimates that the project would require 26 trucks per day for construction materials during peak construction periods. Table 3.48 shows the maximum traffic increases that could be expected to result from the two-way commute of construction workers and truck traffic during construction of the TCEP. These figures include the estimated truck traffic and are based on an estimated peak yearly employment figures of 300 construction workers during year one, 1,050 construction workers during year two, and 1,500 construction workers during year three. These estimated traffic increases do not take into account carpools, shuttles, or other measures that could be taken by Summit or workers to reduce traffic, and as such, these values represent conservative estimates. For the purposes of this analysis, it is also assumed that most of the construction workers would be present on-site between approximately 7:00 a.m. and 5:30 p.m.

Table 3.48. Potential Traffic Increases During TCEP Construction

Roadway	Current AADT	Projected AADT during Year One Construction (increase [%])	Projected AADT during Year Two Construction (increase [%])	Projected AADT during Year Three Construction (increase [%])
I-20 at Penwell	15,580	15,660 (1)	15,685 (1)	15,730 (1)
I-20, east of FM 866 exit	16,700	17,350 (4)	18,840 (13)	19,750 (18)
FM 866	1,500	2,120 (41)	3,535 (136)	4,400 (193)
FM 1601	20	50 (150)	125 (525)	170 (750)

During TCEP construction, there would be increased traffic volume along I-20, FM 866, and FM 1601 caused by daily construction worker commuting, and trucking of construction materials and waste products into and out of the polygen plant site. Daily traffic volume along I-20 from Odessa to the FM 866 exit would experience a 4–18 percent increase in average daily traffic during the three-year construction period. The increase in the daily traffic volume along I-20 from FM 866 to FM 1601 during the construction period would be approximately 1 percent.

Projected use of FM 866 for 95 percent of total TCEP construction traffic would represent a 41-, 136-, and 193-percent increase over current traffic for Years One, Two and Three, respectively. During periods of higher construction employment, using FM 866 as the primary access route to the polygen plant could result in traffic delays along the exit ramp of I-20 (Exit 104), as traffic slowed to the 30 mi (48 km) per hour exit ramp speed. Upon exiting I-20, ramp traffic would need to merge with the existing traffic on the frontage road (controlled by a yield sign for existing frontage road traffic) but would come to a complete stop at the intersection with FM 866 before turning north. Because this is a two-way stop for frontage road traffic only, existing traffic on FM 866 would not stop to facilitate entry of TCEP traffic onto FM 866. TCEP commuters and truck traffic would also have to turn across opposing FM 866 traffic to enter the polygen plant site access road. Each of these slowing/stopping points could result in an increase in percent time spent following slow vehicles, a key indicator in determining LOS. The traffic route would be reversed as workers left the polygen plant site at the end of the workday. However, workers would not cross opposing FM 866 traffic and would have no stopping points along the route, other than yielding to opposing traffic before turning onto the eastbound I-20 entrance ramp.

The use of FM 866 as primary access to the polygen plant site from I-20 would entail the construction of a 3.7-mi (6-km) access road leading from the polygen plant site to FM 866. This route would be constructed at the beginning of plant construction. This could result in temporary localized traffic delays during construction of the access road, as well as an increase in traffic due to road construction workforce and equipment.

Use of FM 1601 as an emergency and secondary access to the polygen plant site during construction would also result in changes to existing roads and traffic conditions. This access option would require construction of either an at-rail-grade crossing or a below-rail underpass at the UPRR rail line. Because the rail line is elevated, construction of an at-rail-grade crossing would require a redesign and reconstruction of a portion of the existing CR 1216 (Avenue G) to raise the roadway up to rail level. Construction activities would result in temporary localized traffic delays and a potential rerouting of CR 1216 (Avenue G) traffic during construction.

Projected use of FM 1601 for 5 percent of total TCEP construction traffic would represent a 150-, 525-, and 750-percent increase over current traffic for Years One, Two and Three, respectively. Depending on the timing of this traffic, there could be delays along the frontage road, the intersection between the frontage road and FM 1601 (which is controlled by a four-way stop sign), or the intersection of FM 1601 and CR 1216 (Avenue G) (which is controlled by a stop sign for FM 1601 traffic only). If an at-rail-grade crossing is constructed as part of the proposed access road, passing trains would result in an additional three- to five-minute delay to traffic.

Operations

Table 3.49 shows the maximum traffic increases that could be expected to result from the two-way commute of workers and truck traffic during polygen plant operations. These figures are based on approximately 150 workers (Summit 2010a) commuting primarily on FM 866. FM 1601 would remain a secondary access route with a use of approximately 15 vpd. All truck traffic would use FM 866. Approximately 21 trucks a day would be required for delivery of potable water and removal of slag. If slag is removed from the site by rail, truck traffic would be reduced to one truck per day.

Table 3.49. Potential Traffic Increases during TCEP Peak Operation

Roadway	Current AADT	Projected AADT	Increase (%)
I-20, at Penwell	15,580	15,595	<1
I-20, east of FM 866 exit	16,700	17,034	2
FM 866	1,500	1,835	22
FM 1601	20	35	75

Although potential points of slowed traffic flow would be similar to those described under construction traffic, any resulting delays would be far shorter.

Changes to Level of Service

As noted above, LOS A through C are considered to be acceptable roadway operating and mobility conditions. Based on a traffic analysis that was conducted as part of the FutureGen EIS (a similar energy project that would have used the polygen plant site and the FM 1601 access route), DOE expects that traffic impacts as a result of the TCEP would be minor. For this reason, a full traffic analysis was not conducted. However, to estimate changes to the LOS for FM 866, FM 1601, and I-20 as a result of the TCEP, DOE compared the FutureGen analysis to the expected TCEP construction and operations scenarios. Based on a peak construction workforce of 650 and an operations workforce of 200, the FutureGen traffic study concluded that FM 1601 would degrade from LOS A to LOS D during construction, and from LOS A to LOS B during operations (DOE 2007). The FutureGen analysis forecasted no changes to the LOS for I-20.

During TCEP construction, FM 1601 would provide access for 15–75 workers (5 percent of TCEP traffic). At maximum usage, this figure is 12 percent of the employment figure used in the FutureGen construction traffic analysis; thus FM 1601 is not likely to experience the LOS degradation projected under that scenario and would remain at an acceptable LOS. The continuation of the same commute pattern during the TCEP's operational phase would result in between seven and eight workers using this route, or 4 percent of the employment figure used in the FutureGen operations traffic estimates. Thus, DOE expects that the LOS would remain at an acceptable level during TCEP operations.

The use of FM 866 for 95 percent of the TCEP construction workforce would result in the following numbers of workers using this route daily over the three-year construction period:

- Year one: 285 workers (44 percent of the FutureGen employment figure)
- Year two: 998 workers (153 percent of the FutureGen employment figure)
- Year three: 1,425 workers (219 percent of the FutureGen employment figure)

Because FM 1601 and FM 866 roads are similar in size and capacity, it is assumed that given similar workforce scenarios, the LOS on FM 866 could degrade in a manner similar to that which was estimated for FM 1601 in the FutureGen EIS. Therefore, the TCEP construction workforce during year two and year three would be expected to impact local mobility and degrade LOS to at least the level reported for FM 1601 in the FutureGen traffic analysis; that is, an LOS of D.

During TCEP operations, approximately 140 workers would use FM 866. This is 70 percent of the number of workers used in the FutureGen analysis, which projected a LOS of B during operations. The potential degradation of FM 866 to LOS B represents a conservative estimate of impacts as a result of TCEP operations. LOS B is considered to be an acceptable roadway operating and mobility condition.

Table 3.50 summarizes the anticipated LOS changes resulting from TCEP construction and operation based on comparisons made to the FutureGen EIS traffic analysis.

Table 3.50. Potential Level of Service Changes during TCEP Construction and Operation

Roadway	Current LOS	Construction LOS	Operation LOS
I-20	A	Acceptable (A–C)	Acceptable (A–C)
FM 866	A	Unacceptable (D or lower) during Years 2 and 3	Acceptable (A–C)
FM 1601	A	Acceptable (A–C)	Acceptable (A–C)

3.16.5.2 IMPACTS FROM LINEAR FACILITIES

Construction of the natural gas, CO_2 and transmission utility lines required for TCEP operations could also cause temporary and localized congestion, particularly where these lines would cross existing roads and provide access to the construction staging areas. However, because construction of the utilities would be spread out along lengths of corridors, it is estimated delays to traffic would be minor and temporary.

3.16.5.3 IMPACTS TO RAIL TRANSPORTATION

For this analysis, it was assumed that a substantial portion of the raw and finished materials needed to construct the TCEP and linear facilities would be transported by rail. This would include structural steel, pipes, turbines, generators, separators, heat exchangers, and other components and materials. The rail system would also be used to transport coal to operate the TCEP and materials produced at the TCEP, such as urea, slag, and H_2SO_4.

Westbound trains delivering coal and other supplies would exit off of the UPRR rail line, using a 1-mi (1.6-km) rail spur leading to the polygen plant site. Urea and H_2SO_4 (and potentially slag) produced at the TCEP plant would be uploaded onto empty cars located on-site for eastbound transport from the polygen plant site. Rail facility design has not yet been finalized but would include a 1-mi (0.6-km) rail spur, on-site tracks to accommodate at least two coal unit trains (up to 135 railcars each) and two urea unit trains, a locomotive refueling location and road access for a tank truck, and an area for railcars needing maintenance with access for a railcar repair contractor. Slag and H_2SO_4 may be temporarily stored in railcars awaiting transport. The railcar maintenance area would support lubrication and minor repairs, while the refueling location would fuel a yard engine and, perhaps, plant vehicles.

Construction of new railroad sidetracks would result in temporary and minor adverse impacts to the existing rail lines because of potential interruptions to service as the railroad spur is connected to the existing system (DOE 2007). Once constructed, railcars containing construction or operational materials transported along the UPRR line would be directed onto the TCEP rail spur for unloading, thus preventing delays or congestion along the UPRR line. Additional on-site tracks would be utilized to accommodate trains that need to be loaded/unloaded, thus ensuring that the rail spur would remain open to receive incoming trains.

During full operating capacity, the polygen plant would consume approximately 5,800 tn (5,261 t) of coal per day, which would be delivered to the site by rail. Coal delivery would average three 135-car unit trains per week, although the maximum capacity of the TCEP for coal delivery would be up to five 135-car unit trains per day. Rail transport of urea produced at the polygen plant would average one train per week. Produced slag and H_2SO_4 could also be transported by rail. Details have not yet been finalized, but could entail an increase of rail traffic of one to two trains per month. This total additional rail transport (an average of up to six 135-car unit trains per week) represents a 5 percent increase over the existing rail traffic of 119 trains per week along the UPRR line near the proposed TCEP plant site and would not represent an increase that would exceed system capacity nor cause delay to existing railway operations. Each additional train added to the UPRR system would have the potential to delay traffic attempting to cross an at-grade rail crossing by approximately three to five minutes. UPRR is aware of the rail transport needs of the TCEP and has included them in company forecasts (Union Pacific Corporation 2009).

3.16.6 Mitigation

Mitigation measures that Summit would implement as part of the construction and operation of the TCEP are described in Section 2.5. Additional mitigation measures that Summit could implement or that DOE could require as a condition of approval to further reduce road transportation impacts are as follows:

- Coordinating with local authorities regarding the movement of oversized loads, construction equipment, and materials to prevent unnecessary traffic congestion and increased road hazards during the construction period.
- Coordinating with local authorities to implement detour plans, warning signs, and traffic-diversion equipment to improve traffic flow and road safety if construction-related traffic disruptions would be necessary.
- Conducting a traffic analysis at the primary access road intersections to determine the impact to intersection LOS and assess the need for additional mitigation measures such as installation of traffic signals, construction of dedicated turn lanes and queue storage at the frontage road intersections, and acceleration and deceleration lanes into and out of the main access intersection.
- Implementing a worker shuttle bus and/or carpooling program to reduce the number of worker vehicles commuting to and from the TCEP.
- Staggering the worker shift start and end times to reduce the peaking of construction worker traffic entering and exiting the TCEP.
- Coordinating with UPRR to connect sidetracks during lowest levels of existing rail traffic to reduce the potential of delaying existing railroad traffic.
- Coordinating with UPRR on construction methods to ensure minimal impacts to rail traffic if a separated grade rail crossing is constructed on FM 1601.

3.17 Materials and Waste Management

3.17.1 Background

Construction and operation of the TCEP would require a source of coal and other materials and access to markets for H_2SO_4, urea, captured CO_2, argon gas, and slag and the ability to dispose of any waste that is generated. This section discusses the management of the materials needed for the construction and operation of the proposed polygen plant and the management of wastes that would be generated. The section also describes the impact of the demands posed by the TCEP on the supply of construction and operational materials in the region and the impacts to regional waste management resources.

3.17.2 Region of Influence

The ROI includes the waste management facilities, industries that could use the TCEP by-products, and suppliers of construction materials, coal, and process chemicals that would be used in the construction and operation of the proposed polygen plant and associated linear facilities. The extent of the ROI varies by material and waste type. For example, the ROI for construction material suppliers and solid waste disposal facilities is small (within approximately 50 mi [80 km] of the proposed site) because these types of resources are widely available and the large volumes of materials that would be needed or waste that would be generated are costly to transport over large distances. Treatment and disposal facilities for hazardous waste are less common, and the associated ROI is within approximately 100 mi (161 km) of the proposed site.

3.17.3 Methodology and Indicators

The impacts analysis for materials and waste resources used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. Potential impacts and their indicators are shown in Table 3.51.

Table 3.51. Indicators of Potential Materials and Waste Impacts

Potential Impact	Impact Indicator
Increase in demand from construction and operation of the TCEP on the capacities of material suppliers in the ROI.	Types and quantities of required materials.
Effect of TCEP-produced CO_2, urea, H_2SO_4, and slag on regional demand and access to markets.	Quantities of produced products.
Effect on the capacity of waste management facilities including hazardous waste-collection services and nonhazardous waste landfills.	Types and quantities of sanitary waste, nonhazardous solid waste products, recyclable materials, and hazardous waste products.

Uncertainty regarding some of the specific equipment venders and detailed project design that would be employed in the polygen plant site made it difficult to precisely quantify some of the operational materials requirements and waste generation. A conservative, maximum value for each item was used in the analysis to provide an upper limit for the potential impacts of the equipment vendors and final designs that could be selected. The analysis is based on the best available information and is bounded by the assumptions DOE has made with regard to the project design and equipment venders. Where necessary, DOE used NEPA documentation and design information for facilities of similar scope and size to augment the TCEP-specific information.

The impacts of the transportation of materials to the site and wastes from the site are addressed in Section 3.16, Transportation.

3.17.4 Affected Environment

This section describes the availability of construction materials and process materials and the capacity of municipal, industrial, and hazardous waste disposal facilities to manage the wastes that would be generated by the TCEP.

3.17.4.1 CONSTRUCTION MATERIALS

Construction of the proposed TCEP would require local access to concrete, asphalt, and aggregate and fill materials, among others. A number of suppliers and producers of construction materials are available in the area, and a sample of the surrounding construction materials industry is provided below, including the suppliers' capacity if that information was available.

Concrete

A number of large and small companies in the Midland–Odessa area would be available to provide concrete for the TCEP. Most companies could set up portable concrete plants at the site to meet the demand. The below list includes the available concrete suppliers for the TCEP:

- Vines Ready-Mixed Concrete is the largest supplier of concrete in the area, with a capacity of 100 cubic yards (76 m^3) per hour. It has existing plants in Odessa, Midland, Big Spring, and Crane (Vines Ready-Mixed Concrete 2010).
- Transit Mix Concrete and Materials Company is located in Midland. No production quantities were given but the company did verify it could support the anticipated project needs. (Schilhap 2010).
- Odessa Concrete Supply is capable of producing 850 cubic yards (650 m^3) per day (Hetrick 2010).

Asphalt

Jones Brothers Dirt and Paving Contractors, Inc., in Odessa is the largest supplier of asphalt in the region with a capacity of 2,500 tn (2,268 t) of asphalt per day.

Aggregate and Fill Material

Aggregate suppliers in the Midland–Odessa area include Transit Mix Concrete and Materials Company, Jones Brothers Dirt and Paving Contractors, Inc., Barnett Sand & Gravel, and Capitol Aggregates. Fill material is readily available throughout the region. The largest suppliers include Jones Brothers Dirt and Paving Contractors, Inc., Vines Ready-Mixed Concrete, and Van Zandt Paving.

Steel, Piping, and Process Units

In addition to the construction materials discussed above, construction of the TCEP would also require other building materials including structural steel, piping, and various process units, such as the coal gasifiers, combustions turbines, and other chemical process units. These items would be supplied by various vendors both local and nonlocal and would be delivered to the site by either truck or rail. Laydown areas would be established as part of the construction process that would provide temporary storage for these materials.

3.17.4.2 PROCESS-RELATED MATERIALS

Coal

The TCEP would use low-sulfur, Powder River Basin sub-bituminous coal from Wyoming. This coal would be Wyodak seam coal from Rio Tinto's Cordero Rojo Mine, located approximately 25 mi (40 km) south of Gillette, Wyoming. An alternate coal, used for other design considerations, would be Wyodak-Anderson seam coal from Peabody Energy's North Antelope Rochelle Mine, located approximately 65 mi (105 km) south of Gillette, Wyoming. The Cordero Rojo Mine produced 41.6 tn (37.7 t) in 2009, and the Antelope Rochelle Mine produced 108.7 tn (98.6 t) during the same period (Boyd 2010). The annual volume of coal proposed for TCEP (2.1 million tn [1.9 million t] per year) would be 4.6 percent and 1.75 percent of the 2009 output of these mines, respectively. (Boyd 2010).

Process Chemical Supply Markets

Process chemical requirements for the TCEP (see Table 2.3) would include common water treatment and conditioning chemicals, lubricants, and other industrial supplies that are widely used in the industry and that have broad regional and national availability. Suppliers of process water and waste water treatment chemicals are located close to the proposed project area (e.g., in and near the cities of Midland and Odessa).

3.17.4.3 WASTES

Construction of the TCEP would generate construction debris waste that would require off-site disposal. In addition, operation of the plant would generate industrial and hazardous waste that would require off-site disposal. Table 3.52 lists available industrial hazardous and nonhazardous waste landfills in the region and state, their approximate distances from the TCEP, and their current capacities (where available).

Industrial waste is waste produced by industrial activity. Hazardous (or toxic) waste, chemical waste, industrial solid waste and municipal solid waste are designations of industrial waste.
Municipal solid waste is commonly known as trash or garbage, is a combination of all of a city's solid and semisolid waste. It includes mainly household or domestic waste, but it can also contain commercial and industrial waste with the exception of industrial hazardous waste.
Hazardous (or toxic) waste is waste from industrial practices that causes a threat to human or environmental health and is regulated under the Resource Conservation and Recovery Act.
Chemical waste is waste that is made from harmful chemicals. Specific chemical wastes may or may not be classified as a hazardous waste.

Table 3.52. Municipal, Industrial, and Hazardous Waste Landfills in the Region of Influence

Landfill	City/State	Approximate Distance from TCEP (mi [km])	Available Capacity
Municipal Landfills			
Charter Waste Landfill	Odessa, Texas	4 (6)	26 million tn (99 years)
City of Midland Landfill	Midland, Texas	38 (61)	17 million tn (60 years)
Industrial Waste Landfills (nonhazardous)			
Charter Waste Landfill	Odessa, Texas	4 (6)	26 million tn (99 years)
Waste Control Specialists	Andrews, Texas	50 (80)	Not disclosed
Lea Landfill	Hobbs, New Mexico	100 (180)	Not disclosed
Hazardous Waste Landfills			
Waste Control Specialists	Andrews, Texas	50 (80)	Dependent on chemical composition
US Ecology Texas/Texas Ecologists, Inc.	Robstown, Texas	485 (780)	Dependent on chemical composition
Clean Harbor/Laidlaw	Deer Park, Texas	565 (909)	Dependent on chemical composition

Source: TCEQ (2010b).

3.17.5 Environmental Impacts of Summit's Proposed Project

3.17.5.1 CONSTRUCTION IMPACTS

Construction materials would be ordered in the correct sizes and number, resulting in small amounts of excess material that could be saved for use on a different project and very small amounts of waste to be disposed in a permitted landfill accepting construction debris. Heavy equipment would be used that require fuel, oils, lubricants, and coolants. Should any of these require disposal, they would be special waste or hazardous waste and appropriately managed by the construction contractor. Precautions would be taken to mitigate the impacts of petroleum and chemical spills and personnel would be trained and equipped to respond to spills when they occur. Solid and hazardous waste disposal capacity in the region is detailed in Table 3.52 and Section 3.17.4.3. Impacts to waste collection services or disposal capacity would be small.

Polygen Plant Site

Polygen plant construction materials would consist primarily of structural steel beams and steel piping, tanks, and valves. Locally obtained materials would include crushed stone, sand, and lumber for the proposed facilities and temporary structures (e.g., enclosures, forms, and scaffolding). Components of the facilities would also include concrete, ductwork, insulation, electrical cable, lighting fixtures, and transformers. Sources for these construction materials are well established regionally, and the quantities of materials required to construct the proposed polygen plant would not create demand or supply impacts.

Waste from construction of the proposed facilities would include excess materials, metal scraps, and pallets, crates, and other packing materials. Excess supplies of new materials would be returned to vendors or be retained for future use. Surplus paint and other consumables, partial spools of electrical cable, and similar leftover materials would also be retained for possible future use in maintenance, repairs, and modifications. Scrap metal that could not be reused on-site would be sold to scrap dealers. Other scrap materials could also be recycled through commercial vendors. Packaging material (e.g., wooden pallets and crates), support cradles used for shipping large vessels and heavy components, and cardboard and plastic packaging would be collected in dumpsters and periodically transported off-site for disposal.

Construction equipment would include cranes, forklifts, air compressors, welding machines, trucks, and trailers. Operation of heavy equipment would require oils, lubricants, and coolants. Should any of these require disposal, they would be special waste or hazardous waste and appropriately managed by the construction contractor.

Petroleum products are sometimes spilled at construction sites as a result of equipment failure (split hydraulic lines, broken fittings) or human error (overfilled tanks). To mitigate the impacts of spills, use of petroleum products, solvents, and other hazardous materials would be restricted to designated areas equipped with spill containment measures appropriate to the hazard and volume of material being stored on the construction site. Refueling, lubrication, and degreasing of vehicles and heavy equipment would take place in restricted areas. A SPCC plan would be prepared in accordance with 40 C.F.R. § 112.7. Personnel would be trained to respond to petroleum and chemical spills and the necessary spill control equipment would be available on-site and immediately accessible.

Debris would be generated as a result of clearing and grading. Only 300 ac (121 ha) of the site would be required for the facilities comprising the polygen plant envelope (see Figure 2.3). Any excavated material could be used as fill on the site. This debris would be disposed on-site or transported to an off-site landfill for disposal.

The waste requiring disposal could be disposed of at permitted off-site landfills. Area industrial landfills would have sufficient capacity to receive nonhazardous construction debris waste (see Table 3.52). Because the quantity of waste from project construction would be small in comparison with available landfill capacity, the impact of the disposal of this waste would be low.

Linear Facilities

The following linear facilities and pipelines would be constructed to support the proposed TCEP:

- Up to 36.8-mi (59.2-km) of transmission line in new ROWs (maximum case, several options being evaluated)
- Process water supply pipeline corridors up to 41.2 mi (66.3 km) using new ROWs (maximum case, several options being evaluated)
- A 1.1-mi-long (1.8-km-long) CO_2 pipeline using new ROWs to connect to the existing Kinder Morgan CO_2 pipeline system
- A natural gas pipeline

Most corridors would require clearing of vegetation and grading, creating land clearing debris that may require removal from the site. The transmission line would be cleared of hazard trees but other low-growing vegetation such as mesquite would be primarily left in place. Construction debris disposal capacity is available at area landfills (see Table 3.52).

The construction of the pipelines, transmission lines, and access roads would require pipe, joining and welding materials including compressed gases, steel cable and structures, insulated wiring for transmission lines, and building construction materials such as lumber and masonry materials. Sources for these construction materials are well established regionally, and the quantities of materials required to construct the infrastructure would not create demand or supply impacts.

The proposed polygen plant site would be served by I-20 and two access roads. On-site roads would be needed in the polygen plant site.

The materials needed for on-site and access road construction are concrete, aggregate, and asphalt. Road construction results in minimal waste due to the ability to recycle and reuse these materials. Excavated soil would be used for fill elsewhere along the route and asphalt would be recycled. Road construction would require heavy equipment that would need fuel, oils, lubricants, and coolants. Should any of these require disposal, they would be special waste or hazardous waste and appropriately managed by the construction contractor. Precautions would be taken to mitigate the impacts of petroleum and chemical spills and personnel would be trained and equipped to respond to spills when they occur. Solid and hazardous waste disposal capacity in the region is detailed in Table 3.52 and Section 3.17.4.3. Impacts to waste collection services or disposal capacity would be small.

The materials needed for construction of the on-site loop track and rail spur would be steel for rails and precast concrete rail bed ties, and rock for ballast. The sources for rails and rail bed ties are well established regionally; none of the quantities of materials required for constructing a rail spur would create demand or supply impacts. Furthermore, these materials would be ordered in the correct sizes and number, resulting in small amounts of excess material that could be saved for use on a different project and very small amounts of waste to be disposed in a permitted landfill accepting construction debris. In addition, to the materials to be installed, construction of the rail spur would require fuel, oils, lubricants, and coolants for heavy machinery, and compressed gasses for welding. Should any of these require disposal, they would be special waste or hazardous waste and shipped to a permitted hazardous waste treatment and disposal facility. Precautions would be taken to mitigate the impacts of petroleum and chemical spills, and personnel would be trained and equipped to respond to spills when they occur. Solid and hazardous waste disposal capacity in the region is detailed in Table 3.52 and Section 3.17.4.3. Impacts to waste collection services or disposal capacity would be small.

3.17.5.2 OPERATIONAL IMPACTS

Polygen Plant Site

The TCEP is being designed to use Powder River Basin coal from Wyoming. Coal consumption would be approximately 5,800 tn (5,261.7 t) per day or up to 2.1 million tn (1.91 million t) per year. This represents 2.2 percent of the 95.4 million tn (86.6 million t) of coal of all types consumed by electric utilities in the state in 2009 (Energy Information Administration 2010a). Coal would be delivered to the proposed polygen plant site by rail and stored in two coal piles, each providing storage capacity for approximately nine days of operation with approximately 36 days inactive storage. Runoff from the coal storage areas would be collected and treated in the plant's ZLD waste water treatment system.

Table 2.3 provides the estimated on-site storage requirements of toxic and hazardous materials, assuming a 30-day supply would be maintained at the polygen plant site. Potential impacts from storage of the chemicals are discussed in Section 3.18, Human Health, Safety, and Accidents. These chemicals are commonly used in industrial facilities and widely available from regional and national suppliers. The coal gasification process would consume H_2SO_4, sodium hypochlorite, and lime. The sulfur produced by the polygen plant itself would be sufficient to meet the need for H_2SO_4, assuming a complete conversion of the sulfur to H_2SO_4. There are sodium hypochlorite producers located throughout the U.S., including Texas, and availability is high. Chemical Lime, one of the 10 largest lime producers in the U.S., operates plants in Texas, including nearby Bosque County (U.S. Geological Survey 2010b). Given that the chemicals that would be needed to operate the polygen plant are common industrial chemicals that are widely available and produced in large quantities in the U.S., the chemical consumption impact would be minimal.

Argon and H_2SO_4 would be by-products of the gasification and syngas cleanup processes and would be made available for commercial sale. Slag (an inert by-product of the gasification process) could be sold as a raw material for manufacturing cement and other products.

The coal gasification process would generate approximately 489 tn (444 t) of slag per day (178,485 tn [161,919 t] per year). Although slag is considered a potential revenue-producing stream and would be actively marketed by Summit, DOE assumed for purposes of this analysis that all of the slag would be disposed of at the closest nonhazardous industrial waste landfill. The Charter Waste Landfill in Odessa has a 26-million-tn (24-million-metric-t) capacity, is the closest nonhazardous landfill, and would use the TCEP's slag as an intermediate cover over waste material during the day.

Summit estimates that up to 23,360 tn (21,191 t) of clarifier sludge and filter cake from the ZLD process would be generated annually. The filter cake is expected to be nonhazardous but would be tested to confirm its characteristics. As with the inert slag, the clarifier sludge and filter cake would be disposed of at the Charter Waste Landfill.

Chemical waste would be generated by periodic cleaning of the HRSG and turbines. The wet cooling tower option has a greater demand for biocide usage (e.g., bleach). This waste would consist of alkaline and acidic cleaning solutions and wash water, which are likely to contain high concentrations of heavy metals. Chemical cleaning would be performed by outside contractors who would be responsible for the removal of associated waste products from the site. Precautions would be taken to prevent releases by providing spill containment for tanks used to store cleaning solutions and waste. Other waste would include solids generated by water and waste water treatment systems, such as activated carbon used in sour water treatment. Sulfur-impregnated activated carbon would be used to remove Hg from the syngas. This Hg sorbent would be replaced periodically and the spent carbon would likely be hazardous waste. The spent carbon would be regenerated and reused at the site. It could also be returned to the manufacturer for treatment and recycling or transferred to an off-site hazardous waste treatment facility. Used oils and used oil filters would be collected and transported off-site by a contractor for recycling or disposal. Given the municipal, industrial, and hazardous waste disposal capacities available in the region, the impact of disposal of TCEP-generated waste would be minimal. With the small amount of hazardous waste (e.g., paints, solvents, and spent carbon) that would be generated and the availability of commercial disposal facilities, the impact of managing TCEP operational wastes would be small.

Sanitary waste is spent water from residences and facilities that carries bodily wastes, washing water, food preparation wastes, laundry wastes, and other waste products of normal living. Based on approximately 30 gal (114 L) generated per day per person, the expected sanitary waste water discharge would total up to 4,500 gal (17,000 L) per day during operation (150 workers). This waste would be collected and discharged directly to an on-site underground septic disposal field. Thus, sanitary waste disposal for the TCEP would have no impact to the capacity of local waste water treatment facilities.

Linear Facilities

During normal operations, the transmission lines and pipelines would not require additional materials and would not generate waste, other than cleared vegetation, if necessary, that could be disposed of at a nonhazardous waste landfill.

On-site roads would require periodic resurfacing at a frequency dependent on the level of use and weathering. Asphalt removed from the road surface would be recycled. Road resurfacing would involve heavy equipment that would require oils, lubricants, and coolants. Should any of these require disposal, they would be special waste or hazardous waste and appropriately managed by the construction contractor.

Maintenance of the rail spur would consist of replacing the rails and equipment at a frequency dependent on the level of use and weathering. Replacement materials would be obtained in the correct sizes and quantities from established suppliers, and the small amount of waste remaining after materials are reused or recycled would be disposed of in a permitted facility. Any special or hazardous waste (e.g., oils and coolants) generated during rail replacement would be managed by the contractor.

3.17.6 Mitigation

Mitigation measures that Summit would implement as part of the construction and operation of the TCEP are described in Table 2.8 of Chapter 2. Because no impacts would occur, no additional mitigation measures specific to materials and waste management resources would be necessary.

3.18 Human Health, Safety, and Accidents

3.18.1 Background

This section describes the potential human health and safety impacts associated with construction and operation of the TCEP. Health and safety impacts are evaluated in terms of potential risks to both workers and the general public. This section addresses occupational and public safety and health, including worker injuries, transportation safety, pipeline safety, exposure to contaminated sites, and risks to workers and the surrounding community from accidents that could occur at the polygen plant site.

As with any U.S. energy infrastructure, the TCEP could be the target of terrorist attacks or sabotage. DOE evaluated the potential impacts from a sabotage or terrorism event by analyzing major and minor system failures or accidents at the proposed polygen plant site, as well as gas releases along the CO_2 and natural gas pipeline(s) and at injection wells. The accident analyses evaluated the outcome of catastrophic events without determining the motivation behind the incident. Thus, such outcomes could be representative of the impacts from a sabotage or terrorism event. The level of risk is estimated based on the current conceptual design of the proposed TCEP; applicable health, safety, and spill prevention regulations; and expected operating procedures.

3.18.2 Region of Influence

The ROI for the occupational safety and health analysis is those areas where workers would be located. The ROI for potential worker and public health impacts is the modeled hazard zone where a specified threshold of risk would be exceeded by fire, explosion, or release of hazardous materials. This zone was determined through analysis of release conditions, weather, terrain, and mixture thermodynamics (Appendix C). The ROI for the analysis of CO_2 health and safety impacts is the modeled hazard zone for which there is a risk posed by leakages. For transportation safety, the ROI consists of the roadways on which TCEP workers and delivery vehicles would be traveling. The ROI for analysis of exposure to contaminated soils is the area within 100 ft (30 m) of the polygen plant property boundaries and linear facility ROWs.

3.18.3 Methodology and Indicators

The impacts analysis for human health, safety, and accidents used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. Potential impacts and their indicators are shown in Table 3.53.

Table 3.53. Indicators of Potential Impacts to Human Health and Safety

Potential Impact	Impact Indicator
Potential for worker injury and death during construction and operation of the facility	Total recordable incidents, lost workday cases, and fatalities
Increase in traffic during construction and operation could lead to increased roadway accidents	LOS rating for traffic and qualitative description on what that means to accident risks
Accidents or fatalities caused by rail transport of supplies, particularly at at-grade crossings	Number/location of at-grade rail crossings, estimated rail traffic and qualitative description on what that means to accident risks
Exposure to pollutants of potential concern during construction and operation of the facility	Number of sensitive receptors near the project area, including facility workers
A risk to public health and safety from electromagnetic field exposure or exposure to charged particulates	Location of new transmission lines; number of sensitive receptors near the project area, including facility workers
Exposure to pollutants of potential concern due to intentional destructive acts (i.e., sabotage)	Proximity to sensitive receptors, including facility workers
CO_2 or natural gas leaks, explosion, or fire due to construction or operation of the facility	
CO_2 or natural gas leaks, explosion, or fire due to intentional destructive acts (i.e., sabotage)	

The occupational safety and health analysis used BLS accident and incident rate data for activities that would be associated with the polygen plant and linear facilities. A quantitative risk analysis (QRA) was prepared to assess the level of risk posed to workers and the public by accidental releases from the proposed polygen plant or associated natural gas and CO_2 pipelines. The QRA is contained in Appendix C.

The analysis of risk from CO_2 pipeline and EOR activities was based on the analysis conducted for the FutureGen EIS, a similar energy project that would have used the same plant site and, for injection of CO_2, a sequestration site in the same Permian Basin region where the TCEP's CO_2 would be used for EOR (Tetra Tech 2007). The FutureGen analysis used data from analog sites to estimate risks to the public from the transport of $C0_2$, wellhead failures, or upward leakages from the injection reservoirs due to a variety of release mechanisms. Although the TCEP would be selling the CO_2 to others for EOR, these same failure scenarios would apply.

The transportation safety analysis used motor vehicle fatality rates and safety risks for at-grade rail crossings.

3.18.4 Affected Environment

3.18.4.1 OCCUPATIONAL SAFETY AND HEALTH

Worker safety in construction and industrial settings is regulated by OSHA. The TCEP would be subject to OSHA standards during construction and operations (e.g., OSHA General Industry Standards [29 C.F.R. Part 1910] and the OSHA Construction Industry Standards [29 C.F.R. Part 1926]). OSHA standards are designed to protect workers from potential construction and industrial accidents, as well as to minimize exposure to workplace hazards (e.g., noise, chemicals). Table 3.54 summarizes 2008 safety statistics from the BLS for industry categories that are relevant to the TCEP.

Table 3.54. National Statistics for Workplace Hazards

Industry	Nonfatal Recordable Incidents (per 100 full-time equivalent workers)	Lost Workdays (per 100 full-time equivalent workers)	Fatalities (per 100,000 full-time equivalent workers)*
Construction	4.7	2.5	9.7
Utilities (electric power generation, transmission, control, and distribution)	3.5	1.9	3.9
Chemical manufacturing	2.7	1.6	2.5

Sources: BLS (2008a, 2008b).

* In 2008, the Census of Fatal Occupational Injuries implemented a new methodology using hours worked for fatal work injury rate calculations rather than employment. The new methodology included a fatality rate for general manufacturing only, not chemical manufacturing specifically. For additional information on the fatal work injury rate methodology changes, please review BLS (2010c).

Limited data on polygen facilities are available; therefore, statistics from utility industry and chemical manufacturing have been referenced in this analysis. Construction of gasification facilities has long been a part of the chemical manufacturing industry. Similarly, construction and operation of combined-cycle power plants has long been part the electric utility industry. Therefore, the workplace hazards associated with the various components of the polygen plant are represented in the statistics presented in Table 3.54.

In the utility industry, electrical shocks, burns, boiler fires and explosions, and contact with hazardous chemicals are among the most common hazards to power plant workers (Hansen 2005). According to the National Board of Boiler and Pressure Vessel Inspectors, between 1999 and 2003, 1,478 boiler accidents were reported, resulting in 143 injuries and 26 deaths (power boilers include utility boilers, as well as boilers used by other industries for cogeneration and on-site power production) (National Board of Boiler and Pressure Vessel Inspectors 2010). Many power plant workers are also routinely exposed to dangerous chemicals such as corrosives (acids and bases), oxidizers, and solvents.

Falls account for the greatest number of fatalities in the construction industry, followed by transportation incidents and worker contact with electricity. Overexertion, being struck by an object, and falls were the most commonly reported reasons for lost workdays. Other common injuries include sprain and strains, and cuts or lacerations (Meyer and Pegula 2004).

In the chemical manufacturing sector, the leading causes of death in 2008 were fires and explosions, exposure to harmful substances, contact with objects and equipment, and assaults and violent acts[3] (BLS 2008a). In the manufacturing industry as a whole, the leading causes for lost workdays are contact with objects or equipment, overexertion, repetitive motion injuries, and falls (National Occupational Research Agenda and National Institute for Occupational Safety and Health 2010).

3.18.4.2 TRANSPORTATION SAFETY

Road Safety

Texas uses the Crash Records Information System to collect and analyze motor vehicle crash data. Table 3.55 contains the fatality rate per 100 million vehicle mi (161 million vehicle km) traveled from 2003 to 2009 in Texas. This table also includes TxDOT's estimate of the fatality rate per 100 million mi (161 million km) traveled from 2010 to 2014. Based on a 16 percent decrease in the state traffic fatality rate since 2003, TxDOT estimates a continued reduction through 2014.

Table 3.55. Texas Department of Transportation Fatality Rate 2003–2009 and Estimated Fatality Rate 2010–2014

Calendar Year	Rate per 100 Million Vehicle Miles (km) Traveled*
2003	1.75 (2.81)
2004	1.61 (2.59)
2005	1.52 (2.45)
2006	1.49 (2.40)
2007	1.43 (2.30)
2008	1.48 (2.38)
2009	1.47 (2.37)
2010	1.45 (2.33)
2011	1.43 (2.30)
2012	1.41 (2.27)
2013	1.39 (2.24)
2014	1.38 (2.22)

*Data for 2010–2014 are estimated.

Source: TxDOT (2010a).

[3] Includes violence by persons, self-inflicted injury, and attacks by animals.

Railroad Safety

Railroad Crossings

A structure that allows one track to cross another track or a highway at the same elevation is referred to as an at-grade crossing. A structure or set of structures allowing two tracks, or one or more tracks, and a highway to cross each other at different elevations is referred to as a grade-separated crossing. Grade-separated crossings are provided by either a railroad bridge over a highway or a road bridge over a railroad.

Trespassing on railroad property and collisions at highway-rail grade crossings are the two leading causes of death in the entire railroad industry, far surpassing worker or passenger fatalities (U.S. Department of Transportation 2004). At-grade rail-highway crossings can also contribute to motor traffic bottlenecks depending on their location. In addition, the presence of at-grade crossings near medical facilities can affect emergency response times due to ambulances delayed by railroad traffic.

Texas has the largest number of public highway-rail at-grade crossings in the nation and typically leads the nation in the annual number of automobile-train involved collisions (fatalities and injuries) at public highway-rail at-grade crossings. The incorporation of safety improvements at highway-rail crossings, such as train-activated signal systems, has shown to be a significant factor in reducing collisions involving motor vehicles and trains. As of 2009, Texas had 10,045 public highway-rail at-grade crossings, approximately 57 percent of which are equipped with active warning signal equipment (TxDOT 2010b). In Ector County, there are 36 at-grade crossings, of which 25 are public road crossings and the remainder are located on private roads or are pedestrian crossings (Federal Railroad Administration 2010a). On the portion of the UPRR line between the polygen plant and the city of Odessa, there are 25 at-grade crossings. There are at least seven hospitals or medical centers in downtown Odessa that are located within 0.5 mi (0.8 km) of the at-grade crossings for either Crane or Muskingum Avenues.

Since 1975, there were 66 reported incidents including seven fatalities, 25 injuries, and 34 incidents with property damage on the portion of the UPRR line between the polygen plant and the city of Odessa (Federal Railroad Administration 2010a). Twelve incidents along the UPRR line involved the transportation of hazardous materials. However, reports indicate that no releases of hazardous materials occurred during the incidents (Federal Railroad Administration 2010a).

The UPRR annually operates 17 trains a day, seven days a week, along the track near the proposed polygen plant (see Section 3.16, Transportation). UPRR's track structure in the ROI is rated as Class 5 by the Federal Railroad Administration. Class 5 tracks are suitable for 70-mi-per-hour (112.6-km-per-hour) operation (UPRR 2006, as cited in Horizon Environmental Services 2006b). However, coal cars can only operate at a maximum of 50 mi (80 km) per hour per timetable (UPRR 2004, as cited in Horizon Environmental Services 2006). Each 135-car unit coal train supplying the TCEP could take approximately two minutes to clear a public at-grade crossing at the maximum speed of 50 mi (80 km) per hour.

Track Safety

Railroads annually transport more than 1.5 million carloads of hazardous cargo, including toxic gases such as anhydrous NH_3. More than 99.99 percent of rail hazardous material shipments reached their destinations without a release caused by a train accident, and rail hazardous material accident rates are down 81 percent since 1980 (Association of American Railroads 2009).

Hazardous materials produced by TCEP operation would be transported on the UPRR rail system. The UPRR system covers 23 states in the western two-thirds of the U.S. and is the nation's largest hauler of chemicals (UPRR 2010). In 2009, transport in the UPRR chemical sector (including petroleum, plastics, soda ash, fertilizer and industrial chemicals) comprised 16 percent of UPRR's freight revenue. Additionally, the hazardous waste segment of the industrial products sector saw shipments double in 2009, largely driven by new uranium tailings business in Utah (UPRR 2009).

In 2006, a national hazardous materials audit was conducted to determine the level of Class I railroad compliance with the requirements for on-train placement of hazardous materials and accurate hazard communications on trains. UPRR had a noncompliance rate of 7.1 percent, the lowest of the seven Class I railroads inspected.

For 2009, UPRR reported a total of 148,651,734 rail mi (239,231,800 rail km) in the entire UPRR rail system and 441 train accidents (a train accident is defined as any event involving ontrack rail equipment that results in monetary damage to the equipment and track above a certain threshold) (Federal Railroad Administration 2009). Three of the accidents (0.68 percent of the total number of accidents) resulted in hazardous material releases from six railcars. There were no fatalities, although 200 people were evacuated (Federal Railroad Administration 2009). The primary causes of the accidents were human factors (26 percent), track defects (34 percent), and equipment, signal defects, or other causes (14 percent, 3 percent, and 18 percent, respectively).

As of August 2010, annual rail mileage for the UPRR rail system was 104,941,993 rail mi (168,887,800 rail km), with 297 train accidents (Federal Railroad Administration 2010b). Three of these accidents resulted in a hazardous material release from three railcars (1.01 percent of the total number of accidents). There were no fatalities and no evacuations. Primary causes of the accidents were human factors (31 percent), track defects (39 percent), and equipment, signal defects, or other causes (13 percent, 3 percent, and 20 percent, respectively) (Federal Railroad Administration 2010b).

Based on the total mileage in the UPRR system, the 2009 and 2010 accident rates are 2.97 and 2.83 accidents per million rail mi (per 161 million rail km), respectively (Federal Railroad Administration 2009 and 2010b).

3.18.4.3 CARBON DIOXIDE AND NATURAL GAS PIPELINE SAFETY

The U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration, Office of Pipeline Safety governs pipeline safety. The Pipeline and Hazardous Materials Safety Administration is the primary federal regulatory agency responsible for establishing and enforcing regulations related to pipeline safety, reliability, and environmental protection. Through certification by Office of Pipeline Safety, the State of Texas also regulates, inspects, and enforces intrastate gas and liquid pipeline safety requirements. This work is performed by the Pipeline Safety Division of the RRC. Operator compliance with state and federal pipeline safety regulations is monitored through a comprehensive inspection and enforcement program comprising field inspections of operations, maintenance, and construction activities; programmatic inspections of operator procedures, processes, and records; incident investigations and corrective actions; and through direct dialogue with operator management (Office of Pipeline Safety 2010). In Texas, there are approximately 222,285 mi (357,733 km) of hazardous liquid and natural gas pipelines, including 165,910 mi, (267,006 km) of natural gas gathering, transmission and distribution lines, and 1,521 mi (2,448 km) of CO_2 transmission pipelines (Office of Pipeline Safety 2010). Between 2000 and 2009, there were 53 significant accidents associated with all pipelines (Office of Pipeline Safety 2010). This translates to approximately one accident per 4,200 mi (6,759 km) of pipeline.

> The Pipeline and Hazardous Materials Safety Administration defines **significant incidents** as those incidents reported by pipeline operators when any of the following specifically defined consequences occur: 1) fatality or injury requiring in-patient hospitalization; 2) $50,000 or more in total costs, measured in 1984 dollars; 3) highly volatile liquid releases of five barrels or more or other liquid releases of 50 barrels or more; or 4) liquid releases resulting in an unintentional fire or explosion.

3.18.4.4 EXPOSURE TO CONTAMINATED SITES

Exposure to certain chemicals can adversely affect human health through toxic reactions, carcinogenic effects, or both. Chemical exposure can occur from chemicals present in water or in soil from past industrial activities.

A Phase I environmental site assessment was performed on the proposed polygen plant site in April 2006 (Horizon Environmental Services 2006). The results of that assessment did not indicate any recorded or observed soil contamination on the site. A review of state records also indicates that there is no known ground water contamination on or within 1.0 mi (1.6 km) of the proposed polygen plant site (Horizon Environmental Services 2006). Given the widespread and historic use of land on the polygen plant site and in most of the linear facilities for petroleum and gas production, it is possible that oil or chemical leaks have occurred on the site or in the corridors. The linear facilities were not included in the assessment, and no studies have been done for those corridors.

3.18.5 Environmental Impacts of Summit's Proposed Project

3.18.5.1 OCCUPATIONAL HEALTH AND SAFETY

TCEP Construction

Using the OSHA workplace hazards statistics presented earlier, Table 3.56 depicts the total estimated number of recordable incidents, lost workdays, and fatalities that could occur during the three-year construction period, assuming a TCEP construction workforce of 650 workers during that period.

Table 3.56. Estimated Workplace Hazard Statistics for the Three-year TCEP Construction Period

Workforce	Recordable Incidents		Lost Workdays		Fatalities	
	Recordable Incident Rate per 100 Full-time Equivalent Workers	Total Recordable Incidents (nonfatal)	Rate of Lost Workdays per 100 Full-time Equivalent Workers	Total Lost Workdays	Fatality Rate per 100,000 Full-time Equivalent Workers	Total Fatalities
Construction (650)	4.7	92	2.5	49	9.7	< 1

Risks and hazards associated with construction of power lines, substations, access roads, public road upgrades, rail improvements, and pipelines would be addressed through a worker protection program currently under development by Summit for the TCEP. Many of these types of construction activities would be undertaken by companies specializing in this type of work and would be governed by their internal worker protection programs.

Emergency services during construction would be coordinated with the local fire departments, police departments, paramedics, and hospitals. A first-aid office would be located on-site for minor first-aid incidents. Trained and certified health, safety, and environmental personnel would be on-site to respond to and coordinate emergency response. All temporary facilities would have fire extinguishers, and fire protection would be provided in work areas where welding work would be performed.

TCEP Operations

TCEP operations would require approximately 150 workers. These workers would perform activities included in both chemical manufacturing and utility industries workplace hazard statistics; however, it is currently unknown how many workers would perform each type of activity. Therefore, the highest number of the two industry's statistics (as reported in Table 3.54) has been used in this analysis, and is shown in Table 3.57.

Based on these rates, Table 3.57 also presents the estimated yearly number of recordable incidents, lost workdays, and fatalities for an operations workforce of 150 workers. Over the life of the project, which is estimated to be 30 years, this would result in 158 recordable incidents, 122 lost workdays, and fewer than one fatality. The risk of fatality related to specific TCEP processes is discussed in more detail in Section 3.18.5.2.

Table 3.57. Estimated Annual and Total (30 years) Workplace Hazard Statistics for the TCEP

Workforce	Recordable Incidents		Lost Workdays		Fatalities	
	Recordable Incident Rate per 100 Full-time Equivalent Workers	Annual/Total Recordable Incidents (nonfatal)	Rate of Lost Workdays per 100 Full-time Equivalent Workers	Annual/Total Lost Workdays	Fatality Rate per 100,000 Full-time Equivalent Workers	Annual/Total Fatalities
Operations (150)	3.5	5.25/158	2.7	4.1/122	3.9	0.01/0.3

Polygen plant design features and management programs would likely be established to address hazardous materials storage locations, emergency response procedures, worker training requirements, hazard recognition, fire control procedures, hazard communications training, personal protective equipment training, and reporting requirements. For accidental releases, significance criteria would be determined based on federal, state, and local guidelines, and on performance standards and thresholds adopted by responsible agencies.

Spill prevention measures would be developed pursuant to the Clean Water Act and would likely include comprehensive containment and worker safety programs. The comprehensive containment program would specify the use of appropriate tanks and containers, as well as proper secondary containment using walls, dikes, berms, curbs, etc. Worker safety programs would specify that workers are aware of, and trained in, spill containment procedures and related health, safety, and environmental protection policies.

3.18.5.2 TRANSPORTATION SAFETY

Motor Vehicles

During the construction and operations phases, personnel and material would be moved by personal vehicles and trucks. The following assumptions were used in the analysis of the potential for roadway accidents:

- There would be an average of 650 workers per month over the entire three-year TCEP construction period, which is anticipated to occur from 2012 to 2014.
- 150 workers would be required for TCEP operations. The polygen plant would operate for 30 years.
- Construction workers would commute six days per week, 52 weeks per year. Operations personnel would commute five days per week, 48 weeks per year.
- Both construction and operations workers would commute from the Odessa area. Each worker would make one round-trip, for a total commute of 40 mi (64 km) per day. Although some workers could reside closer to the polygen plant site and/or carpool with other workers, this assumption provides a conservative scenario.
- Approximately 26 trucks per day for potable water and other construction materials would be required during peak construction periods. Approximately 21 trucks per day would be

required for delivery of potable water and removal of slag during operations. If slag is removed from the site by rail, truck traffic would be reduced to one truck per day. These trucks would also be traveling to and from the Odessa area.

Based on these assumptions, approximately 25 million mi (40 million km) would be driven over the three-year construction period. Based on a TxDOT 2012–2014 average fatal accident rate of 1.39 fatalities per 100 million vehicle mi (161 million km) traveled, fewer than one fatality (approximately 0.35) would be expected to occur due to the movement of workers and supplies using trucks and personal vehicles during construction of the TCEP. During the 30-year operations period, approximately 44 million mi (71 million km) would be driven. Using the 2014 TxDOT fatal accident rate, fewer than one fatality (approximately 0.61) would be expected to occur due to the travel of workers during TCEP operations. This estimate does not incorporate any further reductions or increases in the fatality rate beyond the 2014 estimate provided by TxDOT.

Railroads

TCEP Rail Facilities, and Supply and Product Transport

Rail facility design has not yet been finalized but would include a 1-mi (0.6-km) rail spur, on-site tracks to accommodate at least two coal unit trains (up to 135 railcars each) and two urea unit trains, a locomotive refueling location for a yard engine (i.e., a small locomotive) with road access for a tank truck, and an area for railcars needing repairs with access for a railcar repair contractor. The refueling station is expected to contain one or more fuel storage tanks similar in size to those at a typical gasoline filling station. The maintenance area would support the minor maintenance and lubrication of the railcars and yard engine. The maintenance area would store small quantities of grease, oil, and solvents. The sizes of tanks and the quantities of materials that could be stored on-site have not been determined at this time.

During construction, some supplies could be transported by rail. These materials have not been quantified but would not include hazardous materials. During operation of the TCEP, coal, urea, argon, H_2SO_4, and perhaps slag would be transported by rail. As reported in Section 3.18.4.2, UPRR's 2009 and 2010 accident rates were 2.97 and 2.83 per 1 million rail mi (1.6 million rail km) traveled, respectively. TCEP-related transportation would add to the number of rail miles in the UPRR system. Assuming a Powder River Basin mine origin near Gillette, Wyoming, for the coal supply, and traveling along identified UPRR coal delivery routes, the proposed coal route would be approximately 1,800 mi (2,896 km) long. Rail transport of three trains per week of coal to the TCEP would result in 281,000 rail mi (183,465 km) annually. Using the higher reported accident rate, the addition of TCEP rail transport would result in approximately 0.83 accidents annually (approximately 25 rail accidents over the entire life of the project).

Urea, argon, and H_2SO_4 would also be transported off the polygen plant site by rail. Rail transport of urea produced at the polygen plant would average one train per week. Buyers have not been secured, but preliminary information indicates that urea would likely be transported to the Midwestern U.S. Slag and H_2SO_4 rail needs have not yet been fully determined, but could entail an increase of rail traffic of one to two trains per month. UPRR is currently working with Summit to develop a comprehensive transportation plan that would meet Summit's needs and be consistent UPRR's delivery capabilities and obligations (Mullen 2009). Detailed loading and unloading procedures would be developed based on specific design and piping arrangement of rail tank cars and site conditions. Detailed H_2SO_4 unloading procedures and safety regulations can be found in the following industry and government publications:

- 49 C.F.R. Parts 171–181, Department of Transportation
- 29 C.F.R. Part 1910, Department of Labor (OSHA)

Transport of these products would also add to the number of rail miles in the UPRR system. Assuming a Midwestern U.S. destination requiring 1,500 mi (2,414 km) of rail travel, TCEP rail transport of one train per week for urea and two trains for other materials would result in an additional 114,000 rail mi (183,465 rail km) annually. Using the higher reported accident rate, the addition of TCEP rail transport would result in approximately 0.33 accidents annually (approximately 10 rail accidents over the entire life of the project).

Given the overall low frequency of hazardous material spills on railroads, the risk of a release of TCEP materials during rail transport would be low. The speed, path and harm of an accidental release of a toxic gas or vapor would depend on the type of chemical, wind, weather, time, geography, and population density of the surrounding area.

At-grade Crossing Safety

With regard to safety issues, the examination of at-grade crossing safety typically considers the expected numbers and locations of at-grade crossings, the volume of both vehicle and rail traffic at those crossings, the nature of road traffic (e.g., trucks or passenger vehicles), the design and safety features of the crossings, and train and vehicle speeds near any crossings.

Coal delivery would average three 135-car unit trains per week, although the maximum capacity for coal delivery would be up to five 135-car unit trains per week. Rail transport of urea produced at the polygen plant would average one train per week. Produced slag and H_2SO_4 may also be transported by rail. Details have not yet been finalized, but could entail an increase of rail traffic of one to two trains per month. This additional rail transport (an average of up to six 135-car unit trains per week) represents a 5 percent increase over the existing rail traffic of 119 trains per week along the UPRR line near the proposed TCEP plant site and would result in a 5 percent increased risk of accidents at the at-grade crossings. Each additional train added to the UPRR system would have the potential to delay any emergency vehicle attempting to cross an at-grade rail crossing by approximately three to five minutes. There are at least seven hospitals or medical centers in downtown Odessa that are located within 0.5 mi (0.8 km) of the at-grade crossings at Crane and Muskingum Avenues. Thus, an increase in rail traffic could result in adverse impacts to general health and safety by impeding emergency vehicles.

Summit proposes to provide secondary and emergency access to the polygen plant site from FM 1601. This would require the construction of a rail crossing. It has not yet been determined if the crossing would be an at-grade or separated grade crossing and, if constructed at-grade, if the crossing would be equipped with active warning signal equipment. Construction of an at-grade rail crossing would result in an increased risk to those accessing the TCEP from FM 1601. The access road would be used by approximately 5 percent of construction and operations traffic on a daily basis. During peak construction (year three), this would result in approximately 150 rail crossings per day. If a collision occurred at the proposed rail crossing during peak TCEP commute times, project traffic could temporarily obstruct emergency vehicle access and delay the response time, particularly during construction. There are no other at-grade rail crossings along the anticipated travel routes to the TCEP.

3.18.5.3 CARBON DIOXIDE AND NATURAL GAS PIPELINE SAFETY

The TCEP would require the installation of approximately 2.7 mi (4.3 km) of new natural gas pipelines and 1.0 mi (1.6 km) of CO_2 pipeline. Statistically, the accident rate associated with these lengths of new pipelines would be negligible. Failure rates specific to the pipeline types and diameter that would be used in the TCEP were incorporated into the accident scenario analysis that is summarized in Section 3.18.5.5 and contained in Appendix C.

3.18.5.4 EXPOSURE TO CONTAMINATED SITES

During construction of the polygen plant and linear facilities, workers could be exposed to soil contamination previously undiscovered on the polygen plant site or along the linear facilities. A Phase I environmental site assessment was performed on the proposed polygen plant site, and no indication of contaminated soils or other potential environmental risks were found. Therefore, the risk of discovering soil contamination during construction of the TCEP would be low.

Linear facilities were not examined as part of the assessment; however, portions of some linear facility features are in previously existing ROWs. These areas have already been disturbed during previous construction projects and presumably have been examined for evidence of soil contamination. All transmission line, natural gas and CO_2 pipeline, and access road options would require construction of new ROWs. The portion of each linear facility option that would require new versus existing ROWs is shown in Table 3.58.

Table 3.58. TCEP Linear Facilities

Linear Facility Option	New ROW (mi [km])	Existing ROW (mi [km])
WL1	21.0 (33.7)	20.0 (32.2)
WL2	8.7 (14.0)	0.06 (0.1)
WL3	9.2 (14.8)	5.4 (8.7)
WL4	1.3 (2.1)	1.3 (2.1)
TL1	9.3 (15.0)	0.0 (0.0)
TL2	8.6 (13.8)	0.0 (0.0)
TL3	2.2 (3.5)	0.0 (0.0)
TL4	0.6 (1.0)	0.0 (0.0)
TL5	36.8 (59.2)	0.0 (0.0)
TL6	32.8 (52.8)	0.0 (0.0)
$C0_2$	1.0 (1.6)	0.0 (0.0)
NG1	2.7 (4.3)	0.0 (0.0)
AR1	0.3 (0.5)	0.0 (0.0)
AR2	3.7 (6.0)	0.0 (0.0)
RR1	1.1 (1.8)	0.0 (0.0)

Most of the linear facilities would not be located in residential areas; however, there are 37 residences within 100 ft (30 m) of the WL1 ROW, 51 residences and one post office located within 100 ft (30 m) of the TL5 ROW, and 39 residences located within 100 ft (30 m) of TL6 ROW. There is one residence within 100 ft (30 m) of the NG1 ROW. Because of their proximity to these proposed ROWs, these residences could be at risk to exposure of hazardous materials that could be exposed during excavation for these linear facilities. However, risk to residents or workers could be substantially reduced through proper due diligence, which starts by conducting a Phase 1 environmental site assessment along unexamined ROW sections prior to construction. If this assessment identified potential environmental risks along these ROWs, it should be followed by Phase II (testing) and Phase III (removal and disposal of contaminated materials) assessments, as necessary, to reduce the risk (see Section 3.18.6, Mitigation).

3.18.5.5 POLYGEN PLANT RISK ANALYSES

This section summarizes the results of the analysis of potential impacts to human health that would result from an accident, equipment failure, or intentional destructive acts such as sabotage or terrorism involving TCEP process units and pipelines associated with flammable, acutely toxic, or asphyxiant releases. Although the probability of an act of sabotage or terrorism cannot be quantified, it is possible to estimate the potential human health effects of such an attack on the TCEP facilities, which would be similar to what could occur as a result of a component failure or human error.

In general, accidents that could be associated with TCEP process units include gas releases and exposure to toxic gas clouds (such as those containing H_2S) or asphyxiant gas clouds (such as those containing CO_2), torch fires or flash fires, and vapor cloud explosions. A QRA was conducted to estimate the level of risk posed to the public by potential releases of flammable, toxic, or asphyxiant fluids originating in TCEP process units. The study consisted of four primary steps:

- Selection of potential events that could lead to releases of flammable, toxic, and asphyxiant fluids at rates sufficient to create toxic or asphyxiant vapor clouds, flash fires, torch fires, pool fires, and vapor cloud explosions.
- Determination of the annual probability of occurrence of each event.
- Performance of a consequence analysis for each event to determine how far the toxic and asphyxiant vapor clouds could travel in lethal concentrations and the extent of all flammable hazards to lethal levels with the available mitigation systems in place.
- Combination of the consequence modeling results with the annual probabilities to calculate the risk to the public from the proposed TCEP and associated pipelines.

The analysis, which was conducted by Quest (2010) and contained as Appendix C, identifies eight toxic materials that would be present at the TCEP: CO, H_2S, NH_3, hydrogen cyanide, H_2SO_4, SO_2, hydrogen chloride, and COS. Two asphyxiants would also be present: CO_2 and N_2.

The QRA identifies several flammable gas mixtures. Additional localized hazards such as coal dust and urea piles were not included in the QRA because exposure to these mixtures would not extend off-site. Transportation accidents that could occur are discussed in Section 3.18.4.2. The QRA also identifies the following TCEP process units, associated pipelines, and storage facilities handling the aforementioned materials:

- NH_3 synthesis unit

- Hg removal and acid gas removal units
- H_2SO_4 plant
- CO_2 compression and drying unit
- Gasification unit
- Sour shift and gas cooling units
- Blowdown and sour water system
- Urea synthesis
- Air separation unit
- Gas turbine unit
- Anhydrous NH_3 storage
- CO_2 pipeline
- Natural gas pipeline

Results

QRA data indicate that toxic hazards would be dominated by the potential releases of NH_3 gas from the pipeline leading from the NH_3 synthesis unit to the urea synthesis plant or through NH_3 production or storage processes. Hazards associated with NH_3 gas releases could extend beyond the plant site boundaries. Risks would be greatest to those workers closest to the NH_3 synthesis unit (Cornwall 2010).

The highest level of fire risk in the TCEP would result from processes involving the production and transfer of syngas. Fire hazards at the polygen plant site would not extend beyond the plant itself (Cornwall 2010).

Risk calculations are expressed as a numerical measure representing the chance or probability that an individual in any one location would be exposed to a fatal hazard during a one-year period. Risk numerical values are further defined in Table 3.59.

Table 3.59. Risk Level Terminology and Numerical Values

Numerical Value	Shorthand Notation	Chance per Year of Fatality
1.0×10^{-3}	10^{-3}	One chance in 1,000 of a fatality annually
1.0×10^{-4}	10^{-4}	One chance in 10,000 of a fatality annually
1.0×10^{-5}	10^{-5}	One chance in 100,000 of a fatality annually
1.0×10^{-6}	10^{-6}	One chance in 1 million of a fatality annually
1.0×10^{-7}	10^{-7}	One chance in 10 million of a fatality annually
1.0×10^{-8}	10^{-8}	One chance in 100 million of a fatality annually

As shown above, a value of 1.0×10^{-6} (or 10^{-6} in shorthand notation) represents one chance in 1 million per year of a fatality caused by a release originating in the polygen plant or associated pipelines. If this risk level is predicted to occur at a particular location, it represents the annual chance of fatality at that location due to any of the potential releases from the TCEP equipment.

The risk probabilities contained in the QRA are expressed in contours. Each contour line represents the probability of human fatality in relationship to the polygen plant. Figure 3.31 presents the levels of risk of exposure to a lethal dose of a toxic material or exposure to a lethal asphyxiant level or exposure to a lethal radiant or overpressure exposure for all the potential releases evaluated. For example, the dark blue line labeled 10^{-6} represents the risk of fatality described above (i.e., a one in 1 million annual chance of a fatality as a result of any flammable, toxic, or asphyxiant fluid release occurring in the project area, the natural gas connector pipeline, or the CO_2 connector pipeline). The highest risk depicted in the contours indicates a one in 1,000 chance of a fatality; the lowest risk represents a one in 100 million chance.

Under all scenarios, plant workers would be the most at risk of injury or death. Quest has indicated that some assumptions underlying the analysis, such as the amount of equipment, consequences of equipment failure, and locations of individuals at all times of the day are conservative (i.e., overstated), and as such, the risk contours over-predict the risks.

For pipelines outside the project area, the QRA depicts risk as transects. A risk transect plots the annual risk of fatality caused by a release from the pipeline against the perpendicular distance from the pipeline. This method of risk presentation provides a simple method of risk comparison for multiple pipelines. Figure 3.32 presents the calculated risk transects for the incoming 4-in (10-cm) natural gas and 10-in (25-cm) export CO_2 pipelines associated with the TCEP.

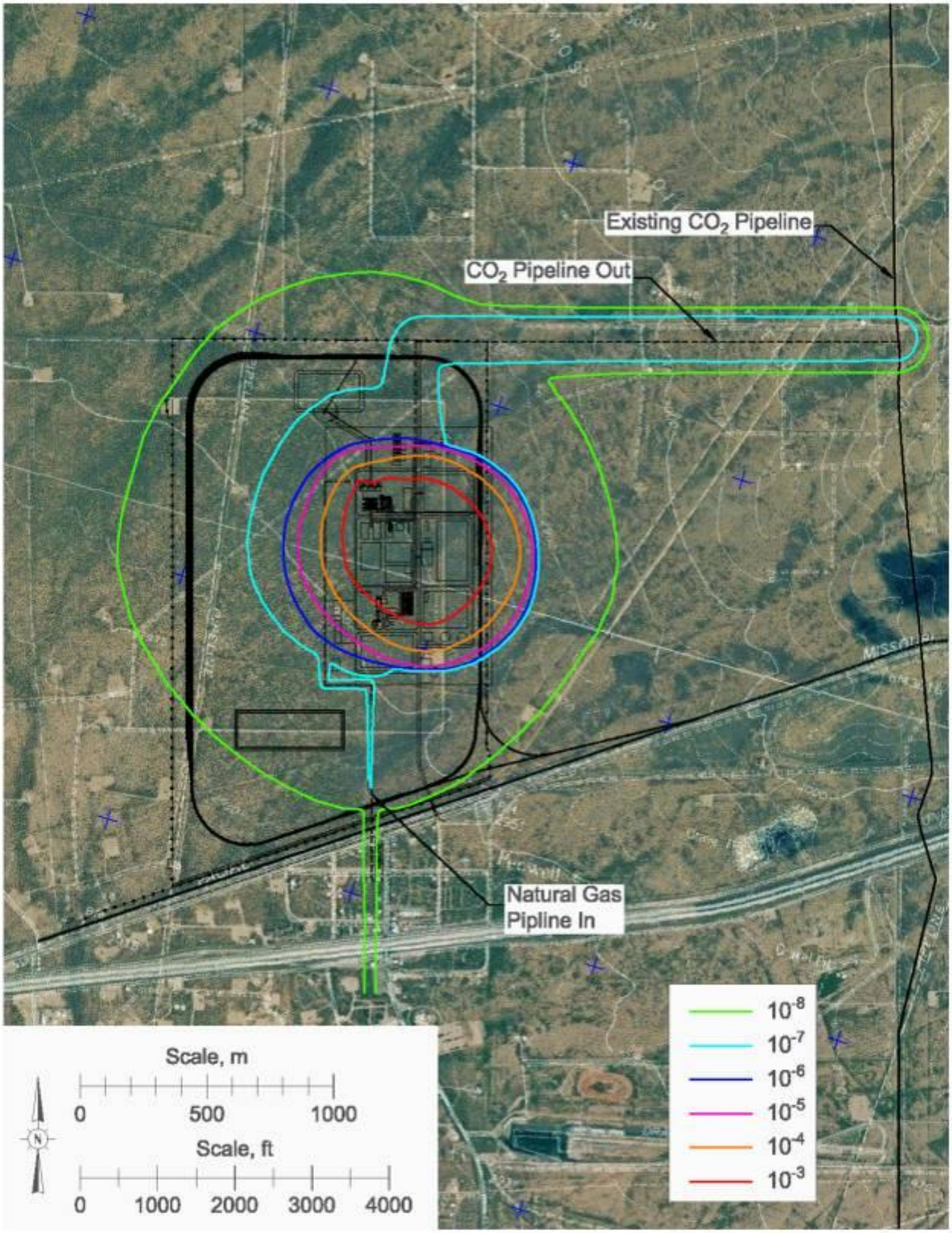

Figure 3.31. TCEP quantitative risk analysis risk contours (Quest 2010).

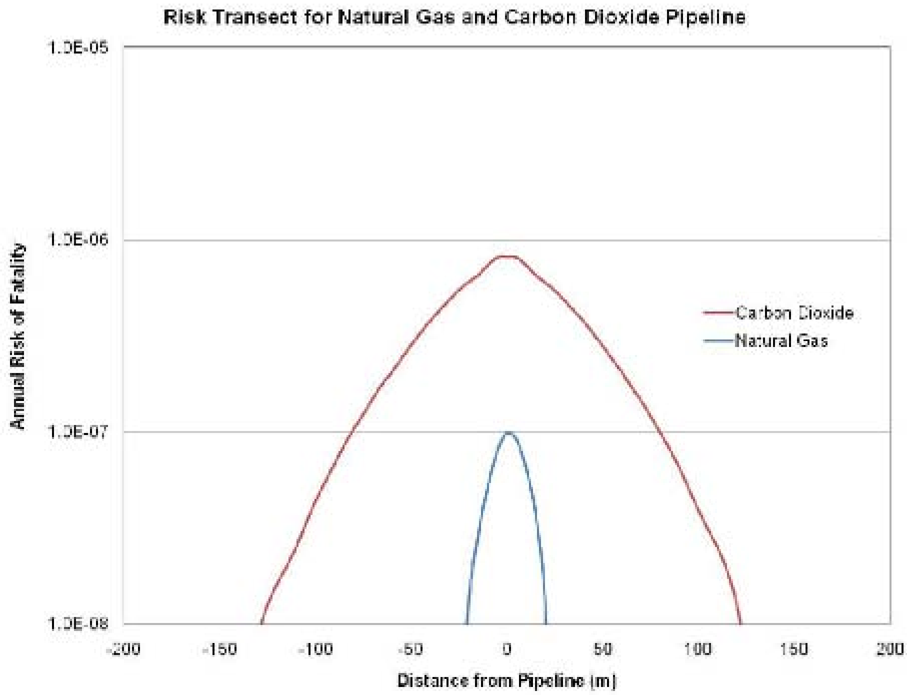

Figure 3.32. Risk transect for TCEP carbon dioxide and natural gas pipelines (Quest 2010).

As shown above, risk associated with CO_2 is less than 10^{-6} (one chance in 1 million of fatality per year) directly above the pipeline, decreasing to 10^{-7} at approximately 230 ft (70 m) from the pipeline, and to 10^{-8} at approximately 460 ft (140 m) from the pipeline. The natural gas pipeline would pose a lesser risk overall. The 10^{-7} contour shows up directly above the pipeline, but the risk decreases sharply and becomes minimal at approximately 82 ft (25 m) from the pipeline.

Conclusions

The QRA allows the following conclusions:

- The fatality risk levels posed by potential releases of flammable, toxic, and asphyxiant gases from the proposed TCEP and associated pipelines would be low.
- The closest residential area, Penwell, is located over 3,280 ft (1,000 m) to the south of the proposed polygen plant site. The residents in Penwell would not be exposed to any risk levels greater than 1.0×10^{-8} (one chance in 100 million of a fatality annually) from the TCEP.
- The high consequence/low probability of accidental releases associated with the NH_3 storage operations drive the outer (1.0×10^{-7} and 1.0×10^{-8}) risk contours. At the time of this analysis, the anhydrous NH_3 storage options and designs were not completed. Quest used assumptions involving the inventory and location options that may be employed were purposely conservative. The actual risk associated with the NH_3 storage options are expected to be lower when the polygen plant design is finalized. When the actual design is incorporated into the analysis, the 1.0×10^{-7} and 1.0×10^{-8} risk contours are expected to move inward, closer to the TCEP.

- The risks associated with the natural gas and CO_2 pipeline operations are low, below 1.0×10^{-6} in the immediate vicinity of the pipeline.

The QRA found the hazards and risks associated with the proposed TCEP and associated pipelines to be similar to those of process plant operations worldwide that handle low concentrations of toxic materials in gas streams, and concluded that the risks posed by flammable fluids are small because most of the flammable fluids would be processed in the gaseous phase.

3.18.5.6 POST-INJECTION RISK ANALYSES

The TCEP would annually capture approximately 3 million tn (2.7 million t) of CO_2, which would be purchased by others for EOR operations that would ultimately lead to geologic sequestration of the CO_2. The CO_2 stream used for EOR may also contain other gases, including up to 20 ppm H_2S. This section evaluates the potential impacts from CO_2 and H_2S, after injection into subsurface reservoirs.

CO_2 and other gases would remain trapped for extremely long time periods in subsurface reservoirs. However, these gases may also be accidentally released through one of the following key mechanisms (Intergovernmental Panel on Climate Change [IPCC] 2005):

- Upward leakage through the caprock due to either catastrophic failure and quick release or gradual failure and slow release;
- Release through existing faults or induced faults due to the effects of increased pressure;
- Lateral or vertical leakage into nontarget aquifers due to an unknown structural or stratigraphic connection with the target zone, or due to a lack of geochemical trapping and inadequate retention time in the target zone; and
- Upward leakage through inadequately constructed wells, abandoned wells, or undocumented wells.

If CO_2 were to escape the EOR reservoir, it could increase pore pressures in the vadose zone (near-surface unsaturated soils above the water table). This increase in pressure has been known to displace the naturally occurring and radioactive element radon, where it can accumulate in confined areas such as buildings and become a health hazard.

EPA mapped the Permian Basin as an area with a low potential for radon to exceed the recommended upper limit for air concentrations in buildings (EPA 2010f), indicating that there is a low potential for CO_2 to displace radon. If on the rare chance that CO_2 were to leak and radon were present in ore-bearing rocks, radon transport induced by CO_2 leakage would be highly localized over the point of CO_2 leakage.

As part of the FutureGen EIS, DOE evaluated potential accidents associated with carbon sequestration activities and their potential health effects on workers and the general public who may be exposed to the release of CO_2 and H_2S. The FutureGen EIS analysis (Tetra Tech 2007) included the same plant site as that proposed for the TCEP, and it included an injection well field location that would be geologically representative of the Permian Basin oil fields that would be injected with TCEP's CO_2 for purposes of EOR.

The analysis of releases from the geological storage of CO_2 is a new science, and there are no well-established methodologies for modeling these releases (IPCC 2005) or guidance from EPA. Further, many studies have concluded that it is impossible to confidently quantify the likelihood and magnitude of accidental releases of sequestered CO_2 (Vendrig et al. 2003, as cited in Tetra Tech

2007). Therefore, to provide a range of escape estimates for sequestered gases, the analysis used data from an analog database that included the site characteristics and results from studies performed at other CO_2 storage locations and from sites with natural CO_2 accumulations and releases. The expected incidence of pipeline ruptures or punctures was evaluated using existing CO_2 pipeline data. The estimated failure rate of wellhead equipment during operation was based on natural gas injection well experience. Failure frequencies for leakage scenarios were obtained from estimates of releases from existing injection sites and natural releases. Additional information regarding the analogs used in the assessment can be found in the Final Risk Assessment Report (Tetra Tech 2007) for the FutureGen EIS. The potential for accidents considered in this analysis were expressed on a per annum basis: likely (frequency $\geq 1 \times 10^{-2}$ per year), unlikely (frequency from 1×10^{-2} per year to 1×10^{-4}per year), and extremely unlikely (frequency from 1×10^{-4} per year to 1×10^{-6} per year). The following accident scenarios were analyzed for all four potential FutureGen sites, including the Odessa site:

- Ruptures in the pipeline transporting CO_2 and H_2S from the plant to the sequestration site (considered unlikely)
- Punctures in the CO_2 pipeline (considered unlikely to likely depending on the site)
- Wellhead failures at the injection well (considered extremely unlikely)
- Slow upward leakage of CO_2 from the injection well (considered extremely unlikely)
- Slow upward leakage of CO_2 from other existing wells (considered extremely unlikely to unlikely)

The probability of a slow upward leakage of CO_2 from other existing wells is location dependent. In old oil fields with old wells penetrating the reservoir undergoing EOR, the risks would be higher than in newer oil fields because, generally, the condition of existing wells is better in newer fields. Site-specific risks for oil fields that purchase and use TCEP's CO_2 cannot be estimated until the specific fields are identified.

One set of toxicity criteria was identified for short-term post-injection release scenarios consisting of the rupture of a pipeline or wellhead equipment that could result in a rapid release of gases lasting in the range of minutes or hours. The other set of toxicity criteria was identified for release scenarios where long-term releases could occur over longer periods of time as a result of smaller leaks.

The injection well field site used for the FutureGen risk analysis is located approximately 58 mi (93 km) south of the proposed polygen plant site and approximately 8 mi (13 km) from Fort Stockton. The study noted that the area is largely open with a relatively low population density and no sensitive receptors within 50-year sequestration plume footprint.

For both the short- and long-term release scenarios at the FutureGen Odessa site, exposures to CO_2 did not exceed either the acute toxicity criteria (20,000 ppmv) or chronic toxicity (10,000 ppmv) criteria and would therefore be unlikely to pose a risk to residential receptors post-injection. Assumed exposures to H_2S also would not exceed toxicity criteria for the short-term release scenarios. Further, H_2S was not assumed to be released through the caprock and would not exceed toxicity criteria for long-term releases through both existing and induced faults. However, long-term releases of H_2S from all three types of wells examined (CO_2 injection wells, abandoned oil and gas wells, and undocumented, abandoned, or poorly constructed wells) could result in exposures to concentrations that exceeded the toxicity criteria within 909 ft (227 m) of the release.

The analysis concluded that fewer than one person would be potentially affected by slow leakage of H_2S at the CO_2 injection well or other deep well and that the frequency of failure was quite low. However, the number of people affected at the time of such a release would depend on wind direction, speed, and atmospheric stability.

Currently, the entire Permian Basin has been identified as the potential area for TCEP-related EOR activities. Although the FutureGen injection well field location is in the general area targeted for EOR and contains similar geologic formations, the location where TCEP-related EOR activities would take place may or may not have the same population density. As a result, although the release scenarios and downwind distances of concern are likely to be similar, the numbers of residents or sensitive receptors that could be exposed cannot be estimated until a more exact area for EOR is identified.

The FutureGen report indicated that the only likely ecological effects from assumed releases of CO_2 and H_2S were olfactory effects in several insects. These effects would not be expected to significantly affect ecological communities. However, it should be noted that no ecological toxicity criteria were available for H_2S.

3.18.5.7 HAZARDOUS AIR POLLUTANTS

HAPs, also known as air toxics, are pollutants that cause or possibly cause cancer in humans or may cause adverse environmental and ecological effects. As discussed more fully in Section 3.3, Air Quality, a health effects evaluation was performed for the emissions of hazardous pollutants from the TCEP's operations using the TCEQ ESLs. The maximum predicted concentrations for all identified toxic compounds were below their respective ESLs, except for Tier I short-term coal dust. However, because the Tier II maximum concentration at a nonindustrial receptor was lower than the Tier I short-term ESL, the coal dust concentrations met the Tier II requirements for public health and no further analysis was performed, pursuant to TCEQ regulations.

3.18.5.8 TRANSMISSION LINES AND ELECTROMAGNETIC FIELDS

Magnetic fields can be induced by the movement of electrons in a wire (current) and electric fields are created by voltage, the force that drives the electrical current. All electrical wiring, devices, and equipment including transformers, switchyards, and transmission lines produce electromagnetic fields. The strength of these fields diminishes rapidly with distance from the source. Building material, insulation, trees, and other obstructions can reduce electric fields, but do not significantly reduce magnetic fields. Electrical field strength is measured in kilovolts per meter. Magnetic field strength is expressed as a unit of magnetic induction (Gauss) and is normally expressed as a milligauss, which is one thousandth of a Gauss. The average residential electric appliance typically has an electrical field of less than 0.003 kV/ft (0.01 kV/m). In most residences, when in a room away from electrical appliances, the magnetic field is typically less than 2 milligauss. However, very close to an appliance carrying a high current, the magnetic field can be thousands of milligauss.

Electric fields from power lines are relatively stable because line voltage does not vary much. However, magnetic fields on most lines fluctuate greatly as the current changes in response to changing loads (consumption or demand).

Transmission lines contribute a relatively small portion of the electric and magnetic fields to which people are exposed. Nonetheless, over the past two decades, some members of the scientific community and the public have expressed concern regarding human health effects from electromagnetic fields during the transmission of electrical current from power plants. The scientific evidence suggesting that electromagnetic field exposures pose a health risk is weak. The strongest evidence for health effects comes from observations of human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults (National Institute of Environmental Health Sciences 1999). The National Institute of Environmental Health Sciences report concluded that, "extremely low-frequency magnetic field exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard" (National Institute of Environmental Health Sciences 1999:1). Although a fair amount of uncertainty still exists about the electromagnetic field health effects issue, the following determinations have been established from the information:

- Any exposure-related health risk to an individual would likely be small;
- The types of exposures that are most biologically significant have not been established;
- Most health concerns relate to magnetic fields; and
- Measures employed for electromagnetic field reduction can affect line safety, reliability, efficiency, and maintainability, depending on the type and extent of such measures.

3.18.6 Mitigation

Mitigation measures that Summit would implement as part of the construction and operation of the TCEP are described in Table 2.8 of Chapter 2. Additional mitigation measures that Summit could implement or that DOE could require as a condition of approval to further reduce impacts to human health and safety are:

- Constructing a separated grade rail crossing at the intersection of FM 1601 and the UPRR or including active warning signals at an at-grade crossing at that location to reduce risk to TCEP workers accessing the plant site

Conducting a Phase I environmental site assessment along unexamined ROW sections prior to construction of the linear facilities would reduce the risk of exposure to potentially hazardous materials that could be uncovered during excavation. If a Phase 1 assessment identifies potential environmental risks along the ROWs, it should be followed by Phase II (testing) and Phase III (removal and disposal of contaminated materials) assessments, as necessary, to reduce this risk.

3.19 Noise and Vibration

3.19.1 Background

3.19.1.1 NOISE

Noise is defined as unwanted sound because it interferes with speech communication and hearing or is otherwise considered annoying. The term "unwanted" can be subjective in nature and can vary greatly among individuals. An individual's response to noise is influenced by the type of noise, perceived importance of the noise, appropriateness in the setting, time of day, type of activity during which the noise occurs, and the sensitivity of the individual.

Sound is measured in decibels and is based on a logarithmic scale to account for the wide range of audible sound intensities. Under the logarithmic scale for sound (and noise), a 10-decibel (dB) increase would increase sound intensity by 10 times; a 20-dB increase would increase sound intensity by 100 times. As a result, methods have been developed for weighting the sound frequency spectrum to approximate the response of the human ear. The dBA uses a sound range of 0–140 dBA and is the most widely used weighted scale for environmental noise assessments because of its relative convenience and accuracy in correlating with people's judgments of what constitutes noise. Typical A-weighted sound and noise levels associated with common activities or situations are shown in Table 3.60.

Table 3.60. Typical A-weighted Sound Levels

Sound Source	Sound Level (dBA)	Typical Response
Carrier deck jet operation	140	Limits amplified speech
Jackhammer	130	Painfully loud
Jet takeoff (200 ft [61.0 m])	120	Threshold of feeling pain
Auto horn (3 ft [0.91 m])		
Riveting machine	110	
Jet takeoff (2,000 ft [609.6 m])		
Shout (0.5 ft [0.15 m])	100	Very annoying
New York subway station		
Heavy truck (50 ft [15.2 m])	90	Hearing damage (8-hour exposure)
Pneumatic drill (50 ft [15.2 m])		
Passenger train (100 ft [30.5 m])	80	Annoying
Helicopter (in flight, 500 ft [152.4 m])		
Freight train (50 ft [15.2 m])		
Freeway traffic (50 ft [15.2 m])	70	Intrusive
Air conditioning unit (20 ft [6.1 m])	60	
Light automobile traffic (50 ft [15.2 m])		

Table 3.60. Typical A-weighted Sound Levels

Sound Source	Sound Level (dBA)	Typical Response
Normal speech (15 ft [4.6 m])	50	Quiet
Living room	40	
Bedroom		
Library		
Soft whisper (15 ft [4.6 m])	30	Very quiet
Broadcasting studio	20	
	10	Just audible
	0	Threshold of hearing

Source: Council on Environmental Quality (1970).

People tend to respond to variations in sound pressure in a logarithmic manner. For example, when comparing similar sounds (e.g., changes in traffic noise levels) a 3-dBA change in sound-pressure level is considered detectable by the human ear in most situations. A 5-dBA change is readily noticeable by most people, and a 10-dBA change is perceived to be a doubling (or halving) of sound or noise.

When used by itself, a dBA value represents a sound level at a given instant or at a maximum level; however, noises can vary in level and duration. Those levels that vary over time and are applicable to this noise assessment are identified by two A-weighted scale descriptors: the equivalent sound level (Leq) and the day-night level (Ldn). Leq represents a steady-state sound with the same energy and A-weighted level as measured continuously over a given time period. It is used only when the durations and levels of sound, not the time of occurrence (day or night), are relevant. Ldn is defined as the energy average of an A-weighted sound level occurring during a 24-hour period, with an additional 10-dBA weighting imposed on Leq levels occurring during nighttime hours (10:00 p.m. to 7:00 a.m.) to account for a lower tolerance to noise at night when people are sleeping.

3.19.1.2 VIBRATION

Vibration consists of rapidly fluctuating motions with an average motion of zero. Ground-borne vibration can be a major concern for off-site damage to existing structures and can be potentially annoying or disturbing to humans and wildlife. Typical outdoor sources of perceptible ground-borne vibration are construction activities such as blasting or pile driving, steel-wheeled trains, and traffic on rough roads. Common effects of vibration include shaking of building structures (i.e., floors or windows), rumbling sounds, and—in some extreme cases—damage to buildings (Federal Transit Administration [FTA] 2006).

The measurement of ground vibration is peak particle velocity, which is the maximum speed (measured in inches per second or millimeters per second) at which a point on the ground moves relative to its static state. Although peak particle velocity is appropriate for evaluating the potential of building damage, it is not necessarily suitable for determining human response. The root-mean-square vibration velocity level is expressed in velocity decibels, meaning the vibration velocity in decibels relative to 1 microinch per second, and more appropriately describes effects of human disturbance from ground-borne vibration. Human perceptibility of vibration has a threshold of 65 velocity dB, but human response is not usually significant until vibrations exceed 70 velocity dB. Bulldozers and other heavy-tracked equipment generate vibration levels of approximately 96 velocity dB. The threshold for minor structural damage is 100 velocity dB or a peak particle velocity of 0.12 in per second (3.05 mm per second) for fragile buildings (FTA 2006).

3.19.2 Region of Influence

The noise and vibration ROI is the area within which there would be potential noise impacts from polygen plant construction and operation on nearby residential areas, and potential impacts on residents from project-related linear construction and commuter traffic noise. The ROI boundary for the polygen plant noise is a 1-mi (1.6-km) radius around the site perimeter. The ROI boundary for access roads is 0.25 mi (0.4 km) from the ROW boundary, based on the attenuation distance from a 90-dBA noise level (a heavy truck at 50 ft [15 m] as shown in Table 3.60) to the 62-dBA background level DOE observed in its FutureGen EIS (DOE 2007). The ROI for noise is dependent on the magnitude of noise emissions that would be generated and on existing or ambient noise levels, which would affect the degree of the noise impact.

3.19.3 Methodology and Indicators

The impacts analysis for noise and vibration used several indicators to assess type, magnitude, and severity of potential impacts from TCEP construction and operations. Potential impacts and their indicators are shown in Table 3.61.

Table 3.61. Indicators of Potential Noise and Vibration Impacts

<table>
<tr><th>Potential Impact</th><th>Impact Indicator</th></tr>
<tr><td>Disturbance to human receptors from increases in noise or vibration as a result of construction or operation of the TCEP</td><td rowspan="2">Estimated construction and operational noise levels at key receptors
Acres of land impacted from construction and operation disturbance that exceeds ambient noise levels</td></tr>
<tr><td>Disturbance to human receptors from increases in noise or vibration as a result of an increase in vehicle/rail traffic patterns and volumes</td></tr>
</table>

EPA has developed residential noise guidelines to protect human health and welfare (EPA 1974). EPA sound-level guidelines do not provide an absolute measure of noise impact, but rather a consensus on potential community interference. The EPA residential guidelines developed to protect against hearing loss established a safety threshold at 70 dBA/24-hour Leq; guidelines to minimize outdoor activity interference and annoyance have a short-term threshold of 65 dBA and a long-term threshold of 55 dBA Ldn. These threshold levels were used to analyze impacts from TCEP operations.

FTA established noise guidelines for transportation and construction projects to protect human health and safety (FTA 2006). FTA noise thresholds for project construction are shown in Table 3.62. These FTA thresholds were used in analyzing potential noise impacts that could be caused during TCEP construction and startup. Potential noise impacts caused by project operations were analyzed using EPA noise threshold levels discussed above because EPA guidelines have long-term noise levels thresholds for protecting human health and safety.

Table 3.62. Federal Transit Administration Construction Noise Thresholds

Land Use	8-Hour Leq (dBA)		Ldn (dBA)
	Day	Night	30-day Average
Residential	80	70	75*
Commercial	85	85	80†
Industrial	90	90	85†

Source: FTA (2006).

*In urban areas with very high ambient noise levels (Ldn > 65 dB), Ldn from construction activities should not exceed existing ambient + 10 dB.

†24-hour Leq, not Ldn.

3.19.3.1 NOISE

For this analysis, adverse impacts were considered to be noise intensities that would be caused by construction or operation of the TCEP that exceeded the FTA acceptable threshold levels for residential, commercial, and industrial areas. Potential noise-sensitive receptors (that is, people living and/or working near the project area) were identified based on the type of receptor locations (residences, schools, daycare facilities, hospitals, nursing homes, churches, and parks) and their proximity to the polygen plant site and linear facilities.

The evaluation of potential impacts from noise or vibration considered whether the proposed project would cause any of the following conditions:

- Conflict with federal, state, or local noise standards during construction or operation
- Disturbance (change of ≥3 dBA [Leq]) to noise-sensitive receptors from increases in noise or vibration as a result of construction-equipment operation and increases in construction vehicle or rail traffic patterns and volumes
- Disturbance (change of ≥3 dBA [Leq]) to noise-sensitive receptors from increases in noise or vibration as a result of operation activities, including increases in vehicle-traffic patterns and volumes and increases in railcar volumes

Baseline noise monitoring was conducted at the proposed polygen plant site on June 19, 2007, by DOE for the FutureGen EIS (DOE 2007). DOE conducted ambient noise monitoring to quantify baseline (ambient) noise levels at the nearest sensitive receptor site to the proposed TCEP. During field reconnaissance efforts for the TCEP (July 7–9 and August 30–September 2, 2010), DOE determined that sensitive receptor locations had remained relatively constant since 2007, and that the monitoring location used in 2007 remains the closest location to the polygen plant site. Because no discernable development has occurred in the area of the monitoring location to date, and traffic conditions have remained relatively constant, DOE determined that ambient noise data collected in 2007 are applicable to and sufficient for use as baseline conditions for the TCEP noise analysis.

DOE evaluated noise levels produced by both stationary sources (construction and operation equipment) and mobile sources (construction and operational vehicle and rail traffic). Standardized noise intensity and noise attenuation equations were used for the stationary source and mobile source analyses, and are shown below.

For both the stationary and mobile source analyses, standard sound equations were used (California Department of Transportation 1998) to predict ambient noise levels at the sensitive receptor location and compare the proposed project traffic-noise volumes. For the analysis, it was assumed that noise intensities below the FTA and EPA thresholds for human health and safety would have no adverse impacts to human health and safety.

3.19.3.2 VIBRATION

DOE used a screening process to determine the potential effects of ground-borne vibrations (e.g., blasting or pile driving, steel-wheeled trains, traffic on rough roads) on the identified vibration-sensitive receptors. If the distance from the source of ground-borne vibrations to a sensitive receptor is greater than 200 ft (61 m), FTA considers it reasonable to conclude that no further action is needed (FTA 2006). If sensitive receptors are closer than 200 ft (61 m) to ground-borne vibrations, further assessment criteria are recommended by FTA to quantitatively determine the potential annoyance impacts to humans and the potential damage to building or equipment. There may be potential vibration-related impacts to wildlife in the ROI. Noise and vibration impacts to wildlife are discussed in Section 3.8, Biological Resources.

3.19.4 Affected Environment

3.19.4.1 NOISE

Existing noise sources near the proposed project area include vehicle traffic on I-20, FM 866, FM 1601; traffic on adjacent unpaved roads; localized oil and gas pumping equipment; railroad traffic; and general ambient background noise. There are six noise-sensitive receptor locations south of the proposed polygen plant, mostly in Penwell. These sensitive receptor locations include two permanent residences north of I-20 (SL-1 and SL-2) and four permanent residences south of the highway (SL-3, SL-4, SL-5, and SL-6). These sensitive receptor locations are shown in Figure 3.33.

SL-1 was chosen as the representative monitoring site for the Penwell residences because it is the closest noise-sensitive location to the proposed polygen plant site, approximately 0.25 mi (0.4 km) south of the site boundary (Figure 3.33). Ambient noise data were collected at this site on June 19, 2007, and spanned 10 minutes during the early morning hours (DOE 2007). Local noise sources, overall environmental conditions, and area meteorological conditions were also noted prior to sampling. The air temperature (in degrees Fahrenheit) during the survey was in the mid to upper 70s, with relative humidity averaging 70 percent and barometric pressure averaging 29 in (74 cm) of Hg. DOE recorded an ambient noise level of 62 dBA at SL-1. When compared to a typical Ldn of 50 dBA for rural areas (EPA 1974), ambient noise quality at SL-1 appears to be heavily influenced by existing vehicle traffic on I-20, which is located approximately 800 ft (244 m) south.

Existing ambient noise levels would vary with location and level of human activity. Most of the TCEP linear facilities would pass through rural areas that would likely have Leq values in the range of 47–57 dBA, which is typical of a rural environment (DOE 2007). Areas with greater human activity near the cities of Odessa and Midland would have higher ambient noise levels.

3.19.4.2 VIBRATION

Existing sources of vibration in proximity to the proposed project area include haul truck traffic on I-20 and FM 866. However, no vibration-sensitive receptors (i.e., humans, buildings, and sensitive equipment) are located in the FTA-defined 200-ft (61-m) distance screening and human annoyance threshold (FTA 2006). Therefore, this potential impact was eliminated from further detailed impacts analysis.

3.19.5 Environmental Impacts of the Proposed Project

3.19.5.1 CONSTRUCTION

TCEP construction activities would include site clearing and grading, excavation, foundation laying, building construction, and finishing, all of which would be completed in approximately 36 months. The construction actions would produce increased ambient noise levels that include commuter and construction-vehicle traffic, construction-equipment operation, and steam-venting during polygen plant startup.

<u>Stationary Source Analysis</u>

Polygen Plant Site

The DOE stationary source analysis evaluated potential maximum effects of anticipated construction equipment noise levels at the polygen plant site on sensitive receptors. Table 3.63 presents standard noise levels from common construction equipment at various distances. These typical noise levels do not account for attenuation from air absorption, ground effects, and shielding from intervening topography or structures, all of which would further decrease the dBA levels shown below for each distance. Noise attenuation effects are not accounted for because some attenuation factors such as topography, wind speed and direction, and building shielding are site-specific.

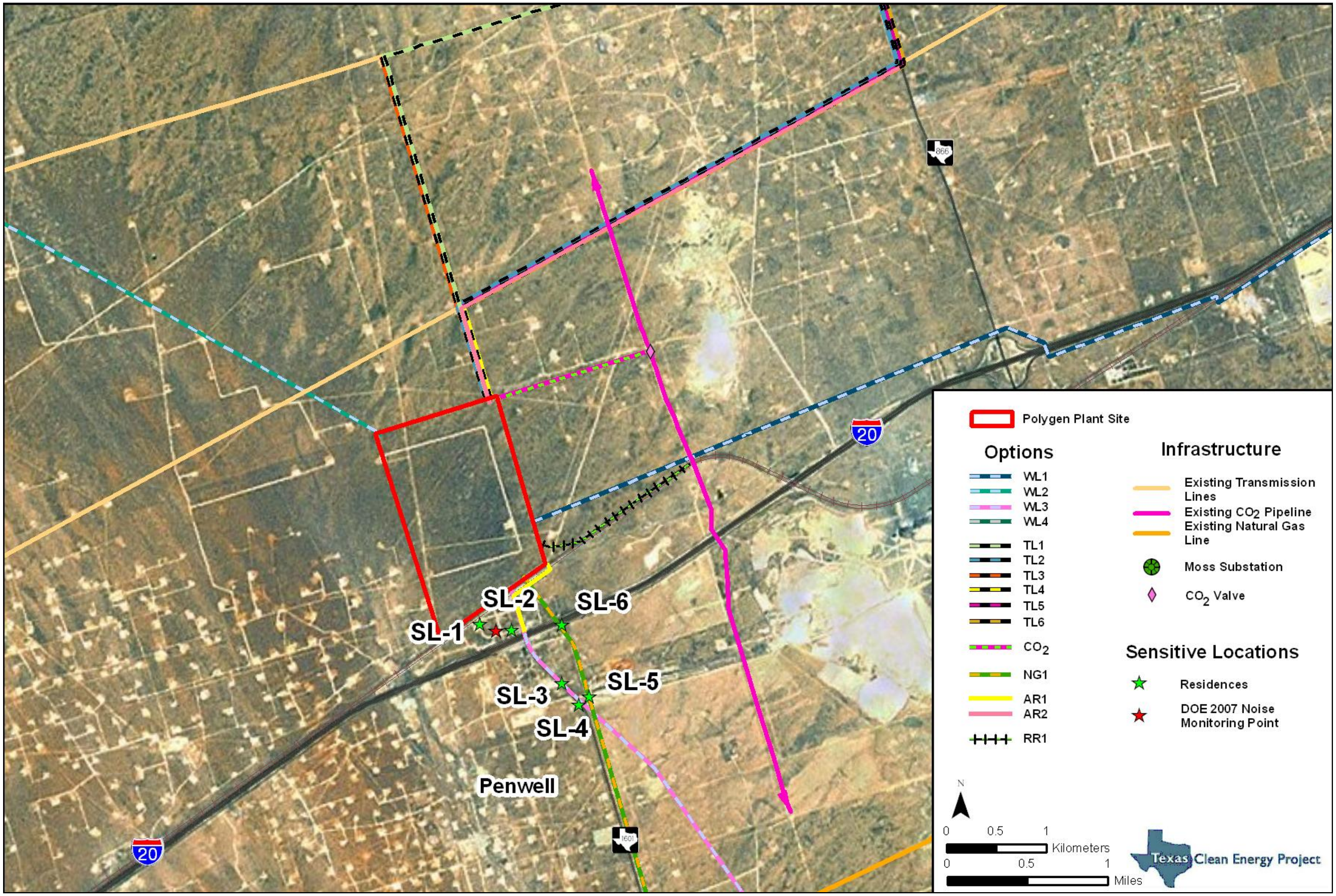

Figure 3.33. Noise receptor locations.

Table 3.63. Noise Levels from Common Construction Equipment

Construction Equipment	Typical Sound Pressure Level (dBA)*				
	50 ft (15 m)	100 ft (31 m)	500 ft (152 m)	1,500 ft (457 m)	3,000 ft (914 m)
Bulldozer (250–700 horsepower)	88	82	68	58	52
Front end loader (6–15 cubic yards)	88	82	68	58	52
Dump trucks (200–400 horsepower)	86	80	66	56	50
Grader (13- to 16-ft blade)	85	79	65	55	49
Shovels (2–5 cubic yards)	84	78	64	54	48
Portable generators (50–200 kilowatts)	84	78	64	54	48
Derrick crane (11–20 tn)	83	77	63	53	47
Mobile crane (11–20 tn)	83	77	63	53	47
Concrete pumps (30–150 cubic yards)	81	75	61	51	45
Tractor (0.75–2.00 cubic yards)	80	74	60	50	44
Un-quieted paving breaker	80	74	60	50	44
Quieted paving breaker	73	67	53	43	36

Source: EPA (1971); Barnes et al. (1976); CH2M Hill (2010).

* Sound attenuation was calculated using the following formula: $dBA_2 = dBA_1 + 20 \, Log_{10} (D_1/D_2)$.

To determine the most conservative or maximum noise levels caused by project construction, the three loudest pieces of construction equipment (bulldozer, front end loader, and dump trucks) were combined. The combined noise level of 92.2 dBA was then attenuated over relative distances from the closest sensitive receptor north of I-20, (the SL-1 receptor site), as well as from the closest sensitive receptor site south of I-20 (SL-6) to the proposed polygen plant site. The existing ambient and proposed distance-attenuated noise levels were then combined to determine the estimated noise level at SL-1 and SL-6. Noise levels that would result from equipment-related construction activities associated with the TCEP are shown in Table 3.64.

Table 3.64. Noise Levels That Would Result from the TCEP at SL-1 and SL-6

Sensitive Receptor Location	Relative Distance (mi [km])	Existing Ambient Noise Level (dBA)	Equipment Noise Level Attenuated by Distance (dBA)	Estimated Noise Level (dBA)	Change in dBA
SL-1	0.25 (0.40)	62	63.8	66.0	4.0
SL-6	0.50 (0.80)	62*	57.7	63.4	1.4

*The ambient noise level at SL-6 was assumed to be the same as that measured for SL-1 because both are located near I-20.

The dBA noise levels presented in Table 3.64 approximate the noise intensity that would be experienced by people outdoors. Sound levels can be reduced by as much as 27 dB indoors, with windows closed. In dwellings with windows open, indoor sound levels can be reduced by up to 17 dB (EPA 1974). Construction-related equipment noise would be perceptible outdoors during the busiest periods of activity at the receptor locations north of I-20. SL-1 would experience a maximum (conservative) 4-dBA increase in noise. Those receptors south of I-20 would likely not hear a substantial noise level increase due to the existing ambient noise levels from vehicular traffic on I-20. The impacts from construction on residential and commercial land uses would be lower than FTA threshold levels, and thus would not be expected to result in adverse impacts on sensitive receptors near the proposed project area.

Intermittent increases in noise prior to and during polygen plant startup and commissioning would result from steam venting, which is a necessary part of the equipment-testing process prior to startup. Venting activities would last no more than two weeks, during which high-pressure steam (or air) would be allowed to escape through an outlet in the piping. A series of short sound blasts, lasting two or three minutes each, may be performed several times daily over that two-week period. Steam venting could be as loud as 120 dBA at the center of the polygen plant site and would attenuate to 84 dBA at the site boundary. Venting noise would further attenuate to 81 dBA at SL-1 and 79 dBA at SL-6. Table 3.65 shows the venting noise impacts that would occur at SL-1 and SL-6. Although substantially adverse on the proposed polygen plant site, these noise increases would be temporary and could be mitigated by limiting steam blows to daytime hours and providing advance notice to Penwell residents. The estimated levels of noise produced during the periods of steam venting would briefly exceed acceptable FTA levels for residential areas, but would meet FTA commercial and industrial-area construction threshold levels.

Table 3.65. Noise Levels That Would Be Caused by Steam Venting at SL-1 and SL-6

Sensitive Receptor	Relative Distance (mi [km])	Existing Ambient Noise Level (dBA)	Steam Venting Noise Level Attenuated by Distance (dBA)	Change in dBA
SL-1	0.25 (0.40)	62	81	19
SL-6	0.50 (0.80)	62	79	17

Linear Facilities

The construction of the linear facilities such as pipelines, access roads, and transmission lines would include site clearing, grading, excavation, foundation work, trenching, pipe laying, structure erection and installation, transmission wire installation, asphalt laying, and finishing work. These activities would require the use of heavy construction equipment that would likely be temporarily audible from locations outside the linear facility ROWs (temporary impacts would be those lasting for days or a few weeks, at most). The noise levels produced by linear-facility construction activities and heavy equipment would vary greatly depending on such factors as the operations being performed, the type of equipment being used, and if sound-attenuating features (e.g., trees, topography, buildings) were present. However, with the exception of NG1, AR1, and WL3, all other proposed linear facilities would enter the project area to the north or east of Penwell, and lie at least 0.5 mi (0.8 km) from the nearest receptors in and around Penwell. The construction of these linear facilities would likely create temporary, adverse noise impacts to sensitive receptors because they would be constructed close to all of the sensitive receptors along FM 1601 and in Penwell.

Additionally, there would be potentially adverse, temporary, construction-related noise impacts to receptors in outlying Odessa residential areas near the ROWs for TL5 and TL6.

Mobile Source Analysis

The DOE mobile source analysis evaluated the potential maximum effects of the anticipated increase in construction-vehicle traffic, including commuting construction workers, and haul trucks carrying equipment, supplies, and materials in and out of the project area. Expected maximum passenger car traffic would be 2,000 vehicle trips per day, with most traffic taking place during shift changes at 7:00 a.m., 5:00 p.m., and 11:00 p.m. Approximately 52 haul trucks per day would also access the project area. Primary access for construction would be on FM 866 (AR2) from I-20. Traffic could also access the proposed polygen plant site from FM 1601 (AR1); however, this road would have limited project-related use, serving as an emergency or supplemental access for TCEP vehicles. Projected AADT during peak construction was estimated for traffic on FM 866 and FM 1601. Noise levels that would result from traffic-related construction activities associated with the TCEP are shown in Table 3.66.

Table 3.66. Projected Traffic Conditions and Noise Increases during TCEP Peak Construction

Roadway	Existing Traffic (AADT*/PCE†)	Projected Traffic During Peak Construction (AADT*/PCE†)	Projected Change in Noise Levels (dBA)
I-20	15,580/116,538	18,630/120,992	0.2
FM 866	1,500/10,005	4,400/14,309	1.6
FM 1601	20/20	150/150	8.8

*AADT data obtained from Table 3.48 in Section 3.16, Transportation.

†PCE = passenger car equivalent, which is the adjusted AADT that accounts for truck sources, where one truck is equivalent to 28 passenger cars.

Traffic screening results indicate that the use of I-20 for construction-related activities would not result in substantial noise impacts on noise-sensitive receptors adjacent to I-20 and FM 866 because there would be an increase of less than 1 dBA for sensitive receptors located along both roadways. There would be a substantial increase (8.8 dBA) in noise intensity along FM 1601 and temporary noise-related impacts (during construction-related shift changes) to the two noise-sensitive receptors locations (SL-1 and SL-2) located north of I-20 in Penwell. The increase in noise along these access roads would meet FTA noise threshold levels, areas with high ambient noise levels (>65 dB) should not exceed that ambient noise by more than 10 dB, and the estimated dB increase from construction traffic would be within that range.

3.19.5.2 OPERATIONS

The TCEP operations-phase actions that would result in increased ambient noise levels include stationary sources such as plant equipment and transmission lines, as well as mobile sources such as worker and delivery vehicle traffic and rail traffic.

Stationary Source Analysis

Polygen plant operation equipment noise sources would be produced by the steam turbine-generator, gas combustion turbine-generator, HRSG, coal delivery and handling system, pumps, fans, compressors, vents, and relieve valves. Design measures used to reduce operational noise levels include locating and orienting plant equipment to minimize sound emissions, providing buffer zones, enclosing noise sources in buildings, installing inlet air silencers for the combustion turbine, and including silencers on plant vents and relief valves.

Based on the proposed design for the polygen plant, operations would produce an estimated Leq of 65 dBA at the southern fence line of the polygen plant site (Fluor 2010). Using this identified source noise level, DOE applied a sound attenuation equation to determine the noise levels at sensitive receptor locations. The operational noise level at the polygen plant boundary is estimated to attenuate to 61 dBA at SL-1 and 59 dBA at SL-6. These noise intensities would exceed the EPA 55 dBA Ldn noise threshold by 6 dBA at SL-1 and by 4 dBA at SL-6 for the long-term health and safety of nearby noise receptors. However, the 55 dBA level is applicable to outdoor activities; indoor noise attenuation, as discussed above, would reduce the long-term indoor noise levels to be in compliance with the EPA health and safety guidelines.

During operations, combustible gas or steam releases would occur from unscheduled restarts of the polygen plant or emergency-pressure safety valve discharges. If a flare operation or pressure safety valve discharge did occur, it could produce an increase in noise levels at the discharge point and temporarily increase the ambient noise levels near the noise source to a range from 96 to 105 dBA. Outdoor receptors within approximately 3,000 ft (914 m) of the polygen plant would experience adverse noise impacts of short, temporary duration. Therefore, receptors at SL-1 and SL-2 would be temporarily and briefly, but adversely affected, by these unpredictable and unscheduled noise increases.

No noise impacts would occur from operation of the pipelines. However, under wet weather conditions, the transmission lines may generate an audible or low frequency noise, commonly referred to as a “humming noise.” The audible noise emitted from transmission lines is caused by the discharge of energy (corona discharge) that occurs when the electrical field strength on the conductor surface is greater than the “breakdown strength” (the field intensity necessary to start a flow of electric current) of the air surrounding the conductor. The intensity of the corona discharge and the resulting audible noise are influenced by atmospheric conditions. Corona noise is generally not noticeable because humans are typically insensitive to low frequency noise. To reduce the potential for corona noise, the TCEP transmission lines would be designed, constructed, and maintained in accordance with current practices that operate below the corona-producing voltage.

Mobile Source Analysis

TCEP-related operations traffic would be intermittent and would be primarily caused from workers’ vehicles and delivery trucks traveling to and from the project area. The TCEP is expected to have approximately 150 full-time workers. As with the construction phase, operations traffic would access the site from the east using FM 866, with the use of FM 1601 as a project secondary or emergency access road. Expected vehicle traffic volume along FM 866 would be approximately 300 car trips and 52 truck trips daily during operation, with most traffic transiting the project area during shift changes at 7:00 a.m., 5:00 p.m., and 11:00 p.m. Noise levels caused by traffic-related operational activities associated with the TCEP are shown in Table 3.67.

Table 3.67. Projected Traffic Conditions and Noise Increases during TCEP Peak Operation

Roadway	Existing Traffic (AADT*/PCE†)	Projected Traffic During Peak Operation (AADT*/PCE†)	Projected Change in Noise Levels (dBA)
I-20	15,580/116,538	15,930/118,022	0.1
FM 866	1,500/10,005	1,835/11,474	0.6
FM 1601	20/20	35/35	2.4

*AADT data obtained from Table 3.49 in Section 3.16, Transportation.

†PCE = passenger car equivalent, which is the adjusted AADT that accounts for truck sources, where one truck is equivalent to 28 passenger cars.

Traffic screening results indicate that the use of I-20 and FM 866 for project operations and commuting would not produce substantial noise impacts on noise-sensitive receptors located along either roadway. As shown in Table 3.67, the projected noise increase from project-related traffic along the main project access way on FM 866 would be negligible. Also, distance attenuation from the roadway to the sensitive receptor locations would further reduce any noise impacts. There would be an increase in noise activity along the secondary access way on FM 1601 (a 2.4-dBA increase) that would affect the two noise-sensitive receptors locations located north of I-20 in Penwell (SL-1 and SL-2). The polygen plant operations and commuter traffic noise would have adverse impacts on sensitive receptors in Penwell, but the TCEP would not likely be the dominant source of noise at the noise-sensitive receptors because both receptor locations are in proximity to the I-20 transportation corridor and are more likely to be affected by noise from the traffic associated with the highway.

FTA provides estimated noise levels for a locomotive, railcars, whistles or horns, and track switches or crossovers as a freight train passes a nearby receptor (FTA 2006). The maximum level values ranging from 76 to 88 dBA are based on an operating speed of 30 mi (48 km) per hour approximately 50 ft (15 m) from the track centerline. Summit estimates that an average of seven 135-car unit trains per week would be required for coal, urea, H_2SO_4, and slag transport. When compared to existing daily trips of 17 trains (or a maximum of 119 trains per 7-day week) (DOE 2007), this would increase rail activity by 6 percent. It should be noted that rail traffic noise levels already exist from trains and cars traveling along the tracks through Penwell, and that the sensitive receptors closest to the rail line (SL-1 and SL-2) are already being impacted by this type of noise. There would be an adverse, minor increase in noise impacts to receptors at SL-1 and SL-2 in Penwell caused by the approximately 3 percent increase in rail traffic because SL-1 lies within 300 ft (91 m) of the track, and SL-2 lies within 1,100 ft (335 m) of the track. Receptors at SL-3 through SL-6 would not be impacted beyond existing conditions because the 3 percent increase in rail traffic would not likely be heard due to distance attenuation of train traffic noise levels and the intervening I-20 traffic.

3.19.6 Mitigation

Mitigation measures that Summit would implement as part of the construction and operation of the TCEP are described in Section 2.5. Additional mitigation measures that Summit could implement or that DOE could require as a condition of approval to further reduce impacts of noise and vibration are:

- minimizing diesel and gasoline generator use for operating construction equipment; and
- improving project area access routes where necessary to minimize traffic congestion, which would shorten commuter-related noise by reducing commuter times

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Chapter 4. Summary Comparison of Impacts for Alternatives

4 SUMMARY COMPARISON OF IMPACTS FOR ALTERNATIVES

Table 4.1 summarizes the potential direct and indirect impacts or consequences that the No Action Alternative and Summit's Proposed Project may have on each of the respective environmental resources considered in this EIS.

Table 4.1. Summary of Impacts from Summit's Proposed TCEP and the No Action Alternative

Resource	Summit's Proposed Project	No Action Alternative*
Air Quality	Project Emissions during Construction Operation of worker vehicles and construction equipment and vehicles would result in criteria pollutant emissions. Land clearing and excavation, road surface construction, and cut and fill operations would generate dust (PM_{10} and $PM_{2.5}$). Impacts resulting from dust emissions would be localized and short term. Project Emissions during Operations Wet cooling towers would emit PM as drift from the evaporative cooling process. Coal delivery trains would emit a small amount of pollutants from the train exhaust and potentially during coal unloading and handling; control devices for transfer, conveyance, and loading would minimize PM emissions. For the plant itself, maximum annual emissions (tons per year), including startup, shutdown, and maintenance emissions, would be as follows: NO_2: 225 tn (204 t) per year (2 percent increase over existing sources in Ector County) CO: 1,173 tn (1,064 t) per year (4 percent increase over the same) SO_2: 251.1 tn (228 t) per year (20 percent increase over the same) PM_{10}: 380 tn (345 t) per year (6 percent increase over the same) $PM_{2.5}$: 367 tn (333 t) per year (20 percent increase over the same) H_2SO_4: 15 tn (14 t) per year Note that only those air contaminants that pertain to the TCEQ-approved air permit are addressed here. Maximum annual emissions would be above both PSD and Clean Air Act Title V Major Source thresholds (100 tn [91 t] per year) for NO_2, SO_2, CO, PM_{10}, and $PM_{2.5}$. Plant-wide emissions of HAPs would be below the individual HAP major source thresholds (10 tn [9 t] per year) as well as the total combined HAPs threshold (25 tn [23 t] per year). **Incremental contributions to NAAQS exceedances**: Operational emissions from the TCEP would not contribute to a PSD exceedance or violation of NAAQS for any criteria pollutants in the region. However, project emissions would incrementally increase the ambient air concentrations of criteria pollutants as demonstrated using dispersion modeling, ranging from an increase (over background concentrations) of up to 9 percent for PM_{10} to 200 percent for NO_2 at the points of maximum impact. **ESLs**: Maximum predicted concentrations for all identified compounds that could have a negative impact to human health were below their respective ESLs, except for Tier I short-term coal dust. However, per the TCEQ, the coal dust concentrations would meet the Tier II requirements. **Hg**: TCEP operations would produce approximately 0.02 tn (0.018 t) of Hg emissions per year. **GHGs**: Annual noncaptured CO_2 emissions from TCEP operations would be approximately 300,000 tn (272,155 t) per year.	Rural land uses, including residential development, grazing, dispersed recreation, and light commercial and industrial development, would continue in the air quality ROI. No exceedances or violations of NAAQS would occur as a result of the current land uses. Risks from HAPs in the project area would continue to be very low.

Table 4.1. Summary of Impacts from Summit's Proposed TCEP and the No Action Alternative

Resource	Summit's Proposed Project	No Action Alternative*
	Proximity to Class I area: PSD Class I visibility impairment analysis was not required for TCEP because the site would be greater than 62 mi (100 km) away from the nearest Class I area. Local Plume Visibility, Shadowing, Fogging, and Water Deposition The project is designed to use air cooling for the power block and mechanical draft wet cooling towers for the chemical processes. No plumes or fogging would result from the use of the dry cooling tower. Water droplets carried with the water vapor plume from the cooling tower (drift) would have the same chemical composition as the water entering and circulating through the tower. Circulating water could contain anti-corrosion, anti-scaling, anti-fouling, and biocidal additives that could create emissions of volatile organic compounds, PM, and toxic compounds in low concentrations. The drift would not cause excessive pitting or corrosion of metal on nearby structures or equipment because of the relatively small amount of water released and the low concentrations of anti-corrosion additives. Similarly, the treatment additives would not cause noticeable adverse impacts on local biota because of the very small amounts released. Potential deposition of solids would occur because the TCEP would use process water, which may contain dissolved and suspended solids. Effects from vapor plumes and deposition would be most pronounced within 300 ft (91 m) of the vapor source and would decrease rapidly with distance from the source. The drift rate and associated deposition of solids would be reduced with drift eliminators; losses would be limited to less than 0.01 percent of the circulation rate. The TCEP would also comply with Texas Administrative Code visibility and opacity requirements to minimize visible NO_x and PM in stack emissions. Odor Two odorous compounds that are regulated by the TCEQ would be emitted from the TCEP in small quantities: H_2S and NH_3. The wind may carry small volumes and may create a nuisance for residents within 1.0 mi (1.6 km) of the polygen plant.	
Climate	Severe Weather **Construction**: Severe temperature or weather conditions could cause a delay in some aspects of construction as well as in materials deliveries. Impacts, if any, would be minimal and temporary because the region's climate is relatively mild and severe climatic conditions would not adversely impact the TCEP. Weather events such as severe thunderstorms, flooding, and/or tornados could also delay construction. If an extreme drought were to occur during construction, increased use of water trucks would be required for fugitive dust control and support of other construction activities. Workers would also be required to wear protective dust masks. **Operations**: It is unlikely that weather extremes, such as very high or very low temperatures or snowfall, would affect operations. It is also unlikely that flooding would affect operations because the polygen plant site would be outside the 100-year floodplain. Relatively frequent tornados in the region do pose a low potential for both direct and indirect impacts to operations. Severe or extreme drought conditions could occur over the planned life of the project and cause increased ambient air concentrations of PM_{10} and $PM_{2.5}$. **Operations**: Wet cooling towers could cause local shadowing and under certain meteorological conditions could cause local ground-level fogging or icing. Such localized occurrences would be infrequent, usually lasting only a few hours.	Existing climate and meteorological conditions in the project area would continue. This area historically experiences a wide spectrum of weather phenomena, including cold and hot days, high winds, heavy rainfall events, thunderstorms, localized floods, and tornadoes.

Table 4.1. Summary of Impacts from Summit's Proposed TCEP and the No Action Alternative

Resource	Summit's Proposed Project	No Action Alternative*
	Technology options: Among the cooling tower options for the chemical process part of the plant, wet cooling towers could cause shadowing and under certain weather conditions could cause ground-level local fogging and icing. Of the three concentrated brine disposal options, solar evaporation ponds could cause ground-level fogging under certain weather conditions.	
Soils, Geology, and Mineral Resources	Soils Potential impacts to soils would be site-specific and primarily occur during construction and would include erosion or compaction, contamination in the event of hazardous material spills, and composition changes due to the introduction of fill material. Spills of hazardous materials would be minimized through the use of controls and measures. Following construction, and as disturbed areas are revegetated, soil impacts would be negligible. **Technology options:** Among the cooling tower options, there could be a slight deposition of salt on surface soils from drift from the wet cooling tower. Of the three concentrated brine disposal options, there would be a potential for local soil contamination at the solar evaporation pond site if the pond liner were to leak. Geology **Polygen plant site**: No impacts to or from geologic features would occur. **Linear facilities**: No impacts to or from geologic features would occur. **Technology options:** Of the three concentrated brine disposal options, deep well injection could pose a slight risk of induced seismic events as a result of increased fluid pressures in the injection reservoirs. Therefore, careful monitoring and control of the fluid pressures in geologic reservoirs would be required to reduce the likelihood of these events. Injected brine and displaced native fluids could migrate from the target strata into other adjoining strata; however, there would be a very low risk of noticeable harm because the water in all of these deeper strata is highly saline. **EOR sequestration site (or sites)**: EOR-related seismic events could occur, but careful monitoring and control of the fluid pressures in geologic reservoirs greatly reduces the likelihood of these events. No other impacts to or from geologic features would occur. Mineral Resources **Polygen plant site**: No impacts to or from mineral resources would occur. **Linear facilities**: Minor obstructions to mineral resources access along the linear facilities could occur during construction and operational phases of the project. No impacts to or from mineral resources would occur. **Technology options**: Of the three concentrated brine disposal options, deep well injection of brine could displace hydrocarbons; however, there would be a very low risk of noticeable harm because the target strata and surrounding strata have been explored for hydrocarbons and found not to have economical deposits in the vicinity of the plant site. Brine water would be injected into formations that are not known to be oil-bearing. **EOR sequestration site (or sites)**: CO_2 from the TCEP would be used by the ongoing EOR industry in the Permian Basin. This use of CO_2 is a well-developed and documented industrial process that would serve as final sequestration for the captured CO_2 from the TCEP. Operation of the polygen plant site would benefit the recovery of oil and gas in the portions of the Permian Basin that would receive CO_2 from the TCEP. Concentrations and pH of dissolved mineral matter could change	Soil and geological resources would remain unchanged, mineral development would continue, and EOR would continue throughout the Permian Basin using natural sources of CO_2.

Table 4.1. Summary of Impacts from Summit's Proposed TCEP and the No Action Alternative

Resource	Summit's Proposed Project	No Action Alternative*
	and potentially hinder access as a result of injected CO_2; however, negligible impacts would occur if suitable drilling practices, well casing materials, and well casing cements are used on wells that penetrate through the CO_2 floods to reach deep petroleum resources.	
Ground Water Resources	<u>Ground Water Quantity</u> **Polygen plant site**: Impervious areas at the plant site would have negligible impacts to aquifer recharge. The TCEP could affect two ground water aquifers, one supplying brackish water for Oxy Permian and the other proposed to supply the FSH main waterline with slightly brackish water. If either of these water supply options is chosen, the TCEP would have a small effect on the total water supply in the region and would represent a small fraction (0.7 percent) of the total water demand in the region (based on the *2011 State Water Plan: Summary of Region F* [TWDB 2010c]). The City of Midland Wastewater Treatment Plant's land application of waste water, as a means of waste water disposal, may be reduced or terminated altogether if WL1 were chosen. **Linear facilities**: Minor impacts to ground water quantity from the water supply options could occur as a result of impervious areas associated with access roads. **Technology options:** Among the cooling tower options, wet cooling towers would have a higher water demand than dry cooling towers. Of the three concentrated brine disposal options, the brine concentrator and filter press option may minimize the plant's demand for water. <u>Ground Water Quality</u> **Polygen plant site**: No impacts during construction would occur, and risks of long-term impacts during operations are limited. Given the good geologic information and uniformity of strata, there would be a low potential for contamination of overlying aquifers by an injection well constructed and operated to RRC and TCEQ standards. **Linear facilities**: No temporary or permanent long-term impacts to ground water quality would occur from the construction or operation of the linear facility options. **Technology options:** Of the three concentrated brine disposal options, the brine concentrator and filter press option as well as the solar evaporation ponds option would provide the potential for the leaching of salt into ground water at any landfill site where the crystallized salt has been placed. Furthermore, there would be a potential for local, shallow ground water contamination at the solar evaporation pond sites should a liner leak. If deep well injection were chosen, there would be a remote possibility for injected brine to displace native fluids to shallow aquifers or for injected brine to migrate into shallow aquifers. **Sequestration sites**: There would be a risk for potential ground water quality impacts associated with 1) the limited potential for upward migration of CO_2, or 2) displaced native fluids through improperly abandoned deep wells or through natural fractures and faults in the rock. However, this risk would be low due to the relatively low-pressure drives associated with EOR activities, the monitoring requirements for oil and gas injection wells, and the types of geologic formations found in the Permian Basin.	Existing activities, such as oil and gas production and land development, would continue in the region with a continuation of the existing trend of impacts. EOR activities would continue on a regional scale, with CO_2 for EOR from natural geological sources rather than from industrial sources.
Surface Water Resources	<u>Wetlands, Waterways, Water Bodies, and Surface Water Quality</u> **Polygen plant site**: No surface water resources are present at the proposed polygen plant site, and no impacts to surface waters would occur.	Oil and gas exploration, land development, ranching, and other

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Resource	Summit's Proposed Project	No Action Alternative*
	Linear facilities: Four wetlands are present within the proposed WL1 and WL3 corridors, with a combined area of 2.16 ac (0.87 ha). Construction activities are likely to result in short-term impacts such as increased turbidity, sedimentation, streambed disturbance, and streambank vegetation removal. After construction is complete, no long-term impacts would occur. **Technology options:** Of the three concentrated brine disposal options, the brine concentrator and filter press option as well as the solar evaporation ponds option would provide a slight potential for the leaching and conveyance of salt into surface water at any landfill site where the crystallized salt has been placed. <u>Floodplains</u> No impacts to floodplains would occur.	existing activities and uses would continue to affect surface water resources in the ROI.
Biological Resources	<u>Terrestrial Species</u> **Polygen plant site**: Construction and operations could result in the permanent loss of up to 300 ac (121 ha) of the Mesquite Shrub-Grassland vegetation community and associated habitat functions. Construction equipment and activities could unintentionally disperse invasive seeds, noxious species seeds, or both. Construction activities could result in direct mortality of slow-moving terrestrial species not able to escape the path of construction equipment. Noise associated with construction could result in wildlife displacement and behavioral changes that could have minimal impacts on reproductive success. Noise associated with plant operations would have negligible effects on wildlife. **Linear facilities**: Construction of the linear facilities would result in the permanent removal of 134–576 ac (54–233 ha) of the Mesquite Shrub-Grassland community and associated habitat functions, based on the smallest and largest combinations of the linear facility options. An additional 115–543 ac (47–220 ha) of habitat could be temporarily removed or disturbed during construction. Impacts to terrestrial species would be similar to those described above. <u>Aquatic Species</u> **Polygen plant site**: No impacts to aquatic species from construction or operation of the polygen plant site would occur. **Linear facilities**: Impacts to aquatic species from construction of WL1 and WL3 could occur as a result of the impacts described for surface waters. Any water quality degradation associated with surface waters would also have the potential to adversely impact aquatic species using those water bodies. <u>Migratory Birds</u> **Polygen plant site**: Up to 300 ac (121 ha) of suitable habitat for scrubland-nesting migratory birds and their nesting sites would be permanently removed. Introduced species (European starlings and house sparrows) commonly associated with development activities (e.g., maintained landscaping, open trash receptacles) could encroach on the plant site and displace or outcompete native songbird species. Migratory birds could experience similar indirect impacts as those described for terrestrial species Overall, there would be no major features at the polygen site that would attract migratory birds. **Linear facilities**: Habitat loss could occur from the construction and operation of some of the linear facility options. Disturbance from construction and operation noise could displace migratory birds from areas adjacent to the linear facilities. Bird mortalities due to collisions with man-made structures associated with the TCEP (e.g., transmission lines) could occur during operation.	Oil and gas exploration, land development, ranching, and other existing activities and uses would continue to affect biological resources in the ROI.

Table 4.1. Summary of Impacts from Summit's Proposed TCEP and the No Action Alternative

Resource	Summit's Proposed Project	No Action Alternative*
	Technology options: Of the three concentrated brine disposal options, solar evaporation ponds could affect water fowl by enticing them to land thereby exposing them to concentrated brine water; however, covering the ponds with netting would deter birds from landing in the brine. <u>Bats</u> Bat mortalities due to collision with man-made structures associated with the TCEP could occur during operation. <u>Rare, Threatened, and Endangered Species</u> **Polygen plant site**: Construction and operation of the polygen plant would result in the loss of 300 ac (121 ha) of Texas horned lizard (state listed, threatened) habitat as well as suitable habitat for 11 state-listed rare species. **Linear facilities**: Construction and operation of linear facilities would result in the loss of Texas horned lizard habitat as well as potential loss of habitat for 11 state-listed rare species. Total acres affected would vary by facility option. Impacts during operation of buried pipelines would be unlikely, and impacts due to operation of transmission lines would be primarily associated with maintenance activities and avian strikes.	
Aesthetics	<u>Polygen Plant Site</u> **Daylight conditions**: The impacts to KOPs 1, 3, 4, 5, and 6 from the polygen plant would be no more than minor, depending on local lighting conditions and atmospheric haze (KOP 1 is Monahans Sandhills State Park). Impacts to KOP 2 (1.6 mi [2.5 km]) east of the polygen plant site, view looking west across the topographic basin) would be different than those affecting the other KOPs. During construction, exposed soil and construction materials would create line and color contrasts. Fugitive dust could create localized haze that may reduce visibility. Impacts would be moderate, direct, and adverse because the size of the site and its proximity to I-20 would attract viewer attention and be a focus of view for westbound and eastbound motorists. During operations, the height and size of the plant structures, cooling towers, and coal storage piles would create moderate, adverse, direct impacts to KOP 2 aesthetics because of the strong form, color, and line contrasts with the surrounding landscape. Water vapor emitted from the cooling tower would increase the degree of contrasts with the surrounding landscape by creating a form and color-contrasting plume. **Night sky conditions**: Adverse impacts to night sky conditions could occur during both construction and operations due to the installation of high-intensity lighting within and around the site. Light reflected upward would create regionally visible light pollution and skyglow. FAA-required strobe lighting (if required) on the top of the cooling tower and the higher polygen plant structures would adversely affect night sky conditions by imposing highly visible, high-intensity flashing lights that would be regionally visible. <u>Linear Facilities</u> **Transmission line**: Direct adverse impacts would occur because the transmission line structures would create visible, intrusive vertical form contrasts in the landscape, and would be visible from major travel routes. Impacts would be minor because 1) large, cross-country transmission lines are presently visible in the ROI; 2) constructing another transmission line would be consistent with the level of development in the ROI; and 3) the lines would be visible to the casual viewer, but because of existing power lines, they would not attract attention or become a focus of viewer attention.	No impacts to aesthetics beyond existing trends (which have stagnated since the 1960s and 1970s when Penwell became largely abandoned) and conditions would occur.

Table 4.1. Summary of Impacts from Summit's Proposed TCEP and the No Action Alternative

Resource	Summit's Proposed Project	No Action Alternative*
	Pipeline structures: Minor adverse impacts would occur during construction because equipment would be visible in the middle ground and background during ROW vegetation and soil removal, trenching, pipeline laying, and pipeline burial. Although pipelines would be buried, negligible long-term impacts to aesthetics could occur because ROWs would be maintained. **Technology options:** Of the three concentrated brine disposal options, solar evaporation ponds would noticeably add to the aesthetic impacts of the polygen plant. Given the presence of oil and gas wells in the vicinity, deep injection wells would minimally affect aesthetics.	
Cultural Resources	<u>Polygen Plant Site</u> Direct impacts could occur to one historical site (consisting of historic-era pump jack foundations and associated debris scatter) that is not eligible for the NRHP. One historical complex or set of buildings, the Rhodes Welding Complex, is considered eligible for the NRHP. Changes to the setting would not affect NRHP eligibility. <u>Linear Facilities</u> There is one previously recorded archaeological site in the WL1 ROW. No evidence of that site was found during ground surveys. No other cultural resources have been documented in the linear facilities corridors. A full cultural resources study would be conducted after the alignments have been finalized and before construction and installation of the facilities. At this time, there appears to be a low probability of impacts to cultural resources. <u>Native American Resources</u> There are no known Native American resources documented in the cultural resources ROI. Impacts associated with increased access (e.g., WL3 and WL4) to areas previously not accessible by roads could occur; however, impacts associated with the project would not occur. Coordination with the Texas Historical Commission occurred in the fall of 2010 and provided concurrence with DOE's findings.	There would be no effect on known or undocumented historic or cultural resources. The ground disturbance associated with construction would not occur, and in situ resources would remain in place. No structures would be built, and therefore no NRHP-eligible properties would be affected.
Land Use	<u>Polygen Plant Site</u> Existing land uses on the 600-ac (243-ha) polygen plant site would be displaced by the TCEP industrial use. Existing subsurface rights would continue to be available for exploration and production. Operation of the polygen plant would not be incompatible with surrounding land uses. Construction and operation of the TCEP would have no notable effect on airspace; however, signal lights would be required atop the stacks. <u>Linear Facilities</u> Existing land uses would be briefly and temporarily affected by construction. During operations, impacts to land use would be limited to the ROW corridor use and maintenance. The amount of ROW land requirements vary by facility option, and the associated impacts would last for the life of the project. The linear facilities would be consistent with the intent of the zoning districts through which they pass. WL1 would temporarily impact 2.4 ac (1.0 ha) of prime farmland, which could be put back to use after construction completion. Construction of NG1, WL1, or both could temporarily impact access to Penwell Knights Raceway Park located south of the polygen plant site; however, impacts could be reduced by coordination with raceway operations.	There would be no impacts to land use beyond a continuation of existing upward trends in residential, commercial, and industrial uses. The area in the polygen plant site would remain undeveloped, and no new land uses would be imposed on the landscape.

Table 4.1. Summary of Impacts from Summit's Proposed TCEP and the No Action Alternative

Resource	Summit's Proposed Project	No Action Alternative*
Socioeconomics	Demographics Impacts to population numbers during construction would be minor because most workers would commute from nearby communities. Impacts to population numbers during operations would be negligible because most of the 150 permanent workers would come from the local population, although some would come from outside the area. Housing Existing housing and hotel/motel supply would be adequate for anticipated employment during construction. There would be no new housing needs as a result of operations. Economics During most of the construction, GDP in the ROI would increase 0.5 percent; during the final year of construction, it would increase 0.7 percent. During operations, GDP in the ROI would increase by 0.2 percent, representing a long-term and beneficial impact for the region. Tax revenue from the TCEP would have a beneficial and long-term impact to the region as revenue would be redistributed to counties, which in turn would allocate and redistributed to local communities.	Existing socioeconomic trends, including population growth and increase in residential, commercial, and industrial development would continue as they are.
Environmental Justice	Construction Activities Construction activities would have neither disproportionately high nor adverse effects on minority or low-income communities. Short-term beneficial impacts could include an increase in employment opportunities with potentially higher wages or supplemental income through jobs created during plant construction. Operations Activities Operations activities would have neither disproportionately high nor adverse effects on minority or low-income communities.	There would be no disproportionately high or adverse effects on minority or low-income communities in the ROI.
Community Services	Law Enforcement, Emergency Response Services, and Health Services Because TCEP workers would come primarily from the existing workforce in the ROI, no impacts to the demand for local law enforcement, emergency response, or health services would occur. Schools Because TCEP workers would come primarily from the existing workforce in the ROI, no increase in school enrollment and no increased burden on the school systems would occur. Recreation Because TCEP workers would come primarily from the existing workforce in the ROI, population-related impacts to recreation (including nearby city, county, and state parks) would not occur. Likewise, no project-induced impacts to the regional recreational experiences would occur.	There would be no impacts to community services in the ROI.
Utility Systems	Polygen Plant Site Existing utilities would not be adversely impacted by construction or operation activities at the polygen plant site. Linear Facilities **Construction activities**: Existing utilities infrastructure could inadvertently be damaged or have service disrupted during construction of the linear facilities. Risk of construction-related impacts would be greatest during trenching activities.	There would be no impacts to utility systems beyond existing trends, which generally include an increase in electricity, CO_2, and water demand.

Table 4.1. Summary of Impacts from Summit's Proposed TCEP and the No Action Alternative

Resource	Summit's Proposed Project	No Action Alternative*
	Operations activities: *TL1–TL6*: There is a potential for system upgrades associated with the interconnection to either the ERCOT or Southwestern Power Pool grid. *WL1:* WL1 could impact the City of Midland Wastewater Treatment Plant. WL1 would divert all or some portion of the water currently being used to irrigate city-owned cropland adjacent to the City of Midland Wastewater Treatment Plant. Current agricultural activities would be reduced by the amount of Midland's waste water diverted under the WL1 option. *WL2 and WL3:* No impacts to water treatment utility systems would occur as a result of WL2 or WL3. *WL4:* The GCA Odessa South Facility would make use of more of its full treatment capacity with the use of WL4. **Technology options:** Among the cooling tower options, the use of a wet cooling tower, instead of a dry cooling tower, for the chemical process part of the TCEP plant may require a larger water supply pipeline than currently proposed under the various waterline options. However, the wet cooling tower option would have a lower electricity demand than the dry cooling tower option. Of the three concentrated brine disposal options, the brine concentrator and filter press option may require the greatest parasitic electricity demand, depending on the choice of equipment. Alternatively, the solar evaporation ponds, if this option were chosen, would require the least parasitic electricity demand.	
Transportation	Roadways **Construction activities**: AADT would increase in four primary locations (listed below). Increases would vary depending on the construction year. *I-20 at Penwell:* 15,580 current AADT; would increase to 15,660, 15,685, and 15,730 projected AADT (1 percent increase) in construction years one, two, and three, respectively. *I-20, east of FM 866 exit:* 16,700 current AADT; would increase to 17,350, 18,840, and 19,750 projected AADT (4 percent, 13 percent, and 18 percent) in construction years one, two, and three, respectively. *FM 866:* 1,500 current AADT; would increase to 2,120, 3,535, and 4,400 projected AADT (41 percent, 136 percent, and 193 percent) in construction years one, two, and three, respectively. *FM 1601:* 20 current AADT; would increase to 50, 125, and 170 projected AADT (150 percent, 525 percent, and 750 percent) in construction years one, two, and three, respectively. Delays associated with merging traffic and increased percent of time spent following slow vehicles would affect LOS of each road. Construction of a 3.7-mi (6.0-km) access road between the polygen plant site and FM 866 would result in temporary, localized traffic delays. Use of FM 1601 for emergency and secondary access to the polygen plant site would require construction of an at-rail grade pass or a below-rail underpass for crossing the UPRR rail line. Construction activities would result in temporary localized traffic delays and a potential rerouting of CR 1216 (Avenue G) traffic during construction. **Operations activities**: AADT would increase in four primary locations during operations (listed below). *I-20 at Penwell:* 15,580 current AADT; would increase to 15,595 projected AADT (<1 percent increase).	There would be no additional roadway traffic imposed on the federal or TxDOT road system, or railroad traffic on the UPRR rail system.

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Resource	Summit's Proposed Project	No Action Alternative*
	I-20, east of FM 866 exit: 16,700 current AADT; would increase to 17,400 projected AADT (2 percent increase). *FM 866:* 1,500 current AADT; would increase to 1,835 projected AADT (22 percent increase). *FM 1601:* 20 current AADT; would increase to 35 projected AADT (75 percent increase). **LOS changes**: *I-20:* No changes are forecast for LOS as a result of the TCEP. *FM 1601:* FM 1601 would remain at an acceptable LOS (A–C) during construction and operations. *FM 866:* FM 866 could degrade to LOS D or lower (unacceptable) during construction years 2 and 3 and would remain at an acceptable LOS (A–C) during operations. Impacts would mostly occur during shift changes. **Impacts from linear facilities**: Construction of the natural gas, CO_2, and transmission lines would cause temporary and localized congestion; impacts would be minor. <u>Railways</u> Increases in rail traffic would occur due to transportation of supplies and products in and out of the polygen plant site. **Construction activities**: Temporary and minor adverse impacts to the existing rail lines would occur as the polygen plant railroad spur (RR1) is connected to the existing system and if an overpass, underpass, or at-grade intersection is constructed for AR1. Once constructed, there would be no delays or congestion along the UPRR line due to unloading of construction materials. **Operations activities**: During operations, there would be an average of six additional 135-car-unit trains per week along the UPRR line, a 5 percent increase over the existing rail traffic. This would not represent an increase that would exceed system capacity nor cause delay to existing railway operations. Because the loading and unloading of TCEP-related materials would occur on the railroad spur, no impacts to the UPRR rail line would occur.	
Materials and Waste Management	<u>Materials Management</u> Construction materials would vary widely, including concrete, crushed stone and aggregate, asphalt, steel, lumber, sand, insulation, wire and cables, joining and welding materials, and other materials. No impacts would occur from the management of these materials. No impacts would occur to the supply of materials as a result of the demand from the project. Operations materials would include coal, natural gas, process water, process chemicals, and commercially marketable products. No impacts from the management of these materials would occur. Plans for delivery, handling, and storage of operations materials would be in place before operation of the project. <u>Waste Management</u> All wastes would be disposed of, treated, or recycled at or through properly licensed facilities. Impacts to the environment as a result of waste management would be minimized. Technology options: Of the three concentrated brine disposal options, the brine concentrator and filter press option and the solar evaporation ponds option would produce crystallized salt to be sent to a landfill; the deep injection well would not.	There would be no change to the amounts of materials and wastes currently generated, stored, or transported on or near the project area.

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Resource	Summit's Proposed Project	No Action Alternative*
	Of the cooling tower options, wet cooling tower operations would have a greater demand for biocides in the cooling water.	
Human Health, Safety, and Accidents	Occupational Health and Safety **Construction activities**: The TCEP construction management would develop manuals with OSHA procedures to assure compliance with OSHA and EPA regulations and to serve as a guide for providing a safe and healthy environment for workers, contractors, visitors, and the community. Based on industry workplace hazard statistics, the TCEP construction workforce could experience 91.65 nonfatal, recordable incidents and 48.75 lost workdays. Statistics imply that fatalities are unlikely (0.19 fatality) during the three-year construction period. **Operations activities**: Polygen plant design features and management programs would be established to address hazards. Based on industry workplace hazard statistics, over the life of the project the TCEP operations workforce could experience 158 recordable incidents, 122 lost workdays, and fewer than one fatality. Transportation Safety **Motor vehicles**: Based on TxDOT 2012–2014 forecasts, approximately 0.35 fatality could occur due to the movement of workers and supplies from trucks and personal vehicles during construction (TxDOT 2010a). During the 30-year operations period, approximately 0.61 fatality could occur as a result of worker travel during operations. **Railroads**: Risk of a hazardous materials spill during rail transport of TCEP products would be low. Construction of an at-grade rail crossing would result in an increased risk to those accessing the TCEP from FM 1601. Each additional train added to the UPRR system could delay emergency vehicles attempting an at-grade rail crossing by approximately three to five minutes. CO_2 and Natural Gas Pipeline Safety The project would require the installation of approximately 2.7 mi (4.3 km) of new natural gas transmission lines and 1.0 mi (1.6 km) of CO_2 pipeline. The probability of an accidental release associated with these lengths of new pipeline would be negligible. Exposure to Contaminated Sites The risk of discovering soils contamination during construction of the polygen plant would be low. Risk to residents or TCEP personnel during linear facility construction could be eliminated through proper due diligence, including conducting a Phase 1 environmental site assessment where needed along ROW sections prior to construction (If necessary) or Phase II environmental site assessments. If necessary, Phase III remedial actions would be performed. Risk Analyses **Polygen plant site**: Toxic hazards would be dominated by the potential releases of NH_3 gas from the pipeline leading from the NH_3 synthesis unit to the urea synthesis plant, or through NH_3 production or storage processes. Risks would be greatest to those workers closest to the NH_3 synthesis unit. The highest level of fire risk in the polygen plant would result from processes involving the production and transfer of syngas. Fire hazards at the polygen plant site would not extend beyond the plant itself. The risk of a person being fatally affected by exposure to a toxic hazard in the event of a release would vary depending on their location relative to the release. The risk per year would range from one in 1,000 to one in 100,000,000 of being killed in the project area. The risk levels posed by potential releases of	There would be no impacts to human health and safety related to occupational safety, traffic fatalities, risks related to the construction of the at-grade rail crossing at FM 1601 or increases in rail traffic, or risks from accidents or intentional acts of destruction at the polygen plant site or its supporting linear facilities.

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Resource	Summit's Proposed Project	No Action Alternative*
	flammable, toxic, and asphyxiant fluids from the proposed TCEP and associated pipelines would be considered acceptable by several international standards. **TCEP CO_2 injection-related activities**: The potential for accidents considered in the analysis were expressed on a per annum basis: likely (frequency ≥ 1×10^{-2} per year); unlikely (frequency from 1×10^{-2} per year to 1×10^{-4} per year), and extremely unlikely (frequency from 1×10^{-4} per year to 1×10^{-6} per year). The following scenarios were analyzed as part of a study for a project similar to the TCEP: • Ruptures in the pipeline transporting CO_2 and H_2S from the plant to the sequestration site (considered unlikely) • Punctures in the CO_2 pipeline (considered unlikely to likely depending on the site) • Wellhead failures at the injection well (considered extremely unlikely) • Slow upward leakage of CO_2 from the injection well (considered extremely unlikely) • Slow upward leakage of CO_2 from other existing wells (considered extremely unlikely to unlikely) Site-specific risk for oil fields that purchase and use TCEP's CO_2 cannot be estimated until after the specific fields are identified. However, for those operators that currently implement CO_2 injection, the CO_2 is a valuable resource that is monitored and recycled back into the oil-bearing formation to minimize future purchases of the gas. The numbers of residents or sensitive receptors that could be exposed to CO_2 cannot be estimated until a more exact area for EOR is identified. However, it can be inferred from the study that if residential receptors are present, assumed downwind distances of concern and exposures to potentially released CO_2 would be unlikely to pose a risk because assumed exposures to CO_2 from EOR activities do not exceed either the acute (for short-term) or chronic (for long-term) toxicity criteria.	
Noise and Vibration	Construction Activities **Stationary source analysis:** *Polygen plant site:* Construction-related equipment noise would be perceptible outdoors during the busiest periods of activity at the Penwell receptor locations north of I-20; however, receptors south of I-20 would likely not hear a substantial noise level increase owing to the existing ambient noise levels from vehicular traffic on I-20. Intermittent increases in noise would result from steam venting prior to and during polygen plant startup and commissioning. Although this venting would briefly exceed acceptable FTA levels for residential areas (series of short blasts over a two-week period), FTA commercial and industrial-area construction threshold levels would bet met. *Linear facilities:* The construction of WL3, TL5, TL6, NG1, and AR1 would likely create temporary, adverse noise impacts to sensitive receptors because the proposed lines would be constructed close to residential receptors near these facilities. **Mobile source analysis**: Use of I-20 and FM 866 for construction-related activities would not result in substantial noise impacts on noise-sensitive receptors (<1 dBA); however, there would be a substantial temporary increase (8.8 dBA) in noise intensity along FM 1601 for the two noise-sensitive receptors located north of I-20	There would be no additional noise impacts beyond the existing trends of noise from traffic and oil and gas development.

Table 4.1. Summary of Impacts from Summit's Proposed TCEP and the No Action Alternative

Resource	Summit's Proposed Project	No Action Alternative*
	in Penwell. The increase in nose along these access roads would meet FTA noise threshold levels. Operations Activities **Stationary source analysis**: Several plant components (e.g., generators, pumps, fans, vents, relief valves, coal delivery/handling system) would generate noise during operations. This operational noise would attenuate to levels at the two closest noise-sensitive receptors in Penwell that slightly exceed the EPA 55 dBA Ldn outdoor noise threshold (exceeding the threshold by 6 and 4 dBA). Long-term indoor noise levels would be in compliance with the EPA health and safety guidelines. Temporary and brief adverse noise impacts from unscheduled restarts or emergency-pressure safety-valve discharges could occur within approximately 3,000 ft (914 m) of the polygen plant. **Mobile Source Analysis**: Use of I-20 and FM 866 for project operations and commuting would not produce substantial noise impacts on noise-sensitive receptors located along either roadway. There would be an increase in noise activity on FM 1601 (a 2.4 dBA increase) that could impact noise-sensitive receptors in Penwell. There would also be an adverse, minor increase in noise impacts to receptors located near the railroad in the ROI caused by the approximately 3 percent increase in rail traffic.	

Note: PM_{10} = PM with aerodynamic diameters equal to or less than 0.00039 in (10 micrometers);
$PM_{2.5}$ = PM with aerodynamic diameters equal to or less than (0.000098 in (2.5 micrometers).

* Summit has stated that, should the TCEP not go forward, the 600-ac (243-ha) polygen plant site would be sold. It is probable that the purchaser of the site would develop that tract for industrial, commercial, or residential uses that could impose impacts to the respective resources shown in this table. The specific impacts would be dependent upon the type of development pursued.

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Chapter 5. Potential Cumulative Effects

5 POTENTIAL CUMULATIVE EFFECTS

5.1 Approach and Analytical Perspective

5.1.1 Background

Compliance with NEPA requires an analysis of cumulative effects for each alternative (40 C.F.R. § 1508.25(c)(3)). Cumulative effects are the collective result of the incremental effects of an action that, when added to the impacts of other past, present, and reasonably foreseeable future actions, would affect the same resources, regardless of what agency or person undertakes those actions (40 C.F.R. § 1508.7). Cumulative effects can result from actions that have individually minor impacts but that collectively impose significant impacts over a period of time. DOE considers a reasonably foreseeable action to be a future action that has a realistic expectation of occurring. These include (but are not limited to) actions under analysis by a regulatory agency, proposals being considered by state or local planners, plans that have begun implementation, or future actions that have been funded.

Humans have been altering the area in which the TCEP would be constructed and operated since people began settling the region. In combination with natural processes, these past and present actions and activities have produced the affected environment, which is described in detail in Chapter 3. The impacts of the proposed TCEP on the existing environment were also described in Chapter 3. In this chapter, DOE describes the potential for cumulative effects of the TCEP and reasonably foreseeable future actions. The following sections describe the process DOE used to identify potential cumulative effects issues, the project impact zones for various resources, the areas of analysis (the resource, ecosystem, or human community that could be affected cumulatively), and the reasonably foreseeable future development actions and trends occurring in the areas of analysis. A two-tiered approach was used to consider and present the cumulative effects related to the most important issues identified by DOE.

5.1.2 Project Impact Zones and Areas of Analysis

Cumulative effects are analyzed on the basis of particular environmental resources or impact areas. Depending on the particular issue, this area of analysis either is a human community (e.g., the Odessa/Midland area), an ecosystem (e.g., the southern High-Plains ecosystem), or a resource as described on a regional, national, or global level (e.g., air quality within an Air-Quality Control Region). Because information and statistics often are compiled by governmental agencies based on their areas of jurisdiction, these political boundaries may be substituted as proxies for the more appropriate natural or socioeconomic boundaries.

For most resources, a project's effects can be mapped as "impact zones" or ROIs, as was done in the analysis of direct and indirect effects in Chapter 3, to facilitate comparison with the effects of other past, recent, and reasonably foreseeable future actions and trends. Figure 5.1 shows the TCEP's ROIs for a number of resources, and it shows the route or general location of the two proposed future projects sponsored by other entities (described in Section 5.1.3).

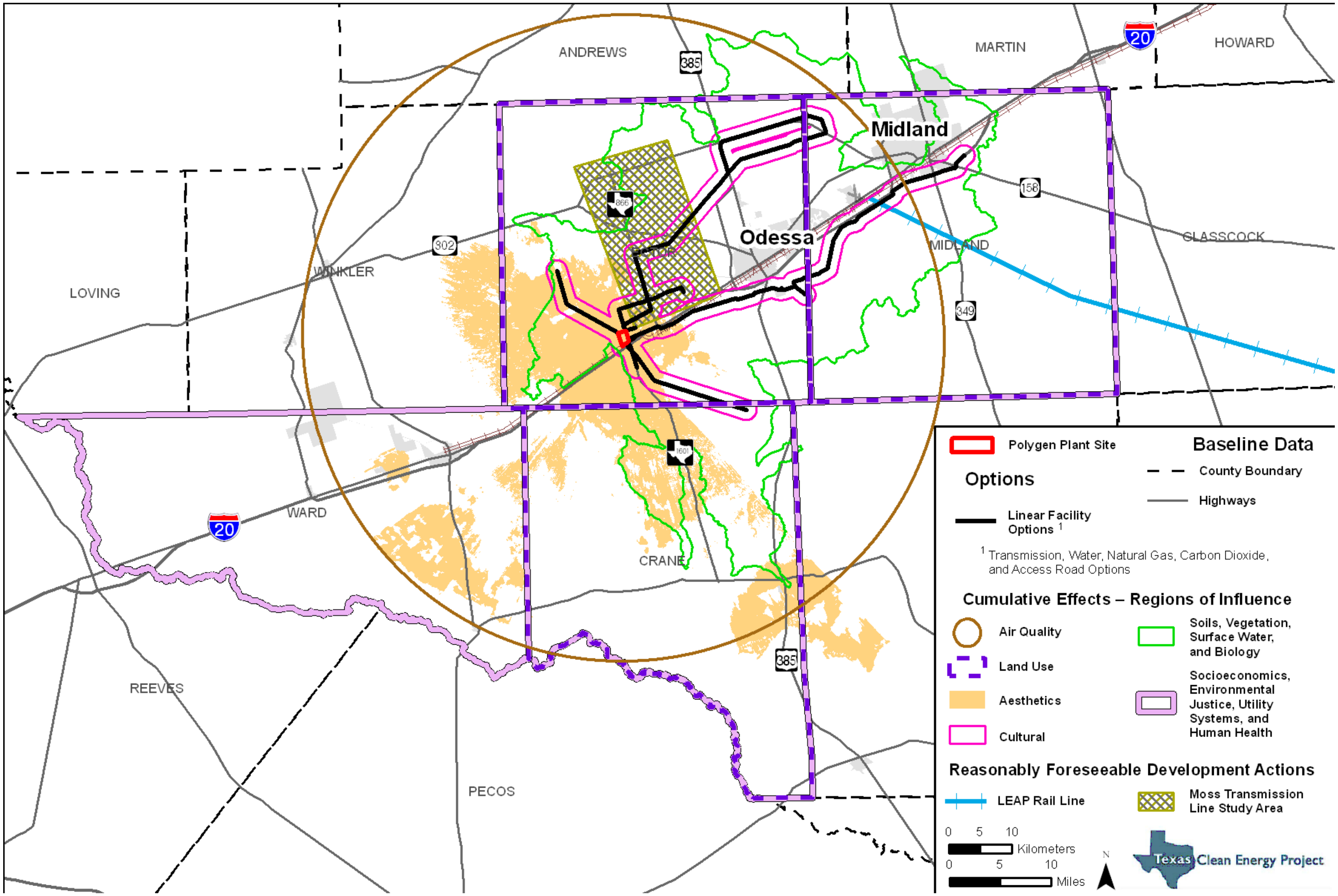

Figure 5.1. Cumulative regions of influence.

5.1.3 Reasonably Foreseeable Future Development: Specific Actions and Trends

For this cumulative effects analysis, reasonably foreseeable future development was considered in the context of 1) specific proposals and 2) general trends in the region. The predicted environmental effects of specific proposals and general development trends were considered together with those of the TCEP to produce a description of the combined or cumulative environmental effects.

To identify specific proposals that might impose cumulative environmental effects in the region, DOE sought information on specific projects, developments, or activities that might have effects that would overlap with those of the TCEP. This included a search for conventional electric power projects, large industrial facilities, transportation projects, large commercial developments, municipal projects, water supply projects, and other such projects in the Odessa region. Two reasonably foreseeable projects were identified: the La Entrada al Pacifico (LEAP) Rail Corridor and the Moss 138-kV Transmission Line Project. Other proposals that were determined to be highly speculative at this point in time (i.e., projects having a significant chance of not going forward as currently proposed) were not considered. Regarding the analysis of trends, a current trend was assumed to continue into the future unless there was reason to believe that the trend may change. Various organizations produce forecasts that can support the analysis of cumulative effects, and these were used where they were available and relevant.

5.1.3.1 LA ENTRADA AL PACIFICO RAIL CORRIDOR

There is an ongoing feasibility study for a new rail corridor to be constructed as part of the existing LEAP trade corridor between the U.S. and Mexico. As shown in Figure 5.1, this proposed rail corridor would connect the existing LEAP line in the cities of Midland and Odessa in Midland and Ector Counties, Texas, respectively, to the existing South Orient rail line in the city of San Angelo, Tom Green County, Texas. No approvals or timelines for this project have been set. It is assumed that there would be an approximately 109-mi (175-km) rail line distance between the Odessa–Midland area and the San Angelo junction with a 15-ft (4.6 m) rail bed width. For purposes of this cumulative effects analysis, the rail corridor is assumed to disturb approximately 198 ac (80 ha) spanning Midland, Glasscock, Reagan, Sterling, and Tom Green Counties (footprint of the project). This approximation is based on available data.

5.1.3.2 MOSS 138-KV TRANSMISSION LINE PROJECT

The Public Utility Commission of Texas recently recognized the need for the completion of a substantial transmission system expansion to address transmission constraints that limit the delivery of electricity within Competitive Renewal Energy Zones to the rest of the ERCOT grid. Oncor was selected by the Public Utility Commission of Texas to build the proposed West B switching station located on State Highway 158, approximately 14 mi (32 km) northwest of the city of Odessa, and to build a 14-mi (32-km) single-circuit 138-kV transmission line that would connect the proposed West B switching station to the existing Moss Switching Station located approximately 6 mi (10 km) southwest of Odessa. It is assumed that a typical 100-ft-wide (30-m-wide) ROW would be used. For purposes of this cumulative effects analysis, the Moss project is assumed to disturb 170 ac (70 ha) (footprint of the project). This approximation is based on existing maps and data for the proposed expansion. At this stage, several alternative routes are being considered for the 14-mi (32-km) transmission line; therefore, the entire study area is identified on Figure 5.1.

5.1.4 Analysis Methodology

DOE assembled an internal team of environmental professionals to propose, list, and classify potential issues related to cumulative effects, based on the results of the public scoping process, the results of the environmental impacts analyses conducted for this EIS, and the assessment of potential environmental impacts of future development and trends in the region. The identified issues were then classified as potentially having a high, intermediate, or low level of importance. Indicators of importance are listed in Table 5.1.

Table 5.1. Indicators of Importance for Cumulative Effects Issues

High importance	• The incremental effect, alone, would generally be considered a *significant impact*, as this phrase is used in context of NEPA review and analysis. • An analysis of cumulative effects for this issue would be required to support a reasoned-decision among the alternatives. • Society, in general, has a history or record of being concerned about this type of cumulative effect, and two or more of the factors of intermediate importance are present.
Intermediate importance	• There is a regulatory/resource threshold or physical limit (e.g., utility capacity) that might be exceeded or that is approaching an exceedance in the cumulative effect, and this potential exceedance of the threshold or physical limit is of significance from the viewpoint of NEPA review, federal decision making, and public disclosure. • There is a governmental organization or nationally recognized nongovernmental organization that has a history or record of being concerned about the cumulative effect. • The cumulative effect issue was raised during the scoping process by either a governmental organization or by more than one nongovernmental entity or person, and the particular issue is not irrelevant or inconsequential in federal decision making. • Issue is indicated to be important judging by the fact that one or more governmental or nongovernmental organizations have published statistics or trends on the issue.
Lesser importance	• Issues not having any of the indicators listed in the two categories above.

Issues identified as having either a high- or intermediate-level of importance were given to resource specialists for further investigation. For each issue, these specialists searched for relevant information on past and current activities and their environmental impacts in the area of concern to establish a basis upon which to consider the TCEP's potential impacts. Trends in past and current activities and their environmental impacts were projected into the future for at least the expected 30-year life of the project, to the extent that the projection was considered to be reasonable. Where usable forecasts were found, a judgment was made as to whether the forecast already encompassed projects such as the TCEP. If not, the potential impacts of the TCEP were added to the forecast.

Table 5.2 describes potential cumulative effects issues with a high- or intermediate-level of importance. Those shown in red were determined to have high importance as defined in Table 5.1 and are discussed in detail in Section 5.2.2. Issues shown in blue were determined to have intermediate importance as described in Table 5.1 and are discussed further in Table 5.3. For all remaining identified issues, DOE determined that no further review was warranted because they do not have any of the seven indicators of importance described in Table 5.1.

Table 5.2. Potential Cumulative Effects Issues for Each Resource

Resource	Cumulative Effects Issues
Air Quality	• Emissions of criteria pollutants, HAPs, dust, Hg, and GHGs • Successful implementation of the TCEP, whereby it encourages the development of other low emissions, carbon capture and storage coal-based power plants in substitution for or as replacements of conventional coal plants nationwide, thereby reducing overall power plant emissions
Climate	• GHG emissions
Soils	• Soil contamination from HAP deposition (e.g., Hg) • Conversion of soils from one quality to another quality (e.g., prime farmland soils converted to nonprime soils) • Construction-related soil erosion and soil loss • Increase in impervious soil cover and its potential effects on soil functions
Mineral Resources	• Production/depletion trend of oil and natural gas, specifically regarding CO_2-based EOR, in the Permian Basin and in the U.S. • Access to limestone resource along Concho Ridge • Patterns and trends in land development that hinder access to oil and gas resources (e.g., drilling site locations)
Ground Water Resources	• Potable water supplies • Increase in water consumption, which could displace other competing water uses • Increase in impervious soil cover as an effect on ground water recharge • Ground water contamination from petroleum resources, CO_2, or brine water as a result of improperly managed EOR activities
Surface Water Resources	• Water consumption impacts on stream flows • Increase in impervious soil cover impacting interflow and flood potential • Surface water contamination from soil erosion or inadequate spill prevention
Biological Resources	• Habitat loss and fragmentation and wildlife displacement associated with land development • Loss or change in vegetation in disturbed areas from native to non-native (potentially invasive) species • Increase in power transmission lines that contribute to bird and bat mortality as a result of collisions with wires and cables • Increase in the amount of roadways and the amount of vehicle traffic, which correlates with animal kills/injury by collisions
Aesthetics	• Industrial, commercial, residential, or agricultural development • Night lighting and night glow impacts in the sky
Cultural Resources	• Potential for disturbance of undiscovered cultural or historic resources
Land Use	• Land use conversions
Socioeconomics	• Housing supply and worker availability • TCEP's CO_2 as a new supply, which could impact the regional CO_2 market and other proposed near-term suppliers of CO_2 in the region

Table 5.2. Potential Cumulative Effects Issues for Each Resource

Resource	Cumulative Effects Issues
Environmental Justice	• Increased CO_2-based EOR possibly causing adverse impacts on minority or low-income populations or communities • Disproportionate and adverse impacts on minority or low-income communities from the construction and operation of the TCEP and other reasonably foreseeable projects
Community Services	• Effects on community services based on the need for construction and operations workers
Utility Systems	• Increase in demand for water as an additional incentive for the FSH pipeline project or other proposed water supply projects given the trends in usage of water and waste water resources • Increase in the load on the power grid and proposed capacity increases in the grid locally
Transportation	• Rail traffic • Vehicle traffic
Materials and Waste Management	• Increase in coal consumption as compared to the national increasing trend of coal consumption, which could result in a further acceleration of national coal consumption and an earlier resource depletion date • Construction materials availability
Human Health, Safety, and Accidents	• Exposures to hazardous air emissions (e.g., Hg) • Increase in rail and vehicle traffic contributing to rail and road traffic accident rates • Increase in CO_2 pipeline mileage, which could increase the risks of an accident • Increase in the amount of high voltage transmission lines and associated hazards
Noise and Vibration	• Noise and vibrations associated with increasing rail and vehicle traffic • Operational noise

Note: Issues coded in red have been determined to have high importance as defined in Table 5.1 and are discussed in detail in Section 5.2.2. Issues coded in blue have been determined to have intermediate importance as described in Table 5.1 and are discussed further in Table 5.3. Issues that are neither coded as blue or red were determined to have none of the importance (see Table 5.1) and, for that reason, were eliminated from further analysis or discussion.

5.2 Cumulative Effects

5.2.1 Cumulative Effects of Intermediate Importance

Issues that have been identified as having intermediate importance are discussed in Table 5.3.

Table 5.3. Evaluation Summary of Cumulative Effects for Issues of Intermediate Importance

Resource	Background/Historical Trends	Contribution from TCEP	Contribution from Other Reasonably Foreseeable Projects (or trends/forecasts)	Total Cumulative Effects	Conclusion
Air Quality	Currently, the ROI and the local counties are an attainment area for all criteria pollutants. There are no regional monitoring/sampling data on which to base a trend analysis; however, the TCEQ reports a statewide trend in decreased emissions (TCEQ 2011).	Operations would increase the concentration of NO_2, PM_{10}, $PM_{2.5}$, and SO_2, ranging from an increase (over current ambient air quality) of up to 9 percent for PM_{10} to 200 percent for NO_2 (1-hour standard) at the points of maximum impact as determined by the Class II air quality modeling performed for the project.	Dust, PM, and emissions from construction of both specifically identified projects would likely occur on a temporary basis during construction. Operation of the LEAP project would result in additional mobile source air emissions from an undetermined increase in rail traffic; no increase in air emissions would occur from the operation of the Moss project.	The TCEP's ROI and the counties hosting this project would remain an attainment area. Cumulative increases in concentrations of air pollutants would likely remain below NAAQS and PSD increments.	Significant adverse cumulative effects on air quality are not expected. Further evaluation not warranted.
Soils	No trend data were identified for HAP deposition as a result of industrial development in the area of analysis.	Potential soil deposition of air pollutants such as Hg could occur, but impacts would be negligible due to the low quantity of emissions (e.g., 0.001 tn [0.0009 t] per year of Hg).	No soil contamination from air pollutants expected beyond the negligible amounts caused by typical mobile emissions from trains.	Cumulative increases in concentrations of air pollutants would continue to remain below thresholds established in air quality standards.	No significant contribution expected to deposition rates and soil accumulation of hazardous substances. Further evaluation not warranted.

Table 5.3. Evaluation Summary of Cumulative Effects for Issues of Intermediate Importance

Resource	Background/Historical Trends	Contribution from TCEP	Contribution from Other Reasonably Foreseeable Projects (or trends/forecasts)	Total Cumulative Effects	Conclusion
Mineral Resources	The estimated oil reserves in the Permian Basin are approximately 95.4 billion barrels. As of 2006, approximately 33.7 billion barrels have been recovered (DOE 2006). Since January 2007, another 716 million barrels have been produced (RRC 2011).	TCEP would add 3 million tn (2.7 t) to the CO_2 market annually. This equates to approximately 9.3 million barrels of oil (DOE 2008).	No contribution from the identified reasonably foreseeable projects is expected. Demand for CO_2 in the EOR process will likely continue to increase. Kinder Morgan, the primary supplier for the Permian Basin, currently has the capacity to produce and deliver approximately 27.5 million tn (24.9 million t) per year. The TCEP would add 3 million tn (2.7 million t) per year. Kinder Morgan does not currently have plans for expansions to their system (Hattenbach 2011).	The available CO_2 supply to the Permian Basin will not increase in the reasonably foreseeable future. The addition of the TCEP CO_2 will provide needed capacity.	The use of CO_2 has allowed the recovery of petroleum resources previously unrecoverable using conventional methods. Historically, EOR has resulted in approximately an 8 percent increase in oil recovery in the Permian Basin. Recovery rates of up to 14 percent are projected (DOE 2006). Further evaluation not warranted.

Table 5.3. Evaluation Summary of Cumulative Effects for Issues of Intermediate Importance

Resource	Background/Historical Trends	Contribution from TCEP	Contribution from Other Reasonably Foreseeable Projects (or trends/forecasts)	Total Cumulative Effects	Conclusion
Biological Resources	Impacts including loss, fragmentation, and displacement to wildlife habitat began to escalate in 1925 with the discovery of oil in the Permian Basin (City of Odessa 2004). Since the 1920s, the region has experienced continual growth with periodic stabilizations, which have been dependent on the vigor of the oil industry (City of Odessa 2004; City of Midland 2005). This upward trend in residential, commercial, and industrial continues to impact wildlife habitat.	TCEP would result in 734–1,176 ac (297–476 ha) of habitat loss.	The LEAP and Moss projects would collectively contribute to approximately 260 ac (105 ha) of habitat loss.	A cumulative 994–1,436 ac (402–581 ha) of habitat loss could occur from the TCEP and reasonably foreseeable projects. Studies quantifying the cumulative trend for impacts to wildlife habitat have not been identified.	The impacts to wildlife habitat resulting from the TCEP combined with the LEAP and Moss projects would not be significant. Continued development in the region, even at a slow rate, could cumulatively have more significant impacts. Further evaluation not warranted.
Cultural Resources	Impacts to cultural resources have occurred as a result of increasing trend in oil and gas development.	The TCEP would result in 734–1,176 ac (297–476 ha) of disturbance. Cultural surveys would be conducted prior to construction activities. Appropriate mitigation (avoidance or recovery) would be implemented. No historic structure would be directly impacted.	The LEAP and Moss projects would collectively contribute to approximately 260 ac (105 ha) of disturbance.	A cumulative 783–1,225 ac (317–496 ha) of disturbance could occur from TCEP and reasonably foreseeable projects with the respective potential for cumulative risk for loss or damage to archaeological sites.	Based on the TCEP's planned mitigation, a low likelihood of significant adverse effects to cultural resources is expected. Further evaluation not warranted.

Table 5.3. Evaluation Summary of Cumulative Effects for Issues of Intermediate Importance

Resource	**Background/Historical Trends**	**Contribution from TCEP**	**Contribution from Other Reasonably Foreseeable Projects (or trends/forecasts)**	**Total Cumulative Effects**	**Conclusion**
Environmental Justice	Disproportionately negative impacts to minority or low-income communities have not occurred as a result of oil and gas exploration and production in the Permian Basin. The location of the oilfields was driven by the geology and not by regional demographics.	Beneficial impacts to populations in the short term from increased employment opportunities during construction phase of the TCEP. Operation of the TCEP would not disproportionately impact minority or low-income communities.	Beneficial impacts to populations in the short term from increased employment opportunities during construction phase of the LEAP and Moss projects.	There could be beneficial impacts to minority or low-income communities in the short term from increased opportunities for employment during the construction phases of the foreseeable projects. On a regional level, there would be no disproportionate impacts to minority or low-income communities as a result of EOR practices associated with TCEP, because the potentially affected oil fields in the Permian Basin are already in place, and future oil field development would be dependent on the geology of the area, not on demographics.	No disproportionately adverse cumulative effects would occur to minority or low-income populations. Further evaluation not warranted.

Table 5.3. Evaluation Summary of Cumulative Effects for Issues of Intermediate Importance

Resource	Background/Historical Trends	Contribution from TCEP	Contribution from Other Reasonably Foreseeable Projects (or trends/forecasts)	Total Cumulative Effects	Conclusion
Utility Systems	ERCOT peak demand of 65,776 MW in 2010 (ERCOT 2010b). Transmission upgrades already needed to facilitate current and historical demands for power, mostly in the large eastern markets in Texas.	TCEP would supply approximately 213 MW of base-load power to the existing grid system.	ERCOT forecast demand to grow to 96,000 MW in 2030. ERCOT projects a need for new generation of approximately 6,400 and 33,000 MW in 2015 and from 50,000 to 70,000 MW in 2030; future demand for transmission capacity to continue to grow based on projected growth in demand for power. The Moss project would increase the efficiency in the delivery of electricity produced in the Competitive Renewal Energy Zones to the electric market. The LEAP project is not anticipated to place a significant demand on existing utility services.	TCEP would provide needed base-load generation to support growth in ERCOT demand. Upgrades to existing transmission system would likely be required as a result. The foreseeable Moss project would increase the delivery efficiency of electricity to support growth in ERCOT demand and would be expected to support the transmission of the TCEP's electricity to markets.	The TCEP and Moss project combined would be beneficial to supply and would convey electricity to the electricity demand areas. Further evaluation not warranted.

Table 5.3. Evaluation Summary of Cumulative Effects for Issues of Intermediate Importance

Resource	Background/Historical Trends	Contribution from TCEP	Contribution from Other Reasonably Foreseeable Projects (or trends/forecasts)	Total Cumulative Effects	Conclusion
Materials and Waste Management	261 billion tn (236 billion t) of U.S. coal reserves (Energy Information Administration 2010a) were recognized in 2009. This would supply the U.S. at current demand levels for approximately 230 years. Total demand for U.S. coal reached 1.12 billion tn (1.01 billion t) in 2008 and production was 1.17 billion tn (1.06 billion t) (National Mining Association 2011).	The TCEP would consume 2.1 million tn (1.9 million t) per year of coal, which would contribute 0.02 percent to the U.S. consumption of the recognized coal reserves over the life of the project (30 years).	No coal consumption is expected to occur from the reasonably foreseeable projects described in this Chapter. On a national level, the U.S. coal demand has increased only slightly over recent years. The Energy Information Administration is currently projecting a 0.4 percent per year increase in U.S. coal demand until 2030, with no prediction made further into the future (Energy Information Administration 2010b).	The TCEP's contribution appears to be included in the national forecast made by the Energy Information Administration (or is within the error in this projection) (Energy Information Administration 2010b).	At Energy Information Administration's forecast rate of acceleration in coal consumption (0.4 percent per year), there is approximately a 160-year coal supply in the currently recognized reserves, with or without the TCEP's individual consumption. Further evaluation not warranted.
Human Health, Safety, and Accidents	Impacts to human health and safety historically increased with the new work associated with the industrial revolution (Aldrich 2001), such as the oil and gas industry in the ROI. Current safety programs and OSHA requirements has contributed to the decreasing impacts to human health and safety (Aldrich 2001).	Increase in risks to human health and safety (5.25 recordable incidents per year) related to TCEP operation. Increase in risks associated with TCEP vehicle traffic from vehicle accidents (< 1 fatality over life of project).	Potential increase in risks to human health and safety from power line operations from worker exposure to electrocution, injury from falling, and structural failure as a result of the Moss project. Potential increase in rail injuries from construction of the LEAP project.	Projected recordable incidents for the TCEP are low. Potential for risks with the Moss project would be lower because fewer personnel would be needed to operate the transmission line. Given the current railroad safety programs in place, significant increases in risk associated with the LEAP project would not be anticipated.	There is a low likelihood for significant cumulative effect to human health, safety, and accidents in the ROI. Further evaluation not warranted.

5.2.2 Cumulative Effects of High Importance

This section addresses potential cumulative effects of GHG emissions and water consumption as a result of the construction and operation of the TCEP and specific future proposals and general trends in the cumulative effects ROIs. DOE identified these two cumulative effects issues as having high importance. GHG emissions are widely associated with global climate change, a topic of national debate. Further, during the public scoping process for this EIS, water consumption by the TCEP and its possible impacts on regional water supplies was identified as an important environmental issue for the people of West Texas.

5.2.2.1 CLIMATE CHANGE

The human and natural causes of climate change and the impacts of climate change are global in scope. GHG emissions, which have been shown to contribute to climate change, do not remain localized, but become mixed with the general composition of the Earth's atmosphere. Therefore, this analysis cannot separate the particular contribution of TCEP GHG emissions to regional or global climate change from the many other past, present, and reasonably foreseeable projects that have produced or would produce or mitigate GHG emissions. Rather, this analysis focuses on the cumulative effects of GHG emissions and climate change from a global perspective.

Background

A worldwide environmental issue is the likelihood of changes in the global climate as a consequence of global warming produced by increasing atmospheric concentrations of GHGs (IPCC 2007a). The atmosphere allows a large percentage of incoming solar radiation to pass through to the Earth's surface, where it is converted to heat energy (infrared radiation) that is more readily absorbed by GHGs than by incoming solar radiation. The heat energy absorbed near the Earth's surface increases the temperature of air, soil, and water.

GHGs include water vapor, CO_2, methane, nitrous oxide, O_3, and several chlorofluorocarbons. Although GHGs constitute a small percentage of the Earth's atmosphere, they are entirely responsible for its heat-trapping properties. Water vapor, a natural component of the atmosphere, is the most abundant GHG, but its atmospheric concentration is driven primarily by changes in the Earth's temperature. As such, water vapor simply serves to amplify the effects of other GHGs such as CO_2. The second-most abundant GHG is CO_2, which remains in the atmosphere for long periods of time. Due to human activities, atmospheric CO_2 concentrations have increased by approximately 35 percent over preindustrial levels. Fossil fuel burning, specifically from power production and transportation, is the primary contributor to increasing concentrations of CO_2 (IPCC 2007a). In the U.S., stationary CO_2 emission sources include energy facilities (such as coal and natural gas power plants) and industrial facilities. Industrial processes that emit these gases include cement manufacture, limestone and dolomite calcination, soda ash manufacture and consumption, CO_2 manufacture, and aluminum production (Energy Information Administration 2009). In addition, industrial and agricultural activities release GHGs other than CO_2—notably methane, NO_x, O_3, and chlorofluorocarbons—to the atmosphere, where they can remain for long periods of time.

In the preindustrial era (before 1750 A.D.), the concentration of CO_2 in the atmosphere appears to have been 275 to 285 ppm (IPCC 2007a). In 1958, C.D. Keeling and others began measuring the concentration of atmospheric CO_2 at Mauna Loa in Hawaii (Keeling et al. 1976). The data collected by Keeling's team and others since then indicate that the amount of CO_2 in the atmosphere has been steadily increasing from approximately 316 ppm in 1959 to 386 ppm in 2008 (National Oceanic and Atmospheric Administration 2010b). This increase in atmospheric CO_2 is attributed almost entirely to human activities.

Impacts of Greenhouse Gases on Climate

Climate is usually defined as the average weather of a region, or more rigorously as the statistical description of a region's weather in terms of the means and variability of relevant parameters over time periods ranging from months to thousands of years. The relevant parameters include temperature, precipitation, wind, and dates of meteorological events such as first and last frosts, beginning and end of rainy seasons, and appearance and disappearance of pack ice. Because GHGs in the atmosphere absorb energy that would otherwise radiate into space, the possibility that human-caused emissions of these gases could result in warming that might eventually alter climate was recognized soon after the data from Mauna Loa and elsewhere confirmed that the atmosphere's content of CO_2 was steadily increasing (IPCC 2007a; National Oceanic and Atmospheric Administration 2010b).

Changes in climate are difficult to detect because of the natural and complex variability in meteorological patterns over long periods of time and across broad geographical regions. There is much uncertainty regarding the extent of global warming caused by human-induced GHG emissions, the climate changes this warming has or will produce, and the appropriate strategies for stabilizing the concentrations of GHGs in the atmosphere. The World Meteorological Organization and United Nations Environment Programme established the IPCC to provide an objective source of information about global warming and climate change, and IPCC's reports are generally considered to be an authoritative source of information on these issues.

According to the IPCC fourth assessment report, "[w]arming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level" (IPCC 2007b). The IPCC report finds that the global average surface temperature has increased by approximately 0.74 degrees Celsius in the last 100 years, global average sea level has risen approximately 150 millimeters over the same period, and cold days, cold nights, and frosts over most land areas have become less frequent during the past 50 years. The report concludes that most of the temperature increases since the middle of the twentieth century "is very likely due to the observed increase in anthropogenic [GHG] concentrations."

The 2007 report estimates that, at present, CO_2 accounts for approximately 77 percent of the global warming potential attributable to human-caused releases of GHGs, with most (74 percent) of this CO_2 coming from the combustion of fossil fuels. Although the report considers a variety of future scenarios regarding GHG emissions, CO_2 would continue to contribute more than 70 percent of the total warming potential under all of the scenarios. The IPCC therefore believes that further warming is inevitable, but that this warming and its effects on climate could be mitigated by stabilizing the atmosphere's concentration of CO_2 through the use of 1) "low-carbon technologies" for power production and industrial processes, 2) more efficient use of energy, and 3) management of terrestrial ecosystems to capture atmospheric CO_2 (IPCC 2007b).

Environmental Impacts of Climate Changes

The IPCC and the U.S. Climate Change Science Program have examined the potential environmental impacts of climate change at global, national, and regional scales. The IPCC report states that, in addition to increases in global surface temperatures, the impacts of climate change on the global environment may include

- more frequent heat waves, droughts, and fires;
- rising sea levels and coastal flooding;
- melting glaciers, ice caps, and polar ice sheets;
- more severe hurricane activity and increases in frequency and intensity of severe precipitation;
- spread of infectious diseases to new regions;
- loss of wildlife habitats; and
- heart and respiratory ailments from higher concentrations of ground-level O_3 (IPCC 2007b).

On a national scale, average surface temperatures in the U.S. have increased, with the last decade being the warmest in more than a century of direct observations (U.S. Climate Change Science Program 2008). Impacts on the environment attributed to climate change that have been observed in North America include

- extended periods of high fire risk and large increases in burned areas;
- increased intensity, duration, and frequency of heat waves;
- decreased snowpack, increased winter and early spring flooding potentials, and reduced summer stream flows in the western mountains; and
- increased stress on biological communities and habitat in coastal areas (IPCC 2007b).

On a regional scale, there is greater natural variability in climate parameters that makes it difficult to attribute particular environmental impacts to climate change (IPCC 2007b). However, based on observational evidence, there is likely to be an increasing degree of impacts such as coral reef bleaching, loss of specific wildlife habitats, reductions in the area of certain ecosystems, and smaller yields of major cereal crops in the tropics (IPCC 2007b). For the northern hemisphere, regional climate change could affect physical and biological systems, agriculture, forests, and amounts of allergenic pollens (IPCC 2007b).

TCEP Potential Greenhouse Gas Emissions

In proposing to construct and operate the TCEP, Summit seeks to demonstrate the technical and economic feasibility of capturing a high percentage of CO_2 produced by the use of coal as a feedstock in an IGCC electricity and chemicals production plant. Carbon in the coal would be converted mostly into syngas components: CO_2, CO, and small amounts of COS and other carbon forms. The polygen plant's water-gas shift reactor and acid gas removal units would convert most of the CO and COS in the syngas into CO_2. Accounting for the combustion of natural gas along with the gasification of coal, approximately 90 percent of the total CO_2 produced at the plant would be captured. Approximately 95 percent of the carbon in the coal feedstock would be captured as CO_2.

Carbon in the coal used at the TCEP would take one of three primary pathways:

1. Approximately 5 percent of the coal's carbon would not be captured and would pass through as CO_2 or would be converted to CO_2 in the combustion turbine and duct burner as small amounts of carbon-bearing compounds are fully oxidized. This CO_2 emission to the

atmosphere would amount to approximately 0.3 million tn (0.27 million t) per year during normal plant operations, or 9 million tn (8 million t) over a 30-year life of the plant. A small amount of carbon would go into slag and particulates. Preferably the slag would be sold for beneficial uses; alternatively it would be sent to a landfill. Most of the particulates would be filtered out of the syngas and sent to a landfill.

2. Approximately 90 percent of the coal's carbon would be captured as CO_2 that would be sold in the regional (Permian Basin) EOR market with an expectation of permanent sequestration of almost all of these molecules of CO_2. This CO_2 product would amount to approximately 3.0 million tn (2.7 million t) per year during normal plant operations or 90 million tn (82 million t) over a 30-year life of the plant.

3. Approximately 11 percent of the coal's carbon would be captured as CO_2 that would be used to make urea to be sold on the national market with no expectation of permanent sequestration of these molecules of CO_2. Because the urea would be used to make fertilizer, this CO_2 is assumed to remain in the surface and near surface environment of the Earth but would benefit the production of crops and vegetation. The CO_2 captured in the urea product would amount to approximately 0.39 million tn (0.36 million t) per year during normal plant operations or 12 million tn (11 million t) over a 30-year life of the plant.

The electric power sector in the U.S. releases approximately 2.64 billion tn (2.40 billion t) of CO_2 annually; U.S. coal-fired power plants account for 2.17 billion tn (1.97 billion t) of that amount (EPA 2010g). Globally, 54 billion tn (49 billion t) of CO_2-equivalent anthropogenic GHGs are emitted annually, with fossil fuel combustion contributing approximately 32 billion tn (29 billion t) of that amount. Annual emissions of CO_2 from the TCEP would add to these emissions.

If the TCEP is not built, it cannot be assumed that the additional emissions attributed to the TCEP would be avoided. Other less efficient and/or more CO_2-emitting fossil fuel power plants might be constructed in its place, existing plants might produce more power thereby increasing their CO_2 emissions, or existing, less efficient and/or more CO_2-emitting fossil fuel power plants might remain online instead of being replaced.

It is likely that new fossil fuel-based electricity generating plants will be built in Texas and elsewhere in the U.S. Although renewable energy projects have been proposed and are being developed in Texas, as they are in other parts of the country, ERCOT has projected demand for additional generating capacity in Texas (including replacement of some existing capacity) that is greater than the projected capacity of new renewable sources. Similar projections have been made in other regions of the U.S. Renewable sources (wind and solar) also are intermittent, requiring additional base-load to firm up electric power supplies. Although a DOE decision to contribute funding to the TCEP would not make it "reasonably foreseeable," within the meaning of 40 C.F.R. § 1508.7 that future fossil fuel-based power plants will incorporate carbon capture, successful construction and operation of the TCEP could demonstrate the feasibility of incorporating the capture of CO_2, making it more likely that it could be incorporated into future fossil fuel-powered electricity generation. Should the TCEP demonstrate the feasibility of utility-scale electric power generation with carbon capture, it could result in the incorporation of carbon capture in future power plant construction, with resulting reductions in CO_2 emissions from new electricity generating capacity built in the future.

Because the TCEP is designed for 90 percent carbon capture, the TCEP represents a step toward reducing GHG emissions from producing electric power both from coal and natural gas.

5.2.2.2 WATER RESOURCES

Background

The proposed TCEP is located within the TWDB Water Planning Region F. Region F includes 32 counties in West Texas extending from Brownwood, McCulloch, and Mason Counties in the east to Reeves County in the West. Borden and Scurry Counties comprise the northern boundary and Pecos, Crockett, Sutton and Kimble Counties make up the southern boundary. As of 2010, approximately 72 percent of current water demand is associated with agricultural irrigation, with lesser amounts used for municipal, mining, steam electric power generation, livestock watering, and manufacturing purposes.

Water sources within Region F are 17 surface water reservoirs and 11 aquifers supplying ground water. Approximately 70 percent of the region's existing water supply consists of ground water from the Ogallala, Edwards-Trinity (Plateau), Edwards-Trinity (High Plains), and Pecos Valley Aquifers. Based on existing ground water supplies in the region (all aquifers), the TCEP has the potential to use approximately 0.7 percent of the annual available ground water, depending on the water source option selected by Summit.

Potable Water

The city of Odessa and the city of Midland get their potable water primarily from man-made reservoirs, with lesser amounts of water supplied from ground water aquifers. In Ector County, approximately 7.0 billion gal (26.6 billion L) or 21,583 ac-ft of water was used for municipal purposes in 2007 (TWDB 2011). Of that amount, approximately 6.0 billion gal (22.8 billion L) or 18,493 ac-ft came from surface water sources and 1.0 billion gal (3.7 billion L) or 3,070 ac-ft came from ground water sources. In Midland County, approximately 9.2 billion gal (34.8 billion L) or 28,288 ac-ft of water was used for municipal purposes in 2007. Approximately 7.2 billion gal (27.2 billion L) or 22,077 ac-ft came from surface water sources and 2.0 billion gal (7.6 billion L) or 6,211 ac-ft came from ground water sources. DOE reviewed TWDB historical water use data for the period from 1974 through 2004 and found that the trend in both Ector and Midland Counties has been an increase in the use of surface water sources and a corresponding decrease in the use of ground water for potable water.

Nonpotable Water

In Ector County, approximately 1.6 billion gal (6.2 billion L) or 5,069 ac-ft of water was used for nonmunicipal purposes in 2007. Of that amount, approximately 337.9 million gal (1.2 billion L) or 1,037 ac-ft came from surface water sources and 1.3 billion gal (4.9 billion L) or 4,032 ac-ft came from ground water sources. In Midland County, approximately 5.44 billion gal (20.59 billion L) or 16,700 ac-ft of water was used for nonmunicipal purposes in 2007. Approximately 10.7 million gal (40.7 million L) or 33 ac-ft came from surface water sources and 5.43 billion gal (20.55 billion L) or 16,667 ac-ft came from ground water sources.

Supply and Demand Forecasts and Uses

The Region F Water Plan states that the total water demand for the region will increase from 261.7 billion gal (990.9 billion L) or 803,376 ac-ft per year in 2010 to 265.5 billion gal (1.0 trillion L) or 814,991 ac-ft per year by 2060 (TWDB 2010c). TWDB projects that 198.7 billion gal (752.4 billion

L) or 610,000 ac-ft per year will be available in 2060. This represents a projected shortage of 78.2 billion gal (296.0 billion L) or 240,000 ac-ft per year by 2060.

Although none of the reasonably foreseeable projects identified by DOE would consume water, the withdrawal of up to 5.5 million gal (20.8 million L) of water per day, or 6,165 ac-ft per year, for the TCEP could affect future ground water supplies in varying degrees depending on the water source option selected by Summit:

- Gulf Coast Waste Disposal Authority Option: The GCA Waterline option (WL 1) would supply treated municipal waste water for use as process water by the TCEP. The municipal waste water would come from the municipalities of Odessa and Midland. This water would continue to be used and treated by the municipalities regardless of the TCEP's use.

- Oxy Permian Option: Oxy Permian operates a network of pipelines that provide brackish (highly saline and nonpotable) ground water from the Capitan Reef Complex Aquifer. The Oxy Permian Waterline option (WL2) would provide process water to the TCEP from the existing pipeline system. Oxy-Permian would withdraw additional amounts of ground water to meet the TCEP's process water needs.

- Fort Stockton Holdings Option: Currently in the developmental stages, the FSH waterline project has been proposed to provide drinking water to the cities of Midland and Odessa. Under this option, FSH would provide water to the TCEP from two potential waterlines (WL3 and WL4). If it were built, the TCEP could use approximately 10 percent of the total water that would be available through the FSH waterline. The FSH water source would be ground water from the Edwards-Trinity (High Plains) Aquifer located near the city of Fort Stockton, which is approximately 66 mi (106 km) southwest of the proposed TCEP. The FSH water is currently permitted for agricultural irrigation activities on the FSH farms in Fort Stockton. This water has already been accounted for in the 2011 Texas Water Plan (TWDB 2010c), and the FSH mainline project would represent a change in the use for the water rather than a new demand on water.

Conclusions

For WL1, DOE assumes that the municipal waste water from Odessa and Midland would not be used in the future for potable water. Thus, the TCEP's industrial use of the GCA water would not directly affect potable water supplies in the region. However, if the TCEP's use of this municipal waste water caused future users to rely on potable water sources instead of this waste water source, then the TCEP would have an indirect effect on future potable water supplies.

The Oxy Permian system is not utilized at its full capacity and the demand for water from that system for use in EOR has been declining as oil fields are requiring less supplemental water for their EOR needs. The current pumping rate is estimated to be as low as 50 percent of the former peak rate. If Summit chooses WL2, the TCEP's proposed water consumption would not likely affect current or anticipated future EOR water needs.

Although the TCEP's potential use of ground water from the Oxy Permian water supply would not result in an increase over historical pumping rates, it would require Oxy Permian to increase its withdrawal of ground water above current levels. Flow in the small, ephemeral streams of West Texas is driven primarily by rainfall with some contributions from seeps and springs. Increased pumping of ground water could affect flows from seeps and springs that originate in the aquifers where the pumping occurs.

The Oxy Permian water is saline and, for that reason, it is not used as a potable water source and is not likely to be used as a potable water source in the future. As noted above for WL1, if the TCEP's use of this nonpotable saline ground water caused future users to rely on potable water sources instead, then the TCEP would have an indirect effect on future potable water supplies.

Under WL3 and WL3, FSH would convert water currently being used for agriculture to municipal and/or industrial uses, but would not increase current ground water withdrawal rates. Thus, the use of this water for the TCEP would not be expected to impose cumulative effects on ground water availability in the region. To the extent that use of the FSH ground water supplies for the TCEP caused future users to seek potable water sources instead, the TCEP would have an indirect effect on future potable water supplies.

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Chapter 6. Irreversible and Irretrievable Commitments of Resources and Local Short-Term Uses and Long-Term Productivity of the Environment

6 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES AND LOCAL SHORT-TERM USES AND LONG-TERM PRODUCTIVITY OF THE ENVIRONMENT

6.1 Irreversible and Irretrievable Commitments of Resources

A resource commitment is considered irreversible when impacts from its use would limit future use options and the change cannot be reversed, reclaimed, or repaired. Irreversible commitments generally occur to nonrenewable resources such as minerals or cultural resources, and to those resources that are renewable only over long time spans, such as soil productivity.

A resource commitment is considered irretrievable when the use or consumption of the resource is neither renewable nor recoverable for use by future generations until reclamation is successfully applied. Irretrievable commitments generally apply to the loss of production, harvest, or natural resources and are not necessarily irreversible.

The land that would be committed to develop the proposed TCEP would include land used for construction staging areas for the polygen plant and linear facilities, the footprint of the polygen plant, and the footprint of associated linear facilities. Although not all of the 600 ac (243 ha) at the polygen plant site would actually be developed, it is likely that the entire site would be unavailable for other uses. Similarly, the land required for the linear facilities could be restricted from some other uses. However, after the operational life of the polygen plant is over and the plant and linear facilities have been decommissioned and reclaimed, the land would again be available for other uses. Therefore, during the lifespan of the project, land use would experience an irretrievable impact.

The land areas required for the polygen plant and linear facilities would be cleared, graded, and filled, as needed, to suit construction of the project. These actions would result in additional impacts that are irreversible and/or irretrievable. Existing vegetation and soils would be removed, causing mortality of some wildlife, such as burrow-dwelling species and slow-moving species that are unable to relocate when ground-disturbance activities begin. In addition, the vegetation and soil habitats would be lost for future use by wildlife until reclamation could be successfully implemented. The direct mortality of wildlife would be an irreversible impact and the loss of habitat would be an irretrievable impact. It can be argued that the loss of soil (which requires a very long time to generate) would constitute an irreversible and irretrievable resource commitment; however, reclamation would likely include replacing any lost topsoil and not relying on natural soil-producing processes. Therefore, it is likely that the soil removal would ultimately be an irretrievable impact but not irreversible.

The clearing and grading actions also pose a risk to cultural resources that may exist at the polygen plant and linear facilities. If cultural resources were discovered during construction, they would be documented and likely relocated from the site. Disturbances to these resources would be considered irreversible.

Process water would be used primarily in the cooling towers, which would convert the water to vapor. Potable water used during construction and operations would be discharged through a septic system. Because the project would not directly discharge any of the process or potable water directly back to ground water or surface water, much of this water may be lost to the local area and downstream users. This would result in an irretrievable commitment of water resources. In the event the ground water option is used, due to the amount of time required for ground water recharge through the hydrologic cycle, this use could also result in an irreversible commitment of ground water resources.

Aesthetics would experience irretrievable, but not irreversible, commitments during the life of the polygen plant operation. The viewshed would be altered as long as the polygen plant was present.

Although air emissions would be greatly reduced compared to typical coal-fueled electricity generation facilities, there would be some emissions that would contribute to reduced air quality.

Material and energy resources committed for the TCEP would include construction materials (e.g., steel, concrete) and fuels (e.g., coal, diesel, gasoline). All energy used during construction and operation would be irreversible and irretrievable. During operation, the project would use up to 2.1 million tn (1.9 million t) of coal annually. The sub-bituminous coal resources would be irreversibly and irretrievably committed. Based on 2009 U.S. coal production statistics, the TCEP would use approximately 0.42 percent of the sub-bituminous coal produced annually in the U.S. (Energy Information Administration 2010a). The polygen plant would also use natural gas during startup and as a backup fuel. Although the amount of natural gas used would be negligible in relation to local capacity, it would be irreversibly and irretrievably committed.

6.2 Relationship between Short-term Uses of the Environment and Long-term Productivity

Short-term uses of the environment would be associated with construction activities and have been described in Chapter 3. These include, for example, the use of aesthetic, air, wetlands, and transportation resources, as well as the short-term use of land for construction staging areas. Aesthetic impacts affecting nearby residents include the effects to viewsheds from land-clearing activities and increased noise levels. Aesthetics and air quality would both experience short-term impacts from fugitive dust emissions. Although there are no surface waters that would be impacted by the project, there are wetlands along some of the proposed linear facilities sites that would be disturbed or reduced through land-clearing activities The disturbance of these wetlands, as well as general vegetation and wildlife habitat along the linear facilities, would be considered short term because they would likely re-establish after the facilities were constructed. Any reductions in wetlands could be long-term or even permanent. Short-term impacts would also include traffic diversions and disruptions during construction activities.

The long-term impacts of land use for the project are described and discussed above. There would be short-term land use impacts as well. During construction, staging areas and laydown yards would be cleared and made usable. These areas would be reclaimed and restored at the end of the construction phase.

In the long term, the project would support the DOE objective of demonstrating and promoting innovative coal power technologies that can provide the U.S. with clean, reliable, and affordable energy using abundant domestic sources of coal. The proposed project is expected to contribute approximately 213 MW (net) of electricity to the electric grid system. The project, if successful, would serve as an example of a way to either minimize SO_2, NO_x, Hg, CO_2, and PM emissions from coal-fueled power plants or to increase the efficiency in which energy in coal is converted into electricity. If older coal-fueled power plants were replaced with new plants similar to the TCEP, the total U.S. and worldwide emissions of pollutants could be reduced and the efficient use of nonrenewable resources could be improved.

Specifically the successful development of low-emissions electricity production from sub-bituminous coal would further the goal of reducing anthropogenic emissions of CO_2. If the project is approved and developed, the project would establish a precedent for long-term positive impacts on reducing CO_2 emissions per unit of electricity generated. In addition, increased oil production through EOR would result in more complete resource extraction from existing oil fields and increase the benefit-to-cost ratio for each unit extracted. Likewise, the integrated production of urea for fertilizer would benefit the agricultural industry and reduce the need for imports or the development of a separate urea production facility and its corresponding impacts.

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Chapter 7. Permitting and Licensing Requirements

7 PERMITTING AND LICENSING REQUIREMENTS

Table 7.1 identifies and summarizes statutes, regulations, executive orders, and permitting requirements potentially applicable to construction and operation of the TCEP.

Table 7.1. Summary of Federal, State, and Local Laws, Regulations, Policies, and Plans Potentially Applicable to the TCEP

Laws, Regulations, Policies, and Plans	Description
FEDERAL	
Accidental Release Prevention Program/Risk Management Plans (40 C.F.R. Part 68)	These Clean Air Act regulations apply to facilities that may store quantities of toxic or flammable chemicals above listed thresholds. The requirements include conducting process hazards analyses, implementation of work practices to prevent releases, and development of site-specific risk management plans.
Acid Rain Permit (40 C.F.R. Parts 72 and 75)	This permit is required for utility units exceeding threshold limits specified in the regulations. The overall goal of the Acid Rain Emission Program is to achieve significant environmental and public health benefits through reductions in emissions of SO_2 and NO_X, the primary causes of acid rain. This permit requirement is a part of the larger Title V permit, issued pursuant to the Clean Air Act.
American Indian Religious Freedom Act of 1978 (42 U.S.C. § 1996)	This act ensures the protection of sacred locations and access of Native Americans to those sacred locations and traditional resources that are integral to the practice of their religions.
Bald and Golden Eagle Protection Act of 1940 (16 U.S.C. §§ 668–668d)	This law prohibits the take, possession, and commerce of golden eagles and bald eagles, their nests, and eggs except under certain specified conditions.

Table 7.1. Summary of Federal, State, and Local Laws, Regulations, Policies, and Plans Potentially Applicable to the TCEP

Laws, Regulations, Policies, and Plans	Description
Clean Air Act, Title I, IV, and V (40 C.F.R. Parts 50–95)	This act establishes NAAQS set by EPA for certain pervasive pollutants. Specific permits required under the Clean Air Act are addressed separately. *Applicable Titles:* Title I, Air Pollution Prevention and Control, provides the basis for air quality and emission limitations, PSD permitting program, state implementation plans, New Source Performance Standards, and National Emissions Standards for HAPs. Title IV, Acid Deposition Control, establishes limitations on SO_2 and NO_X emissions, permitting requirements, monitoring programs, reporting and recordkeeping requirements, and compliance plans for emission sources. This title requires that emissions of SO_2 from utility sources be limited to the amounts of allowances held by the sources. Title V, Permitting, provides the basis for the Operating Permit Program and establishes permit conditions, including monitoring and analysis, inspections, certification, and reporting. *State-administered programs for Clean Air Act compliance:* Clean Air Interstate Rule (30 TEX. ADMIN. CODE Chapter 101, Subchapter H, Division 7) applies to any stationary, fossil fuel-fired combustion turbine meeting the applicability requirements under 40 C.F.R. Part 96, Subpart AA or Subpart AAA. Clean Air Interstate Rule remains in effect, although it is under litigation. Clean Air Mercury Rule (30 TEX. ADMIN. CODE Chapter 101, Subchapter H, Division 8) requires new and existing coal-fired electric generating units to participate in an EPA-administered nationwide cap-and-trade system to reduce Hg emissions. General Air Operating Permit (30 TEX. ADMIN. CODE Chapter 122) is required for nonmajor sources designated by EPA, through rulemaking, and as specified by federal requirements. If EPA designated the TCEP as a nonexempt, nonmajor source, it would be required to obtain a federal, not a state, operating permit. Texas has no state operating permit program.

Table 7.1. Summary of Federal, State, and Local Laws, Regulations, Policies, and Plans Potentially Applicable to the TCEP

Laws, Regulations, Policies, and Plans	Description
Clean Water Act, Title IV (33 U.S.C. §§ 1251 *et seq.*; 40 C.F.R. Parts 104–140)	This act focuses on improving the quality of water resources by providing a comprehensive framework of standards, technical tools, and financial assistance to address the many causes of pollution and poor water quality, including municipal and industrial waste water discharges, polluted runoff from urban and rural areas, and habitat destruction. *Applicable Sections:* Section 401, Water Quality Certification, provides states with the opportunity to review and approve, condition, or deny all federal permits or licenses that might result in a discharge to state or tribal waters, including wetlands. The major federal permit subject to Section 401 review is a Section 404 permit (see below). Every applicant for a Section 404 permit must request state certification that the proposed activity would not violate state or federal water quality standards. Section 402, National Pollutant Discharge Elimination System Permit, requires sources to obtain permits to discharge effluents and storm waters to surface waters. The Clean Water Act authorizes EPA to delegate permitting, administrative, and enforcement duties to stage governments, with EPA retaining oversight responsibilities. The State of Texas has been delegated National Pollutant Discharge Elimination System authority and therefore would issue the National Pollutant Discharge Elimination System permit. Section 404, Permits for Dredged or Fill Material, regulates the discharge of dredged or fill material in the jurisdictional wetlands and waters of the U.S. The U.S. Army Corps of Engineers has been delegated the responsibility for authorizing these actions. *State-administered programs for Clean Water Act compliance:* Hydrostatic Test Water Discharge Permit (Texas Water Code, Chapter 26) if hydrostatic test water is discharged. A TPDES General Permit No. TXG670000 would be required. TPDES General Construction Storm Water Permit (Texas Water Code, Chapter 26) requires a TPDES permit if a storm water discharge occurs from construction sites disturbing 1 ac (0.5 ha) or more of land. TPDES General Industrial Storm Water Permit (Texas Water Code, Chapter 26) is required for storm water discharges associated with industrial activity.
Compliance Assurance Monitoring Program (40 C.F.R. Part 64)	The federal regulations implementing this program apply to major sources that must obtain a Title V operating permit pursuant to 40 C.F.R. Part 70. The compliance assurance modeling rules are primarily aimed at emission units that are individually above major source thresholds and that utilize control devices to comply with an emission limitation (40 C.F.R. § 64.2).
Determining Conformity of General Federal Actions to State or Federal Implementation Plans (40 C.F.R. Part 51, Subpart W and 40 C.F.R. Part 93)	States and local authorities are responsible for bringing their regions into compliance with NAAQS or in compliance with more stringent standards they may adopt. State implementation plans are EPA-approved plans that set forth the pollution control requirements applicable to the various sources addressed by each state implementation plan. Federal actions must be evaluated for conformity to the local state implementation plan if the project 1) is located in an EPA-designated nonattainment or maintenance area, 2) would result in emissions above major source threshold quantities of a criteria pollutants, 3) is not a listed exempt action, and 4) has not been accounted for in an EPA-approved state implementation plan.

Table 7.1. Summary of Federal, State, and Local Laws, Regulations, Policies, and Plans Potentially Applicable to the TCEP

Laws, Regulations, Policies, and Plans	Description
Emergency Planning and Community Right-to-Know Act of 1986 (42 U.S.C. §§ 11001 *et seq.*; 40 C.F.R. Parts 302–372)	This act requires that inventories of specific chemicals used or stored on-site be reported on a periodic basis to appropriate local, state, and federal agencies. These regulations also require facilities that store, dispense, use, or handle extremely hazardous materials in excess of specified thresholds to report quantity data to specific agencies and organizations. The plant would manufacture, process, or otherwise use a number of substances subject to the act's reporting requirements.
Endangered Species Act of 1973, as amended (16 U.S.C. §§ 1531 *et seq.*; 50 C.F.R. Part 402)	Section 7 of this act requires any federal agency authorizing, funding, or carrying out any action to ensure that the action is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. Section 7 also imposes consultation requirements.
Exempt Wholesale Generator Status (15 U.S.C. §§ 79z–5a(e))	This exempts private generation from certain requirements for public utilities.
Farmland Protection Policy Act (7 U.S.C. §§ 4201 *et seq.*)	This act directs federal agencies to identify and quantify adverse impacts of federal programs on farmland. The act's purpose is to minimize the number of federal programs that contribute to the unnecessary and irreversible conversion of agricultural land to nonagricultural uses.
Federal New Source Review/PSD Permit (40 C.F.R Part 51 and 40 C.F.R. § 52.21)	A component of the Clean Air Act, the PSD program was developed to prevent significant deterioration in the air quality of those areas that meet the NAAQS. In general, the New Source Review/PSD rules define a "major source" as any source with the potential to emit 250 tn (227 t) per year or more of a criteria pollutant. A more stringent threshold is defined for a limited number of "categorical sources," source categories for which the PSD applicability threshold is 100 tn (91 t) per year of any criteria pollutant.
Plant Protection Act (7 U.S.C. §§ 7701 *et seq.*)	This act was established to control the spread of noxious weeds. It prohibits their movement in interstate or foreign commerce, except under permit.
Fish and Wildlife Conservation Act of 1980, as amended (16 U.S.C. §§ 2901 *et seq.*)	This act encourages federal agencies to conserve and promote conservation of nongame fish and wildlife species and their habitats.
Fish and Wildlife Coordination Act of 1934, as amended (16 U.S.C. §§ 661 *et seq.*)	This act requires federal agencies undertaking projects affecting water resources to consult with the USFWS and the state agency responsible for fish and wildlife resources.
GHG Reporting Program (40 C.F.R. Part 98)	Suppliers of fossil fuel or industrial GHGs, manufacturers of vehicles and engines, and facilities that emit 25,000 tn (22,680 t) or more per year of GHG emissions are required to submit annual reports to EPA in accordance with this Clean Air Act requirement.
Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. §§ 703–711)	This act protects birds that have common migration patterns between the U.S. and Canada, Mexico, Japan, and Russia. The act regulates the take and harvest of migratory birds, their nests, and eggs.
National Emissions Standards for HAPs rules (40 C.F.R. Parts 61 and 63)	A component of the Clean Air Act, National Emissions Standards for HAPs rules address health concerns that are considered too localized to be included under the scope of NAAQS. In general, the National Emissions Standards for HAPs rules apply to affected sources that are located at (or are themselves) major sources of HAP emissions, as defined in 40 C.F.R. § 63.2, that is, any stationary source that emits or has the potential to emit (considering controls in the aggregate) 10 tn (9 t) per year or more of any single HAP or 25 tn (23 t) per year or more of any combination of HAP.

Table 7.1. Summary of Federal, State, and Local Laws, Regulations, Policies, and Plans Potentially Applicable to the TCEP

Laws, Regulations, Policies, and Plans	Description
NEPA of 1969, as amended (42 U.S.C. §§ 4321 *et seq.*)	NEPA requires federal agencies to analyze and describe the possible environmental impacts of major federal actions significantly affecting the quality of the human environment. This EIS was prepared in compliance with NEPA.
National Historic Preservation Act of 1996 (16 U.S.C. §§ 470 *et seq.*; 36 C.F.R. Part 800)	Under Section 106 of this act, a federal agency is required to assess the potential impacts of a federal undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the NRHP. The federal agency must also afford the Advisory Council on Historic Preservation established under Title II of the act a reasonable opportunity to comment with regard to such undertaking.
Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. § 3001)	This act directs the Secretary of the Interior to guide the repatriation of federal archaeological collections and collections that are culturally affiliated with Native American tribes and held by museums that receive federal funding. Major actions to be taken under this law include the following: • The establishment of a review committee with monitoring and policymaking responsibilities • The development of regulations for repatriation, including procedures for identifying lineal descent or cultural affiliation needed for claims • The oversight of museum programs designed to meet the inventory requirements and deadlines of this law • The development of procedures to handle unexpected discoveries of graves or grave goods during activities on federal or tribal land This act would only be applicable to the TCEP if human remains or artifacts are unearthed during construction activities.
New Source Performance Standards (40 C.F.R. Part 60)	The federal New Source Performance Standards, promulgated under the Clean Air Act, are technology-based standards applicable to new and modified stationary sources of regulated air emissions. Whereas the NAAQS emphasize on air quality in general, the New Source Performance Standards focus on particular sources of pollutants. The New Source Performance Standards program sets uniform emission limitations for approximately 70 industrial source categories or subcategories of sources that are designated by size as well as type of process. The New Source Review programs are administered by the State of Texas (Control of Air Pollution by Permits for New Construction or Modification, 30 TEX. ADMIN. CODE Chapter 116).
Noise Control Act of 1972, as amended (42 U.S.C. §§ 4901 *et seq.*)	This act directs federal agencies to carry out programs in their jurisdictions "to the fullest extent within their authority" and in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes health and welfare.
Notice to the FAA (14 C.F.R. Part 77)	The FAA must be notified if any structure more than 200 ft (61 m) high would be constructed. The FAA would then determine if the structures would or would not be an obstruction to air navigation.

Table 7.1. Summary of Federal, State, and Local Laws, Regulations, Policies, and Plans Potentially Applicable to the TCEP

Laws, Regulations, Policies, and Plans	Description
Occupational Safety and Health Act of 1970, as amended (29 U.S.C. §§ 651 *et seq.*)	This act requires employers to maintain condition standards or adopt practices reasonably necessary and appropriate to protect workers on the job. *Applicable Rules:* OSHA General Industry Standards (29 C.F.R. Part 1910) define the standards that employers must meet regarding various safety and health measures and/or issues. Examples of the general industry standards include requirements for walking and working surfaces; means of egress; powered platforms and lifts; occupational health and environmental controls; hazardous materials; personal protective equipment; general environmental controls; medical first aid; fire protection; compressed gas and air equipment; materials handling and storage; machinery and machinery guarding; hand and portable powered tools and other handheld equipment; welding, cutting, and brazing; electrical; commercial diving operations; and toxic and hazardous substances. The standards for special industries include provisions for electric power generation, transmission, and distribution, as well. OSHA Construction Industry Standards (29 C.F.R. Part 1926) define the standards that must be met, in addition to the general industry standards, specific to construction activities. Construction-specific standards are defined for general safety and health; occupational health and environmental controls; personal protective and life saving equipment; fire protection and prevention; signs, signals, and barricades; materials handling, storage, use, and disposal; hand and power tools; welding and cutting; electrical; scaffolds; fall protection; helicopters, hoists, elevators, and conveyors; motor vehicles, mechanized equipment, and marine operations; excavations; concrete and masonry construction; steel erection; underground construction, caissons, cofferdams, and compressed air; demolition; blasting and use of explosives; power transmission and distribution; rollover protective structures and overhead protection; ladders; commercial diving operations; and toxic and hazardous substances.
Pollution Prevention Act of 1990 (42 U.S.C. §§13101 *et seq.*)	This act establishes a national policy for waste management and pollution control that focuses first on source reduction, and then on environmentally safe waste recycling, treatment, and disposal.
Resource Conservation and Recovery Act of 1976 (42 U.S.C. §§ 6901 *et seq.* and 40 C.F.R. Parts 239–299)	This act regulates the treatment, storage, and disposal of solid and hazardous wastes. Resource Conservation and Recovery Act Title II, Solid Waste Disposal (known as the Solid Waste Disposal Act), regulates the disposal of solid wastes. Title II, Subtitle C—Hazardous Waste Management, provides for a regulatory system to ensure the environmentally sound management of hazardous wastes from the point of origin to the point of final disposal. Title II, Subtitle D—State or Regional Solid Waste Plans, requires all states to implement 'Solid Waste Plans' that maximize waste reduction and recycling. EPA has delegated authority for implementing Resource Conservation and Recovery Act to the State of Texas through 40 C.F.R. § 272.2201. Resource Conservation and Recovery Act Standard Permits for Storage and Treatment Units (30 TEX. ADMIN. CODE Chapter 305).
Safe Drinking Water Act of 1974 (42 U.S.C. §§ 300 *et seq.*: 40 C.F.R. Part 144)	This act gives EPA the authority to regulate public drinking water supplies by establishing drinking water standards, delegating authority for enforcement of drinking water standards to the states, and protecting aquifers from hazards such as injection of wastes and other materials into wells. The State of Texas implements the Safe Drinking Water Act in Texas (30 TEX. ADMIN. CODE § 290).

Table 7.1. Summary of Federal, State, and Local Laws, Regulations, Policies, and Plans Potentially Applicable to the TCEP

Laws, Regulations, Policies, and Plans	Description
EXECUTIVE ORDERS	
Executive Order No. 12898, Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations	This order directs federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations.
Executive Order No. 13112, Invasive Species	This order directs federal agencies to 1) prevent the introduction of invasive (non-native) species or to monitor and control invasive (non-native) species, 2) provide for restoration of native species, 3) conduct research, 4) promote educational activities, and 5) exercise care in taking actions that could promote the introduction or spread of invasive species.
Executive Order No. 13175, Consultation and Coordination with Indian Tribal Governments	This order directs federal agencies to establish regular and meaningful consultation and collaboration with tribal governments in the development of federal policies that have tribal implications to strengthen U.S. government-to-government relationships with Indian tribes, and to reduce the imposition of unfunded mandates on tribal governments.
Executive Order No. 13186, Responsibilities of Federal Agencies to Protect Migratory Birds	This order requires federal agencies to avoid or minimize the negative impacts of their actions on migratory birds and to take active steps to protect birds and their habitats. Each federal agency taking an action having or likely to have a negative impact to migratory bird populations is directed to work with the USFWS to develop an agreement to conserve those birds. Further, federal agencies must avoid or minimize impacts to migratory bird populations, take reasonable steps that include restoring and enhancing habitat, prevent or abate pollution affecting birds, and incorporate migratory bird conservation into agency planning processes whenever possible. This order requires environmental analyses of federal actions to evaluate effects of those actions on migratory birds, to control the spread and establishment in the wild of exotic animals and plants that could harm migratory birds and their habitats, and either to provide advance notice of actions that could result in the *take* of migratory birds, or to report annually to the USFWS on the numbers of each species taken during the conduct of agency actions.
Executive Order No. 13423, Strengthening Federal Environmental, Energy, and Transportation Management	Executive Order No. 13423 directs federal agencies to conduct their environmental, transportation, and energy-related activities in an environmentally, economically, and fiscally sound, integrated, continuously improving, efficient, and sustainable manner.
Executive Order No. 13514, Federal Leadership in Environmental, Energy, and Economic Performance	Executive Order No. 13514 sets sustainability goals for federal agencies and focuses on making improvements in their environmental, energy, and economic performance. This order establishes an integrated strategy promoting sustainability in the federal government, makes reduction of GHG emissions a priority for federal agencies, and sets goals in the areas of energy efficiency, acquisition, renewable energy, toxics reductions, recycling, renewable energy, sustainable buildings, electronics stewardship, fleets, and water conservation.

Table 7.1. Summary of Federal, State, and Local Laws, Regulations, Policies, and Plans Potentially Applicable to the TCEP

Laws, Regulations, Policies, and Plans	Description
STATE	
Injection Wells (Texas Water Code, Chapter 27; 30 TEX. ADMIN. CODE Chapter 331)	It is the policy of this state and the purpose of this chapter to maintain the quality of fresh water in the state to the extent consistent with the public health and welfare and the operation of existing industries, taking into consideration the economic development of the state, to prevent underground injection that may pollute fresh water, and to require the use of all reasonable methods to implement this policy. Authorization from the RRC is required for injection into a reservoir that is productive of oil, gas, or geothermal resources. This permit will be required if Summit elects to dispose of waste water in an underground injection control well.
On-site Sewage Disposal Systems Septic Permit (30 TEX. ADMIN. CODE Chapter 285; Texas Health and Safety Code, Chapter 366)	A permit would be required for an on-site sewage facility.
Permit for Groundwater Withdrawal and Monitoring Wells (Texas Water Code, Chapter 36)	Permits would be required if the Underground Water Conservation District determines that ground water withdrawals need to be monitored as a result of the TCEP. Currently, no ground water conservation district has been established in Ector County.
Fluid Injection into Productive Reservoirs (16 TEX. ADMIN. CODE § 3.46)	The RRC has jurisdiction over wells into which fluids are injected for enhanced recovery of oil or natural gas as well as jurisdiction over injection wells for geologic storage of CO_2 (16 TEX. ADMIN. CODE Rule § 3.30). A permit from the RRC is required for fluid injection operations in reservoirs productive of oil, gas, or geothermal resources.
Underground Storage of Gas in Productive or Depleted Reservoirs (16 TEX. ADMIN. CODE § 3.96)	The RRC has jurisdiction over wells into which fluids are injected for enhanced recovery of oil or natural gas as well as jurisdiction over injection wells for geologic storage of CO_2 (16 TEX. ADMIN. CODE § 3.30). A permit from the RRC is required for operation of a gas storage project.
Registration of Power Generation Companies and Self-Generators (Public Utility Commission Substantive Rule § 25.109)	Power-generation plants operating in the state of Texas must register with the Public Utility Commission of Texas.
Texas Threatened and Endangered Species Regulations (31 TEX. ADMIN. CODE Chapter 65, Subchapter G and Texas Parks and Wildlife Code Chapter 68)	These laws and regulations protect threatened and endangered species in Texas by prohibiting the taking, possession, transportation, or sale of protected species without the issuance of a permit.
LOCAL	
City of Midland Zoning (Municipal Code 11-1)	The City of Midland Municipal Code: Zoning dictates the types of development or facilities that are allowed in various portions of the city.

Chapter 8. Agencies and Tribes Contacted

8 AGENCIES AND TRIBES CONTACTED

Table 8.1. Agencies and Tribes Contacted

Federal Agencies	State Agencies	Native American Tribes in Texas	Native American Tribes Located Outside Texas
U.S. Army Corps of Engineers, Fort Worth District EPA, Region 6, Regional Environmental Review Coordinator, Office of Planning and Coordination U.S. Department of the Interior, Regional Environmental Office USFWS, Austin Ecological Services Field Office U.S. Department of Transportation, Federal Highway Administration	RRC Texas Bureau of Economic Geology TCEQ, Region 7, Midland TxDOT, Office of Planning and Development TPWD, Wildlife Habitat Assessment Program Texas SHPO, Texas Historical Commission	Lipan Apache Tribe Ysleta del Sur Pueblo Tribe	Apache Tribe of Oklahoma Comanche Nation, Oklahoma Fort Sill Apache Tribe of Oklahoma Kiowa Tribe of Oklahoma Wichita and Affiliated Tribes, Oklahoma Mescalero Apache Tribe of New Mexico

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Chapter 9. Distribution List

9 DISTRIBUTION LIST

Table 9.1. U.S. Senate and House of Representatives Committees

The Honorable Daniel Inouye, Chairman Committee on Appropriations U.S. Senate
The Honorable Thad Cochran, Ranking Member Committee on Appropriations U.S. Senate
The Honorable Dianne Feinstein, Chairwoman Committee on Appropriations, Subcommittee on Energy and Water Development U.S. Senate
The Honorable Lamar Alexander, Ranking Member Committee on Appropriations, Subcommittee on Energy and Water Development U.S. Senate
The Honorable Barbara Boxer, Chairwoman Committee on Environment and Public Works U.S. Senate
The Honorable James M. Inhofe, Ranking Member Committee on Environment and Public Works U.S. Senate
The Honorable Jeff Bingaman, Chairman Committee on Energy and Natural Resources U.S. Senate
The Honorable Lisa Murkowski, Ranking Member Committee on Energy and Natural Resources U.S. Senate
The Honorable Fred Upton, Chairman Committee on Energy and Commerce U.S. House of Representatives
The Honorable Henry A. Waxman, Ranking Member Committee on Energy and Commerce U.S. House of Representatives
The Honorable Harold Rogers, Chairman Committee on Appropriations U.S. House of Representatives
The Honorable Norm Dicks, Ranking Member Committee on Appropriations U.S. House of Representatives
Honorable Rodney P. Frelinghuysen, Chairman Committee on Appropriations, Subcommittee on Energy and Water Development U.S. House of Representatives

Table 9.1. U.S. Senate and House of Representatives Committees

The Honorable Peter J. Visclosky, Ranking Member Committee on Appropriations, Subcommittee on Energy and Water Development U.S. House of Representatives

Table 9.2. United States Senate

The Honorable John Cornyn, Texas	The Honorable Maria Cantwell, Washington
The Honorable Kay Bailey Hutchison, Texas	The Honorable Patty Murray, Washington

Table 9.3. United States House of Representatives

The Honorable Michael Conaway Congressional District 11 of Texas	The Honorable Jay Inslee Congressional District 1 of Washington

Table 9.4. Native American Tribal Leaders

Mr. Louis Maynahonah, Sr. Tribal Chairman Apache Tribe of Oklahoma	Mr. Tom Castillo Homeland Administrator Lipan Apache Tribe
Mr. Jimmy Arterberry Tribal Historic Preservation Officer Comanche Nation	Mr. Mark R. Chino President Mescalero Apache Tribal Government Mescalero Apache Reservation of New Mexico
Mr. Jeff Houser Chairman Fort Sill Apache Tribe of Oklahoma	Mr. Stratford Williams President Wichita and Affiliated Tribes
Mr. Ronald Daws TwoHatchet Chairman Mrs. Jame Eskew Tribal Representative Kiowa Tribe of Oklahoma	Mr. Frank Paiz Governor Mr. Javier Loera War Captain/Tribal Historic Preservation Officer Ysleta del Sur Pueblo Tribe

Table 9.5. Federal Agencies

Mr. Reid Nelson Director, Office of Federal Agency Programs Advisory Council on Historic Preservation	Ms. Julie Sharp Planning Tech/Environmental Protection Assistant National Park Service, Intermountain Region U.S. Department of Interior
Mr. Jeff C. Wright Director, Office of Energy Projects Federal Energy Regulatory Commission	Dr. Stephen R. Spencer Regional Environmental Officer U.S. Department of the Interior
Mr. David Ingersoll Environmental Specialist International Trade Commission	Mr. Willie R. Taylor Director, Office of Environmental Policy and Compliance U.S. Department of the Interior
Mr. Stephen L. Brooks Regulatory Chief U.S. Army Corps of Engineers, Fort Worth District	Ms. Camille Mittelholtz Deputy Director, Office of Safety, Energy and Environment U.S. Department of Transportation
Mr. Steve Swihart Chief, Compliance Section U.S. Army Corps of Engineers, Fort Worth District	Ms. Victoria Rutson Surface Transportation Board U.S. Department of Transportation
Mr. Mark Matusiak Civil Works Policy and Policy Compliance Division Office of Water Project Review U.S. Army Corps of Engineers	Mr. Thomas Cuddy Office of Environment and Energy FAA (AEE-400) U.S. Department of Transportation
Mr. Mark Plank Rural Utilities Service U.S. Department of Agriculture	Ms. Susan Bromm Director, Office of Federal Activities EPA
Ms. Genevieve Walker NEPA Coordinator U.S. Department of Commerce	Ms. Debra Griffin Office of Planning and Coordination EPA - Region 6
Mr. Steve Kokkinakis National Oceanic and Atmospheric Administration Program Planning and Integration U.S. Department of Commerce	Mr. Michael P. Jansky Regional Environmental Review Coordinator EPA - Region 6
Mr. David Anna Office of Communications DOE	Dr. Sharon Osowski Morgan Ecologist EPA - Region 6
Mr. Ed Pfister Environmental Program Manager U.S. Department of Health and Human Services	Ms. Rhonda Smith Office of Planning and Coordination EPA - Region 6
Mr. David Reese Federal Preservation Officer Office of the Chief Administrative Officer Occupational Safety and Environmental Programs U.S. Department of Homeland Security	Mr. Adam Zerrenner Field Supervisor, Austin Ecological Services Field Office USFWS
Ms. Terry Lukes Deputy Regional Environmental Officer U.S. Department of Homeland Security, Federal Emergency Management Agency Region VI	

Table 9.6. National Nongovernmental Organizations

Mr. Frank M. Stewart President American Association of Blacks in Energy	Ms. Michelle Scott Vice President and General Counsel National Audubon Society
Mr. Thomas H. Adams Executive Director American Coal Ash Association	Mr. Robert A. Beck Executive Vice President National Coal Council
Ms. Janice Nolen Assistant Vice President, National Policy and Advocacy American Lung Association	Ms. Meg Power Senior Advisor National Community Action Foundation
Mr. Harry Ng General Counsel American Petroleum Institute	Mr. Rae Cronmiller Environmental Counsel National Rural Electric Cooperative Association
Ms. Joy Ditto Director, Legislative Affairs American Public Power Association	Ms. Elizabeth Merritt Deputy General Counsel National Trust for Historic Preservation
Mr. Richard Liebert Chairman Citizens for Clean Energy, Inc.	Mr. Jim Lyon Senior Vice President, Conservation National Wildlife Federation
Mr. Paul Schwartz National Policy Coordinator Clean Water Action	Mr. David Hawkins Director, Climate Center Natural Resources Defense Council
Dr. Scott C. Yaich Director, Conservation Operations Ducks Unlimited, Inc.	Dr. Allen Hershkowitz Senior Scientist Natural Resources Defense Council
Mr. Trip Van Noppen President Earthjustice	Mr. David Goldstein Director, Energy Program Natural Resources Defense Council
Mr. Richard M. Loughery Director, Environmental Activities Edison Electric Institute	Mr. Kyle Rabin Director Network for New Energy Choices
Ms. Barbara Bauman Tyran Director, Washington Relations Electric Power Research Institute	Ms. Christine Chandler Responsible Environmental Action League
Mr. John Shelk President, CEO Electric Power Supply Association	Mr. Ed Hopkins Director, Environmental Quality Sierra Club
Ms. Anna Aurilio Director, Washington, D.C. Office Environment America	Mr. Jimmie Powell Director, Federal Programs The Nature Conservancy
Ms. Vickie Patton General Counsel Environmental Defense Fund	Mr. David Alberswerth Senior Energy Policy Advisor The Wilderness Society
Mr. Chuck Broscious Board President Environmental Defense Institute	Mr. Bill Eden International Representative United Association

Table 9.6. National Nongovernmental Organizations

Mr. Erich Pica President Friends of the Earth	Mr. Barry K. Worthington Executive Director U.S. Energy Association
Mr. Eddie Johnston Vice President, Research and Deployment Gas Technology Institute	

Table 9.7. State Elected Officials

The Honorable Rick Perry Governor of Texas	The Honorable Tom Russell Craddick House District 82 The Texas State House of Representatives
The Honorable Chris Gregoire Governor of Washington	The Honorable Tryon D. Lewis House District 81 The Texas State House of Representatives
The Honorable Kel Seliger Senate District 31 Texas State Senate	

Table 9.8. State Agencies

Mr. Barry T. Smitherman Chairman Public Utility Commission of Texas	The Honorable Jerry Patterson Commissioner of the Texas General Land Office Texas General Land Office
The Honorable David Porter Commissioner RRC	Mr. Terry Zrubek Governor's Advisor, Water Texas Governor's Office
Mr. Jeff Bertl Director, Region 7-Midland TCEQ	Ms. Denise Stines Francis State Single Point of Contact Office of Budget, Planning, and Policy and State Grants Team Texas Governor's Office
Dr. Bryan W. Shaw Chairman TCEQ	Mr. Toby Baker Governor's Advisor, Natural Resources and Agriculture Texas Governor's Office
The Honorable Todd Staples Agriculture Commissioner Texas Department of Agriculture	Mr. Mark Wolfe Executive Director/SHPO Texas Historical Commission
The Honorable Dr. David L. Lakey Commissioner of State Health Services Texas Department of State Health Services	Mr. Larry Fuentes Park Ranger, Monahans Sandhills State Park TPWD
Ms. Deirdre Delisi Chair TxDOT	Mr. Carter P. Smith Executive Director TPWD

Table 9.8. State Agencies

Mr. Gary J. Law, P.E. Director of Transportation, Planning and Development TxDOT, Odessa District	Ms. Julie Wicker Habitat Assessment Program, Wildlife Division TPWD
Mr. Mike C. McAnally District Engineer TxDOT, Odessa District	Mr. John Grant Chairman, Colorado River Municipal Water District TPWD

Table 9.9. Regional and Local Officials

The Honorable Wes Perry Mayor of Midland	The Honorable Dale Childers Commissioner of Ector County
Mr. Courtney Sharp City Manager City of Midland	The Honorable Freddie Gardner Commissioner of Ector County
The Honorable David B. Cutbirth Mayor of Monahans	The Honorable Susan M. Redford Judge of Ector County
Mr. David Mills City Manager City of Monahans	The Honorable Mike Bradford Judge of Midland County
Mr. Rex Thee Assistant City Manager City of Monahans	Mr. Drew Crutcher Interim Director, Economic Development Odessa Chamber of Commerce
The Honorable Larry Melton Mayor of Odessa	The Honorable Bill Eyler Judge of Upton County
Mr. Richard Morton City Manager City of Odessa	The Honorable Ted Westmoreland Mayor of Kermit
The Honorable John Farmer Judge of Crane County	The Honorable Greg M. Holly Judge of Ward County

Table 9.10. Native American Tribal Organizations

Mr. Jerry R. Pardilla Executive Director National Tribal Environmental Council	Mr. Albert (Brandt) Petrasek DOE Point of Contact State and Tribal Government Working Group Executive Committee

Table 9.11. Regional Nongovernmental Organizations and Governmental Associations

Mr. Bob Benson Executive Director Audubon Texas	Dr. Terry Burns Sierra Club, Lone Star Chapter
Mr. David Foster State Program Coordinator Clean Water Action	Mr. Kenneth Nemeth Executive Director Southern States Energy Board
Mr. Ken Kramer Director Sierra Club, Lone Star Chapter	Dr. James Bergan Director, Science and Stewardship The Nature Conservancy of Texas

Table 9.12. Interested Parties

Mr. Tom Barker	Mr. Carl Jones
Ms. Judy Burkes	Ms. Betty M. Dean
Ms. Alice Cone	Mr. Kevin Doyle
Mr. Charlie Craig	Mr. Mike Stricklin
Mr. Brandon Young	Rhodes & Sons Land Co. Inc.
Ms. Becky Riviera Weiss	Shoe-Bar Ranch, Inc.
Mr. Schuyler Wight	Mr. Derek Sands Platts
Takashi Nakamura Global Environment Unit Consultant JAPAN NUS Co., Ltd	Prof. Paul Friesema Policy & Culture Program Northwestern University
Mr. Santiago Rodriguez GCA	Ms. Kelly F. Goodman Vice President and General Counsel Summit Power Group, Inc.

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Chapter 10. References

10 REFERENCES

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Chapter 11. List of Preparers/Conflict of Interest and Disclosure Forms

11 LIST OF PREPARERS/CONFLICT OF INTEREST AND DISCLOSURE FORMS

11.1 List of Preparers

11.1.1 U.S. Department of Energy, National Energy Technology Laboratory

Mark L. McKoy, DOE Environmental Manager

Jason Lewis, DOE Project Manager

Steve Mascaro, DOE Project Engineer

11.1.2 Lucinda Low Swartz, Esq.

Lucinda Low Swartz, Esq., Environmental Consultant
J.D., Washington College of Law
B.A., Political Science and Administrative Studies (joint major)
30 years of experience in environmental law and regulation, focusing on all aspects of NEPA compliance and leading teams in the preparation of EIS and environmental assessments for federal agencies and in the preparation of NEPA-related environmental reports for private industry.

11.1.3 SWCA Environmental Consultants

Cara Bellavia, Environmental Planner
M.U.E.P., Master of Urban and Environmental Planning
B.A., Anthropology
13 years of experience in environmental consulting, cultural resources management, and environmental planning for NEPA documentation.

Brian Brettschneider, GIS Specialist
Ph.D., Environmental Geography
B.S., Geography
17 years of GIS-related experience performing analysis, map making, data entry, and programming.
11 years of experience with environmental data collection, wetland delineation, agency coordination, and NEPA project management.

Kari Chalker, Managing Editor
B.A., Anthropology
M.A., Liberal Education
More than 10 years of experience as a writer and editor specializing in archaeology, environmental sciences, and NEPA documents, especially EISs tailored for a broad spectrum of readers.

Jeff Connell, Senior Planner
M.A., Public Administration
B.S., Urban and Regional Studies
30 years of experience managing and implementing numerous planning and NEPA projects that address a variety of environmental issues. Completed socioeconomic and land use studies and impacts analyses for numerous EISs. Experienced in socioeconomic modeling, including use of the IMPLAN and REMI modeling platforms.

Charles Coyle, Senior Project Manager, NEPA Principal
M.A., English
B.A., English
15 years of experience in research and development of baseline environmental studies and impacts analyses to meet the requirements of NEPA; management and coordination of EISs, EAs, and other large, complex projects; and technical writing and editing.

Kensley Greuter, TCEP Assistant Project Manager/Biologist
M.S., Biology
B.S., Wildlife and Fisheries Sciences
Eight years of experience in environmental regulatory compliance, wildlife biology, and technical writing for and management of NEPA and Endangered Species Act documents, as well as endangered species issues, wetland delineations, noise analyses, and ecological investigations on projects for federal agencies.

Janet Guinn, Planning Specialist
B.S., *magna cum laude*, Psychology and Anthropology
Eight years of experience as a NEPA planning specialist and project manager in the environmental/engineering fields. Experience includes NEPA analysis and public involvement activities, including public comment analysis.

David Harris, Visual Resource Specialist/Transportation Specialist
M.S., Environmental Science
B.A., English
13 years of experience, including visual analysis and fieldwork; visual simulations preparation and oversight; NEPA project management and quality control/quality assurance oversight; NEPA analysis, technical writing, and documentation, including recreation, transportation, noise, air quality, livestock and grazing, geology, soils, and wild horses; and environmental compliance project management, regulatory compliance, and monitoring.

Andrew Hultgren, Sustainability Project Manager
BSE, Chemical Engineering, Minor Materials Science
Four years of experience in project management and technical leadership of GHG inventories and reporting, GHG regulatory awareness and compliance, climate change risk and opportunity analysis, GHG and sustainability planning, and climate and air quality NEPA analysis.

Dustin Jones, Environmental Scientist
M.S., studies, Wildlife Ecology
B.S., Wildlife Ecology
Eight years of experience in regulatory compliance, permitting, ecological investigations for federal agencies, technical writing, GIS, and environmental management and policy.

James O. Jones, TCEP Project Manager/Subject Matter Expert
M.S., Environmental Management
B.S., Oceanographic Technology
35 years of experience in NEPA documentation, application of environmental policy, regulatory compliance, and ecological investigations on projects for federal agencies.

Greg Larson, Planning Specialist
M.S., Watershed Science
B.A., Physical Geography
Seven years experience in hydrologic and geomorphic studies, restoration planning, Clean Water Act permitting, and NEPA documentation and project management.

Staci K. MacCorkle, PMP/Natural Resource Scientist/Project Manager
B.S., Environmental Science
10 years of experience in natural resource studies and analyses, NEPA documentation, and project management.

Olivia Munzer, Wildlife Ecologist/Project Manager
M.S., Ecology and Organismal Biology
B.S., Biology
Nine years of experience in ecological surveys and studies for federal and state agencies, regulatory compliance, EAs, and NEPA documentation

Matthew Petersen, Senior Ecologist
M.S., Aquatic Ecology
B.S., Wildlife and Fisheries
18 years of experience in NEPA EISs. Acted as both a project manager and resource specialist on many NEPA projects and also has familiarity with related environmental regulatory processes such as the Endangered Species Act, the Clean Water Act, the Clean Air Act, and the National Historic Preservation Act.

Steven O'Brien, Environmental Specialist
B.A., Biology and Chemistry
14 years of experience in technical writing, soil/air/ground water monitoring, environmental site assessments, wetland and soil delineation and permitting, stream and riparian restoration, construction oversight, hazardous materials, project management, soil and hazardous materials resource sections for NEPA/environmental assessment/EIS reports, and biological evaluations for threatened and endangered species.

Abigail Peyton, Cultural Resources Specialist
M.A., Archaeology
B.A., Anthropology
Nine years of experience in conducting archaeological investigations, including survey, NRHP testing, and data recovery; artifact analysis; technical reporting; and compliance with state and federal cultural resource regulations.

John Pecorelli, Technical Editor
B.S., Physical Anthropology
B.S., Journalism and Mass Communication
15 years of experience at all levels in popular and publishing—from the *Los Angeles Times* to the Annenberg Foundation. Experience includes seven years of technical writing, editing, and illustrating for such clients as Microsoft Corporation, Fujitsu, and Intel. Recognition includes first place awards from the Society of Professional Journalists and the Society for Technical Communication.

Ryan Rausch, Environmental Planner
M.S., Environmental Law and Policy
B.S., Biology
Six years of experience in land use, recreation, and utility systems analysis for NEPA documentation, application of environmental policy, regulatory compliance, conservation, and ecological investigations on projects for federal agencies.

Linda Tucker Burfitt, Technical Editor and Publications Specialist
B.A., Communications
A.S., Ecosystem Management and A.F. Forestry
Seven years of experience in technical editing, formatting, and technical writing; three years of experience editing, formatting, and publishing NEPA documents (e.g., EISs, EAs, and resource management plans); and seven years of experience in forest management, specifically forest health (entomology and pathology).

Christina White, Environmental Planner
M.P.P., Economics
B.S., Sociology and Public Relations
Six years of experience in socioeconomic resources, training in input/output econometric modeling systems, and project coordination/management.

Kemble White IV, Regional Scientist
Ph.D., Geology
M.S., Engineering Geology
B.A., Geology and Journalism
10 years of experience as a licensed professional geoscientist (Texas), TCEQ Edwards Aquifer rules compliance investigations, and cave and karst resource compliance investigations under the Endangered Species Act.

Susan Wilmot, Environmental Specialist
Ph.D., Human Dimensions of Ecosystem Science and Management
M.E.M, Environmental Management
B.S., Biology
Nine years of experience in environmental analysis and technical writing for NEPA documentation and research for federal agencies.

11.2 Conflict of Interest and Disclosure Forms

DOE contractors who prepared this draft EIS were required to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. Signed disclosure statements from Lucinda Low Swartz, Esq. and SWCA are shown in Figures 11.1 and 11.2, respectively.

DISCLOSURE STATEMENT
LUCINDA LOW SWARTZ, ESQ.
ENVIRONMENTAL IMPACT STATEMENT
TEXAS CLEAN ENERGY PROJECT – IGCC WITH CARBON CAPTURE & SEQUESTRATION

Regulatory Requirement

Council on Environmental Quality (CEQ) Regulations at 40 CFR 1506.5(c), which have been adopted by the Department of Energy (DOE) at 10 CFR 1021, require contractors who will prepare an Environmental Impact Statement (EIS) to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for the purposes of this disclosure is discussed in the March 23, 1981 guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 FR 18026-18038 at question 17a and b.

"Financial interest or other interest in the outcome of the project" includes "any financial benefits such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g. if the project would aid proposals sponsored by the firm's other clients)." 46 FR 18026-18031.

Disclosure Statement

In accordance with the requirements set forth above, Lucinda Low Swartz, Esq. (Swartz) hereby makes this disclosure statement and certifies that Swartz has no past, present or currently planned financial or other interest in the outcome of the Texas Clean Energy Project, an IGCC with carbon capture and sequestration facility. Swartz agrees that should she become aware of any facts giving rise to a potential future conflict of interest, she will promptly notify the DOE NEPA Director and take any steps necessary to mitigate the conflict.

For the purposes of complete disclosure, Swartz makes the following representations:

1. Swartz has no interest in the Project other than NEPA related work. The Project proponent, Summit Texas Clean Energy, LLC (STCE) has advised that STCE may conduct a competition for a subcontractor to develop NEPA related environmental monitoring plans and perform post-ROD monitoring, if applicable. Swartz may have an interest in submitting a proposal against the subcontract competition.

2. Swartz is not currently performing any environmental work for STCE or its affiliates.

3. Swartz is not currently engaged to perform any future work for STCE or its affiliates or promised any such engagement by STCE or its affiliates. Given that STCE's affiliates develop energy projects, it is possible that Swartz may be engaged to

LLS

perform similar work, such as due diligence studies, site feasibility assessments and permitting work, but no such arrangements exist at this time.

Certified by:

Lucinda Low Swartz 7/1/2010
SIGNATURE DATE

Lucinda Low Swartz, Environmental Consultant
NAME & TITLE (PRINTED)

COMPANY

Figure 11.1. Disclosure statement from Lucinda Low Swartz, Esq.

DISCLOSURE STATEMENT
SWCA INCORPORATED
ENVIRONMENTAL IMPACT STATEMENT
TEXAS CLEAN ENERGY PROJECT – IGCC WITH CARBON CAPTURE & SEQUESTRATION

Regulatory Requirement

Council on Environmental Quality (CEQ) Regulations at 40 CFR 1506.5(c), which have been adopted by the Department of Energy (DOE) at 10 CFR 1021, require contractors who will prepare an Environmental Impact Statement (EIS) to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for the purposes of this disclosure is discussed in the March 23, 1981 guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 FR 18026-18038 at question 17a and b.

"Financial interest or other interest in the outcome of the project" includes "any financial benefits such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g. if the project would aid proposals sponsored by the firm's other clients)." 46 FR 18026-18031.

Disclosure Statement

In accordance with the requirements set forth above, SWCA Incorporated (SWCA) hereby makes this disclosure statement and certifies that SWCA has no past, present or currently planned financial or other interest in the outcome of the Texas Clean Energy Project, an IGCC with carbon capture and sequestration facility. SWCA agrees that should it become aware of any facts giving rise to a potential future conflict of interest, it will promptly notify the DOE NEPA Director and take any steps necessary to mitigate the conflict.

For the purposes of complete disclosure, SWCA makes the following representations:

1. SWCA has no interest in the Project other than NEPA related work. The Project proponent, Summit Texas Clean Energy, LLC (STCE) has advised that STCE may conduct a competition for a subcontractor to develop NEPA related environmental monitoring plans and perform post-ROD monitoring, if applicable. SWCA may have an interest in submitting a proposal against the subcontract competition.

2. SWCA is not currently performing any environmental work for STCE or its affiliates.

3. Given that STCE's affiliates develop energy projects, it is possible that SWCA may be engaged to perform environmental work for a project in which STCE's affiliates are also involved, but SWCA has not been promised any such engagement by STCE, its affiliates, or third parties by virtue of its work for the Project.

4. SWCA is not currently engaged to perform any future work for STCE or its affiliates or promised any such engagement by STCE or its affiliates. It is possible that SWCA may be engaged to perform similar work, such as due diligence studies, site feasibility assessments and permitting work, but no such arrangements exist at this time.

Certified by:

James O. Jones 5/4/2010

SIGNATURE DATE

James O. Jones; Natural Resources Program Director

NAME & TITLE (PRINTED)

SWCA Environmental Consultants

COMPANY

Figure 11.2. Disclosure statement from SWCA Environmental Consultants.

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Chapter 12. Index

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Chapter 13. Glossary

13 GLOSSARY

100-year floodplain	Land that becomes or will become submerged by a flood that has a chance to occur every 100 years.
A-weighted sound level, dBA	Assigns a weight to sound frequencies relative to how sensitive the human ear is to each sound frequency. Frequencies that are less sensitive to the human ear are weighted less than those for which the ear is more sensitive. A-weighted measurements indicate the potential damage a noise might cause to hearing.
Adsorbed	Taken up or transformed into a different form.
Aesthetic	The perception of appearance of features in relation to one's sense of beauty.
Air quality	The cleanliness of the air as measured by the levels of pollutants relative to standards or guideline levels established to protect human health and welfare. Air quality is often expressed in terms of the pollutant for which concentrations are the highest percentage of a standard (e.g., air quality may be unacceptable if the level of one pollutant is 150 percent of its standard, even if levels of other pollutants are well below their respective standards).
Alluvial	Relating to clay, silt, sand, gravel, or similar detrital material deposited by running water.
Ambient noise level	Background noise associated with a given environment. Ambient noise is typically formed as a composite of sounds from many near and far sources, with no particular dominant sound.
Aquatic	Characteristics of or pertaining to water.
Aquifer	Body of rock or sediment that is capable of transmitting ground water and yielding usable quantities of water to wells or springs.
Archaeological resources	Material remains of past activity.
Area of potential effect	The geographic region that may be affected as a result of the construction and operation of the proposed project or alternatives.
Arterial (highway)	A highway generally characterized by its ability to quickly move a relatively large volume of traffic, but often with restricted capacities to serve abutting properties. The arterial system typically provides for high travel. The rural and urban arterial highway systems are connected to provide continuous through movements.
Artesian	Ground water conditions in which water in wells rises above the water level in the aquifer, including conditions in which ground water rises to or above the ground surface.
Attainment	Those areas of the U.S. that meet NAAQS as determined by measurements of air pollutant levels.
Attenuate	To lessen the amount of force, magnitude, or value of something.
Base-load electric power	The amount of power required to meet minimum demands based on reasonable expectations of customer requirements.
Bedrock	The rock of the Earth's crust that is below the soil and largely unweathered.
Biocide	A substance (e.g., chlorine) that is toxic or lethal to many organisms and is used to treat water.
Black water	A liquid mixture from the gasification process that consists of granulated slag, quench water, and unreacted char.
Blowdown	Portion of circulating cooling tower water (or steam or water removed from a boiler) removed to maintain the amount of dissolved solids and other impurities at an acceptable level.

Boiler	A pressurized system in which water is vaporized to steam, the desired end product, by heat transferred from a source of higher temperature, usually the products of combustion from burning fuels.
Brackish	Water that is saltier than fresh water, but less than sea water. Salt content of brackish water is between 0.5 and 30 parts per thousand.
Brine	Water saturated with salt.
CO_2	A colorless, odorless, nonpoisonous, GHG created by combustion and emitted primarily from human activities, such as the burning of fossil fuels to generate electricity and operate motor vehicles.
CO	A colorless, odorless, poisonous gas produced by incomplete fossil fuel combustion.
Carcinogenic	Capable of producing or inducing cancer.
Catalyst	A substance that enables a chemical reaction to proceed at a usually faster rate or under different conditions (as at a lower temperature) than otherwise possible.
Class I area	Under the Clean Air Act, a Class I area is one in which visibility is protected more stringently than under the NAAQS, with only a small increase in pollution allowed. Class I areas include national parks, wilderness areas, monuments, and other areas of special national and cultural significance. Only very slight deterioration of air quality is allowed in Class I areas.
Class I railroad	Railroad with operating revenues exceeding $277.5 million.
Class II area	Most of the country not designated as Class I is designated as Class II. Class II areas are generally cleaner than air quality standards, and moderate increases in new pollution are allowed after a regulatory mandated impacts review.
Class II railroads	Railroad with operating revenues greater than $20.5 million but less than $277.5 million for at least three consecutive years.
Class III railroads	Railroad with less than $10 million in operating revenue; typically short in length.
Clean Water Act	Primary federal law governing water pollution. The Clean Water Act's goals include eliminating toxic substance releases to water, eliminating additional water pollution, and ensuring that surface waters meet standards necessary for human sports and recreation (see National Pollutant Discharge Elimination System).
Coagulation	Becoming viscous or thickened into a coherent mass.
Coal combustion products	Incombustible by-products generated in coal-burning industrial facilities. The by-products are generated in various steps of the process. Coal combustion products generated in the boilers or furnaces are ash and slag. Other by-products such as fly ash and synthetic gypsum are collected in the emission control systems.
Coal gasification	A process that converts coal into a gaseous product, which involves crushing coal into a powder and heating the powder in the presence of steam and O_2 in a reducing or substoichimetric atmosphere. After impurities (e.g., sulfur) are removed, the gas can be used as a fuel or further processed and concentrated into a chemical or liquid fuel.
Collector road	Low- or moderate-capacity road that does not provide a highway or arterial road LOS. A collector route often leads traffic to arterial roads or directly to highways. Occasionally a collector road will fill gaps in a grid system between arterial roads. Traffic volumes and speeds are typically lower than those of arterial highways.
Combined-cycle electric power plant	A power plant that uses both a steam turbine-generator and a combustion turbine-generator at one location to produce electricity.

Combustion turbine	A gas turbine that burns natural gas, fuel oil, or other similar fuels, drives a turbine and generator to produce electricity, and is typically used as the primary generator of electricity in a combined-cycle installation.
Condensate	A liquid obtained by the conversion of a gas or vapor to another state.
Conveyor system	Method used to transport material in a continuous fashion, consisting of a drive, belt, pulleys, and conveyor stands. Material is placed on the belt and is moved by rotating the belt over pulleys.
Cooling tower	A structure that cools heated condenser water by circulating the water along a series of louvers and baffles through which cool, outside air convects naturally or is forced by large fans.
Cooling water	Water that is heated as a result of being used to cool steam and condense it to water.
Corona noise	Noise caused by partial discharges on insulators and in air surrounding electrical conductors of overhead power lines. Corona noise level is dependent on weather conditions.
Cultural resources	Archaeological sites, historical sites (e.g., standing structures), Native American resources, and paleontological resources.
Cumulative effects	The impact to the environment that results from the incremental effect of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time.
Day-night noise level, Ldn	The average A-weighted noise level during a 24-hour day, obtained after addition of 10 decibels to levels measured in the night between 10:00 p.m. and 7:00 a.m.
Decibel, dB	Unit used to convey intensity of sound.
Density	Ratio of a substance’s weight relative to its volume.
Diversion (water)	The amount of water taken from a stream, spring, or well by channel, embankment, or other man-made structure constructed for the purpose of diverting water from one area to another.
Drawdown	The process by which the water table adjacent to a well is lowered after active pumping from an aquifer.
Ecosystem	A community and its environment treated together as a functional system of complementary relationships involving the transfer and circulation of energy and matter.
Effluent	Waste stream flowing into the atmosphere, surface water, ground water, or soil.
Emergent	Erect, rooted herbaceous plants, such as cattails and bulrush, which dominate wetlands.
Emission	A material discharged into the atmosphere from a source operation or activity.
Endangered species	Plants or animals that are in danger of extinction. A federal list of endangered species can be found in 50 C.F.R. § 17.11 (wildlife), 50 C.F.R. § 17.12 (plants), and 50 C.F.R. § 222.23(a) (marine organisms). Texas maintains its list of endangered species with the TPWD.
Environmental justice	The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic groups, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies. Executive Order 12898 directs federal agencies to make achieving environmental justice part of their missions by identifying and addressing disproportionately high and adverse effects of agency programs, policies, and activities on minority and low-income populations.
Equivalent sound level, Leq	Weighting imposed on the equivalent sound levels occurring during nighttime.

Erosion	The process by which particles of soils or other material are removed and transported by water, wind, and/or gravity to some other area.
Evaporation	A physical process by which a liquid is transformed into a gaseous state.
Flocculation	A process by which microscopic substances suspended in a liquid come out of suspension in the form of floc or flakes.
Floodplain	Flat or nearly flat land adjacent to a stream or river that experiences occasional or periodic flooding.
Flue gas	Residual gases after combustion that are vented to the atmosphere through a flue or chimney.
Formation	The primary unit associated with formal geological mapping of an area. Formations possess distinctive geological features and can be combined into “groups” or subdivided into “members.”
Fossil fuel	Coal, oil, or natural gas, formed from vegetation and animals under high pressure and temperatures during a past geological age.
Frequency	The number of cycles of completed occurrences per unit of time of a sound wave, most often measured in Hertz.
Fresh water	Water with a low concentration of salts (typically less than 1,000 ppm of dissolved solids).
Fugitive dust	PM composed of soil; can include emissions from haul roads, wind erosion of exposed surfaces, and other activities in which soil is removed and redistributed.
Gasification	Conversion process to gas or a gas-like phase.
Geologic CO_2 sequestration	CO_2 capture and storage in deep underground geologic formations.
Global warming	The theory that certain gases such as CO_2, methane, and chlorofluorocarbon in the Earth’s atmosphere effectively restrict radiation cooling, thus elevating the Earth’s ambient temperatures or creating a greenhouse effect.
Gray water	Waste water that does not contain serious contaminants.
GHG	Gas that contributes to the greenhouse effect by absorbing infrared radiation and ultimately warming the atmosphere. GHGs include water vapor, nitrous oxide, methane, CO_2, O_3, halogenated fluorocarbons, hydrofluorocarbons, and perfluorinated carbons.
Ground water	Water within a geologic stratum that supplies wells and springs.
Habitat	The environment occupied by individuals of a particular species, population, or community.
HAP	Air pollutants that are not covered by ambient air quality standards but that present, or may present, a threat of adverse health or environmental effects. These include an initial list of 189 chemicals designated by the U.S. Congress that is subject to revision by EPA.
Hazardous waste	A by-product of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity) or appears on special EPA lists.
Heavy metals	Natural trace elements such as lead, Hg, cadmium, and nickel, that are leachable and potentially toxic.
Historic property	Prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the NRHP.
Historical site	A site that is more than 50 years old.
Hydrology	A science dealing with the properties, distribution, and circulation of water on the surface of the land, in the soil and the underlying rocks, and in the atmosphere.
Impoundment	A body of water confined by a dam, dike, floodgate, or other barrier.

Indirect employment/labor	Employment or job created or sustained from a project's purchase of goods and services from businesses in a region.
Induced employment/labor	Employment or job created or sustained when wage incomes of those employed in direct and indirect jobs are spent on the purchase of goods and services in a region.
Industrial and/or process waste	Any liquid, solid, semisolid, or gaseous waste generated when manufacturing a product or performing a service. Examples include cutting oils; paint sludges; equipment cleanings; metallic dust sweepings; used solvents from parts cleaners; and off-specification, contaminated, or recalled wholesale or retail products. The following wastes are not industrial process wastes: uncontaminated packaging materials, uncontaminated machinery components, general household waste, landscape waste, and construction or demolition debris.
Infiltration	The process of water entering the soil at the ground surface and the ensuing movement downward. Infiltration becomes percolation when water has moved below the depth at which it can return to the atmosphere by evaporation or evapotranspiration.
Infrastructure	The underlying foundation of a basic framework, as in a system or organization.
IGCC	A process that uses synthesis gas derived from coal to drive a gas combustion turbine, and exhaust gas from the gas turbine to generate steam from water to drive a steam turbine.
Integration	Organization or structure allowing constituent units to function cooperatively.
Intrusive (noise)	That noise which intrudes over and above the existing ambient noise at a given location. The relative intrusiveness of a sound depends upon its amplitude, duration, frequency, time of occurrence, and tonal or informational content, as well as the prevailing ambient noise level.
Irretrievable commitments	Resources that are lost for a period of time.
Landfill	Waste disposal method where waste material is stockpiled in a designated area until that area is full, at which time the material is buried and reclaimed in accordance with the applicable regulations for that type of landfill.
Laydown area	Material and equipment storage area during the construction phase of a project.
LOS	Measure of traffic operation effectiveness on a particular roadway facility type.
Lithic scatter	Concentration of waste flakes resulting from the manufacture of stone tools.
Loam	A soil composed of a mixture of clay, silt, sand, and organic matter.
Local roads	Public roads and streets not classified as arterials or collectors are classified as local roads. Local roads and streets are characterized by the many points of direct access to adjacent properties and the relatively minor value in accommodating mobility. Speeds and volumes are usually low and trip distances short.
Low income population	A community that has a proportion of low-income population greater than the respective average. Low income populations in an affected area should be identified with the annual statistical poverty thresholds from Bureau of the Census Current Population Reports, Series P-60, Income and Poverty.
Makeup water	Water feed needed to replace that which is lost by evaporation or leakage in a closed-circuit, recycle operation.
Mean sea level	Average ocean surface height at a particular location for all stages of the tide over a specified time interval (generally 19 years).
MW	Unit of power equal to 1 million watts. A power plant with 1 MW of capacity operating continuously for one year could supply electricity to approximately 750 households.
Minority	Individual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic.

Minority population	Identified where either more than 50 percent of the population of the affected area is minority, or the affected area's minority population percentage is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.
Miscible	Property of liquids that allows them to be mixed together and form a single homogeneous phase.
Mitigation	Efforts to lessen the severity or to reduce adverse impacts, including: avoiding the impact altogether by not taking a certain action or parts of an action; minimizing impacts by limiting the degree or magnitude of the action; repairing, rehabilitating, or restoring the affected environment; reducing or eliminating the impact over time by preservation; and compensating for the impact by replacing or providing substitute resources or environments.
Monitoring	Periodic or continuous determination of the amount of substances present in the environment.
Monitoring, mitigation, and verification	Capability to measure the amount of CO_2 stored at a sequestration site, monitor the site for leaks, to verify that the CO_2 is stored in a way that is permanent and not harmful to the host ecosystem, and to respond to CO_2 leakage or ecological damage in the unlikely event that it should occur. Monitoring, mitigation, and verification applies to geologic sequestration and terrestrial sequestration.
NAAQS	Uniform, national air quality standards established by EPA that restrict ambient levels of certain pollutants to protect public health (primary standards) or public welfare (secondary standards). Standards have been set for O_3, CO, particulates, SO_2, NO_2, and lead.
NEPA	Signed into law on January 1, 1970, NEPA declared a national policy to protect the environment and created the Council on Environmental Quality in the Executive Office of the President. To implement the national policy, NEPA requires that environmental factors be considered when federal agencies make decisions, and that a detailed statement of environmental impacts be prepared for all major federal actions significantly affecting the human environment.
National Pollutant Discharge Elimination System	Provision of the Clean Water Act that prohibits discharge of pollutants into U.S. waters unless a special permit is issued by EPA, a state, or where delegated, a tribal government on a Native American reservation.
Native species	Species normally indigenous to an area; not introduced by humans.
New source performance standards	Regulation under Section 111 of the Clean Air Act enforcing stringent emission standards for power plants constructed on or after January 30, 2004.
NO_x	A product of combustion by mobile and stationary sources and a major contributor to the formation of O_3 in the troposphere.
Noise	Any sound that is undesirable because it interferes with speech and hearing; if intense enough, it can damage hearing.
Nonattainment	An area that does not meet air quality standards set by the Clean Air Act for specified localities and time periods; locations where pollutant concentrations are greater than the NAAQS.
NOI	Notice that an EIS will be prepared and considered. It is published in the *Federal Register* as soon as practicable after an agency knows that an EIS is required for a proposed action.
O_3	A form of O_2 found naturally in the stratosphere and that provides a protective layer for shielding the Earth from ultraviolet radiation. O_3 occurring in the lower atmosphere is harmful and is classified as a criteria pollutant.
Palustrine	Living or thriving in a marshy environment.
PM	Fine liquid or solid particles such as dust, smoke, mist, fumes, or smog, found in air or emissions.
Particulates	Small particles of solid or liquid materials that, when suspended in the atmosphere, constitute an atmospheric pollutant.
Peak demand	The maximum rate of electricity use.

Peak particle velocity	Measure of ground vibration. Peak particle velocity is the maximum speed (measured in inches per second or millimeters per second) at which a point on the ground moves relative to its static state.
Peaking capacity	Capacity that is available for use and used to meet peak load, but usually designed to operate for relatively short periods of time.
Permeability	Rate at which fluids flow through the subsurface; reflects the degree to which pore space is connected.
pH	A measure of the acidity or alkalinity of a solution.
Plume	A flowing, often somewhat conical, trail of emissions from a continuous point source.
Point source	A stationary location or fixed facility from which pollutants are discharged or emitted. Also, any single identifiable source of pollution, for example, a pipe, ditch, or stack.
Potable water	Water that is safe and satisfactory for drinking and cooking.
PSD	An EPA program in which federal or state permits are required that are intended to restrict emissions for new or modified sources in places where air quality is already better than required to meet primary and secondary ambient air quality standards.
Prime farmland	Land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oilseed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor, and without intolerable soil erosion.
Proposed action	The activity proposed to accomplish a federal agency's purpose and need. An environmental impacts analysis analyzes the environmental impacts of the proposed action. A proposed action includes the project and its related support activities (pre-construction, construction, and operation, along with post-operational requirements).
Pulverized coal	Crushed coal used to fuel a coal power plant. Currently the principal electric generation technology in the U.S.
Qualitative	Analysis based on professional judgment of quality, generally lacking hard data.
Quantitative	Analysis based on hard data or numbers that can generally be repeated.
Recharge	The movement of water from an unsaturated zone to a saturated zone.
Reclamation	Restoration of land, water bodies, or other affected environmental resources to the original use, or equal to or better alternate use.
Record of Decision	The concluding document of the NEPA process, which states the agency's decision, along with its rationale for its selection, including the major environmental reasons.
Recycle	The process of reusing or reprocessing a material after its initial use.
ROI	The physical area that bounds the environmental, sociologic, economic, or cultural features of interest for the purpose of analysis.
Richter scale	A measure of earthquake magnitude developed by Charles Richter.
Riparian	Pertaining to, situated, or dwelling on the bank of a river or other body of water.
Runoff	The portion of precipitation falling on the land that flows over the surface, rather than soaking into the surface.
Saline	Describes water with high concentrations of salts (typically more than 10,000 ppm dissolved solids), making it unsuitable for use.
Scoping meeting	An early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action.
Scrubber	A device that removes noxious gases from flue gases (such as SO_2) by using absorbents suspended in liquid solution.

Scrub-shrub	Woody vegetation less than 20 ft (6 m) tall. Species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions.
Sediment	Material that has been eroded, transported, and deposited by erosional processes, typically wind, water, and/or glaciers.
Sediment control	The planning and construction of facilities for prevention of excessive damage by water in flood stages.
Sedimentation	The process or action of depositing sediment.
Seismic	Pertaining to, characteristic of, or produced by earthquakes or Earth vibrations.
Selective catalytic reduction	A system to reduce NO_x emissions by injecting a reagent, such as NH_3, into exhaust gas to convert NO_x emissions to N_2 and water via a chemical reduction reaction.
Sensitive receptor	As used in this analysis, any specific resource (i.e., population or facility) that would be more susceptible to the effects of the impact of implementing the proposed action than would otherwise be.
Sequestration	As used in this analysis, the process of injecting CO_2, which has been compressed into a liquid state, into the deep geologic subsurface, potentially isolating CO_2 from the atmosphere for centuries.
Slag	The refuse from melting of metals or reduction of ores.
Sludge	A semisolid residue containing a mixture of solid waste material and water from air or water treatment processes.
Sound pressure level	Measure of a sound's strength or intensity, expressed in dBA. The sound pressure level generated by a steady source of sound will usually vary with distance and direction from the source.
Sour water	Water with dissolved sulfur compounds and other contaminants condensed from synthesis gas.
Spill prevention control and countermeasure plan	A plan that is implemented to protect resources from harmful quantities of petroleum discharges.
Stream	A continually, frequently, or infrequently flowing body of water that follows a defined course. The three classes of streams are: ephemeral—a channel that carries water only during and immediately following rainstorms; intermittent—a watercourse that flows in a well-defined channel during the wet seasons of the year, but not the entire year; and perennial—a watercourse that flows throughout the year or nearly 90 percent of the time in a well-defined channel.
Sub-bituminous	A type of coal used primarily as fuel for electrical power generation, whose properties range between those of lignite and those of bituminous coal. At the lower end of the range it may be dull, dark brown to black, soft, and crumbly. At the higher end of the range it may be bright, jet black, hard, and relatively strong. Sub-bituminous coal contains 20–30 percent moisture by weight. Heating value varies from 7,000 Btu per pound to slightly over 9,000 Btu per pound.
Subsidence	A sinking of a part of the surface topography.
Substation	An assemblage of equipment for the purposes of switching and/or changing or regulating the voltage of electricity.
SO_2	A heavy, pungent, colorless, gaseous air pollutant formed primarily by the combustion of fossil fuels.
Superheat	To heat a vapor not in contact with its liquid to the point at which a lowering of temperature or increase in pressure will not change it to a liquid.
Surface water	All bodies of water on the surface and open to the atmosphere, such as rivers, lakes, reservoirs, ponds, seas, and estuaries.

Syngas	Gas mixture containing varying amounts of CO and hydrogen generated by the gasification of a carbon-containing fuel.
Tail gas	Gas from a processing unit treated as a residue.
Threatened species	Plants or animals likely to become endangered species within the foreseeable future. A federal list of threatened species can be found in 50 C.F.R. § 17.11 (wildlife), 50 C.F.R. § 17.12 (plants), and 50 C.F.R. § 227.4 (marine organisms). Texas maintains a list of threatened species with the TPWD.
Topography	The configuration of a surface including its relief and position of the natural and man-made features.
Topsoil	The upper native soil layer, usually consisting of the A and E horizons.
Transmission corridor	Area used to provide separation between the transmission lines and the general public and to provide access to the transmission lines for construction and maintenance.
Turbidity	Capacity of material suspended in water to scatter light. Highly turbid water is often called muddy, although all manner of suspended particles contribute to turbidity.
Turbine	A machine for directly converting the kinetic energy and/or thermal energy of a flowing fluid (air, hot gas, steam, or water) into useful rotational energy.
Upset or upset condition	An unplanned or unpredictable failure of process components or subsystems that leads to an overall malfunction or temporary shutdown of a power plant or subsystem while an issue with a component is corrected.
Vadose zone	Area of soil between the ground surface and the area directly above the ground water surface (i.e., the water table) of unconfined aquifers.
Vibration	Force that oscillates about a specified reference point. Vibration is commonly expressed in terms of frequency, such as cycles per second, Hertz, cycles per minute, and strokes per minute.
Viewshed	A nonmanaged area with aesthetic value.
Viscosity	Measure of a material's resistance to flow.
Volatile organic compounds	Any organic compound that participates in atmospheric photochemical reactions, except for those designated by EPA as having negligible reactivity.
Waste water	A combination of liquid and water-carried wastes from residences, commercial buildings, and/or industrial facilities.
Water table	The upper limit of the saturated zone (the portion of the ground wholly saturated with water; the upper surface of a zone of saturation above which the majority of pore spaces and fractures are less than 100 percent saturated with water most of the time (unsaturated zone) and below which the opposite is true (saturated zone).
Watershed	A region or area bounded peripherally by a water-parting feature and draining ultimately to a particular watercourse or body of water.
Wetland	Area inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.
ZLD system	A process that separates solids and dissolved constituents from the plant waste water and allows the treated water to be recycled or reused in the industrial process, resulting in no discharge of waste water to the environment.

Appendix A. Consultation Letters

APPENDIX A

Agency and Tribal Consultation

Agency Consultation

SWCA
ENVIRONMENTAL CONSULTANTS
Sound Science. Creative Solutions.

Austin Office
4407 Monterey Oaks Boulevard,
Bldg.1, Suite 110
Austin, TX 78749
Tel 512.476.0891 Fax 512.476.0893
www.swca.com

RECEIVED
SEP 10 2010
History Programs Division

September 3, 2010

Mr. Bill Martin
Texas Historical Commission
1511 Colorado
Austin, Texas 78701

RE: A CULTURAL RESOURCES SURVEY OF PORTIONS OF THE TEXAS CLEAN ENGERGY PROJECT, CRANE, ECTOR, AND MIDLAND COUNTIES

Mr. Martin:

The U.S. Department of Energy (DOE) is preparing an Environmental Impact Statement (EIS) for the proposed Texas Clean Energy Project (TCEP) located in Crane, Ector, and Midland Counties. SWCA, on behalf of the DOE, conducted an archaeological survey, historic structure viewshed analysis, and a limited reconnaissance survey within portions of the TCEP project area. As none of the project is located on public lands, an Antiquities Permit was not required for the survey efforts. However, the DOE would like documented consultation with your office regarding the results presented in the enclosed draft report as, well as any recommendations for further work. The draft cultural report will be included in the appendices of the draft EIS statement. Any recommendations for further work, and subsequent results of additional survey efforts will be incorporated into the final EIS statement. Your prompt attention and comments are appreciated.

Please feel free to contact me by telephone or through email at apeyton@swca.com.

Sincerely,

Abigail Peyton

Abigail Peyton, MA, RPA
SWCA Project Archaeologist
512-476-0891

NO HISTORIC
PROPERTIES AFFECTED
PROJECT MAY PROCEED
by [signature]
for Mark Wolfe
State Historic Preservation Officer
Date 14 October 2010

21450-2010-I-0354

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Albany, OR • Morgantown, WV • Pittsburgh, PA

U.S. DEPARTMENT OF ENERGY

FW-ES	
FS	
AFS	
ALL	Pat
Recvd	ex 22 Sept 2010
Recommend	No Action
OAS	
FILE	23
NO.	Sept
DUE	2010

NO ACTION
Date: 9/27/10
Consultation #: 21450-2010-I-0354
Approved by [signature]
for Adam Zerrenner, Field Supervisor
U.S. FISH & WILDLIFE SERVICE, AUSTIN, TEXAS

September 16, 2010

Mr. Adam Zerrenner, Field Supervisor
Austin Ecological Services Field Office
U.S. Fish and Wildlife Service
10711 Burnet Road, Suite 200
Austin, Texas 78758-4460

Re: Request for Informal Consultation via Section 7 and supporting an Environmental Impact Statement for the Texas Clean Energy Project, Ector County, Texas

Dear Mr. Zerrenner:

The U.S. Department of Energy (DOE) is preparing an Environmental Impact Statement (EIS) for the proposed Texas Clean Energy Project (project) in Ector, Midland, and Crane counties, Texas. The project was selected as eligible to receive $350 million in funding through a competitive process under the Clean Coal Power Initiative program. Because this federal funding is a major federal action as defined by NEPA, approval of funding is subject to NEPA analysis and disclosure through the EIS process. The Notice of Intent to prepare the EIS was published in the Federal Register (Vol. 75, No. 105/Wednesday June 2, 2010) and is enclosed for your review.

Summit Texas Clean Energy, LLC proposes to construct and operate a coal-fueled electric power and chemicals production plant integrated with carbon dioxide (CO_2) capture and geologic sequestration located approximately 15 miles southwest of the City of Odessa in Penwell, Ector County, Texas. The linear facilities for the project include potential process water lines, transmission lines, natural gas pipelines, access roads, and a CO_2 pipeline that spans Ector, Midland, and Crane counties.

At this time we are requesting informal concurrence with the enclosed Federally-Listed Species Habitat Evaluation, including its determinations of *not likely to adversely affect* the following species and/or their critical habitat: bald eagle, black-capped vireo, and sand dune lizard. If your agency concurs with our evaluation, please complete the signature block provided below and return this letter to our office via fax at (304) 285-4403 or email at Summit.EIS@NETL.DOE.GOV. DOE would appreciate your response by October 15, 2010. If you have any questions, please do not hesitate to call at (304) 285-4426.

Sincerely,

Mark L. McKoy

Mark L. McKoy
Environmental Manager
U.S. DOE

Enclosed:
Notice of Intent
Federally Listed Species Habitat Evaluation

3610 Collins Ferry Road, P.O. Box 880, Morgantown, WV 26507

31.798375 -102.295499

Note: Based on prior experience with the USFWS Austin Ecological Services Field Office, the No Action response indicates USFWS has no conflict with the submitted report, which details DOE's findings that no adverse effects to federally listed species or their habitat are likely to occur as a result of the TCEP.

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U.S. DEPARTMENT OF ENERGY

RESPONSE REQUESTED:

_____ Yes, USFWS concurs with DOE's findings and does not wish to receive further information.

_____ No, USFWS does not concur with DOE findings and requests proceeding with the section 7 consultation process.

Signature:_______________________________

Name (Please Print):_______________________

Title: __________________________________

Date:___________________________________

3610 Collins Ferry Road, P.O. Box 880, Morgantown, WV 26507

Tribal Consultation

Tribal Consultation Request Letter

A tribal consultation request letter was submitted in August 2010 by the U.S. Department of Energy (DOE) to each of the individually addressed original contacts for the tribes listed in Table B-1. An example of the submitted consultation letter, response request form, and map enclosure are provided following Table B-1. During subsequent consultation attempts with the tribes, several of the tribal contacts were determined to have changed, and current contacts are identified in Table B-1. Additional and more detailed tribal consultation records, including activity logs and communication records, are included in the project administrative record.

Table B-1. Tribal Contacts for TCEP Tribal Consultation

Original Contact	Current Contact	Alternate Current Contact
Mr. Nathan Tselee NAGPRA Coordinator Apache Tribe of Oklahoma P.O. Box 1220 Anadarko, OK 73005 Phone: 405-247-9493 Fax: 405-247-3153	Mr. Louis Maynahonah, Sr. Tribal Chairman Apache Tribe of Oklahoma P.O. Box 1220 Anadarko, OK 73005 Email: apache_business_committee@yahoo.com Phone: 405-247-9493 Fax: 405-247-3153	
Mr. Wallace Coffey Comanche Nation P.O. Box 908 Lawton, OK 73502 Phone: 580-492-4988 Fax: 580-492-3796	Mr. Jimmy Arterberry Tribal Historic Preservation Officer Comanche Nation P.O. Box 908 Lawton, OK 73502 Email: jimmya@cne-mail.com Phone: (580) 595-9960 or (580) 595-9618 Fax: 580-595-9733	
Mr. Jeff Houser Fort Sill Apache Tribe of Oklahoma Route 2, Box 121 Apache, OK 73006 Phone: 580-588-2298 Fax: 580-588-3133	Mr. Jeff Houser Fort Sill Apache Tribe of Oklahoma Route 2, Box 121 Apache, OK 73006 Phone: 580-588-2298 Fax: 580-588-3133	
Mr. Billy E. Horse Kiowa Tribe of Oklahoma P.O. Box 369 Carnegie, OK 73015 Phone: 580-654-2300 Fax: 580-654-2188	Mrs. Jame Eskew Tribal Representative Kiowa Tribe of Oklahoma P.O. Box 369 Carnegie, OK 73015 Email: mrseskew@yahoo.com Phone: 580-654-2300 Fax: 580-654-2188	Mr. Ronald Daws-TwoHatchet Chairperson Kiowa Tribe of Oklahoma P.O. Box 369 Carnegie, OK 73015 Phone: 580-654-2300 Fax: 580-654-2188
Mr. Tom Castillo Lipan Apache Tribe P.O. Box 8888 Corpus Christi, TX 78468 Phone: 361-215-5121	Mr. Tom Castillo Homeland Administrator Lipan Apache Tribe P.O. Box 8888 Corpus Christi, TX 78468 Email: homeland@lipanapache.org Phone: 361-215-5121	

Original Contact	Current Contact	Alternate Current Contact
Mr. Mark R. Chino President Mescalero Apache Tribal Government 108 Old Mescalero Blvd. Mescalero, NM 88340 Phone: 575-464-4494	Mr. Mark R. Chino President Mescalero Apache Tribal Government 108 Old Mescalero Blvd. Mescalero, NM 88340 Phone: 575-464-4494 and The Mescalero Apache Reservation of New Mexico P.O. Box 176 Mescalero, NM 88340 Phone: 505-455-4494	Mescalero Apache Tribal Government Tribe Administration 101 Central Mescalero Ave. Mescalero, NM 88340 Phone: 575-671-4494 Fax: 505-671-9191
Mr. Gary McAdams President Wichita and Affiliated Tribes Anadarko, OK 73005 Phone: 405-247-2425 Fax: 405-247-2430	Mr. Stratford Williams President Wichita and Affiliated Tribes P.O. Box 729 Anadarko, OK 73005 Phone: 405-247-2425 Fax: 405-247-2430	
Mr. Frank Paiz Governor Ysleta del Sur Pueblo Tribe P.O. Box 17579-Ysleta Station El Paso, TX 79917 Phone: 915-859-8053 Fax: 915-859-4252	Mr. Javier Loera War Captain/Tribal Historic Preservation Officer Ysleta del Sur Pueblo Tribe P.O. Box 17579-Ysleta Station El Paso, TX 79917 Email: jloera@ydsp-nsn.gov Phone: 915-859-8053 Fax: 915-859-4252	Mr. Frank Paiz Governor Ysleta del Sur Pueblo Tribe P.O. Box 17579-Ysleta Station El Paso, TX 79917 Phone: 915-859-8053 Fax: 915-859-4252

August 19, 2010

Name
Title
Organization
Address
City, State Zip

Dear Name:

The U. S. Department of Energy (DOE) is preparing an Environmental Impact Statement (EIS) for the proposed action of providing Federal funding for the proposed Texas Clean Energy Project (TCEP). The project would involve planning, design, construction, and operation, by Summit Texas Clean Energy, LLC, of a coal-fueled electric power and chemicals production plant integrated with carbon dioxide (CO_2) capture and geologic sequestration. The TCEP will consist of a 600-acre power plant facility and approximately 85 miles of associated linear utility features located in Crane, Ector, and Midland Counties, Texas.

The DOE would like to solicit your input on the project to determine if your tribe has any concerns or issues about the project. In particular, we are interested in learning whether or not this project has the potential to impact any significant archaeological, religious, or cultural sites. DOE is requesting that you (or your designated representative) submit to my office any concerns or issues you may have or notify my office if you are aware of any significant archaeological, religious, or cultural sites within the areas of potential impact.

To assist in your review, the enclosed maps illustrate the potential areas where construction impacts may occur. Impacts to archaeological resources (if present) could occur as a result of site development and other land-disturbing activities from the project. Please also take into account any traditional properties in the vicinity that may be visually impacted by the proposed project.

Please contact me via telephone (800-432-8330, ext. 4426), fax (304-285-4403) or email (Summit.EIS@netl.doe.gov) with any concerns. Thank you for your participation in this important project.

In addition, please sign the signature line below and return a signed copy to my attention if you (or your representative) want to continue to receive information about the project or if you wish to provide review comments on the Section 106 or NEPA documents.

Sincerely,

Mark L. McKoy

Mark L. McKoy
Environmental Manager

Enclosure:
Project location map

RESPONSE REQUESTED:

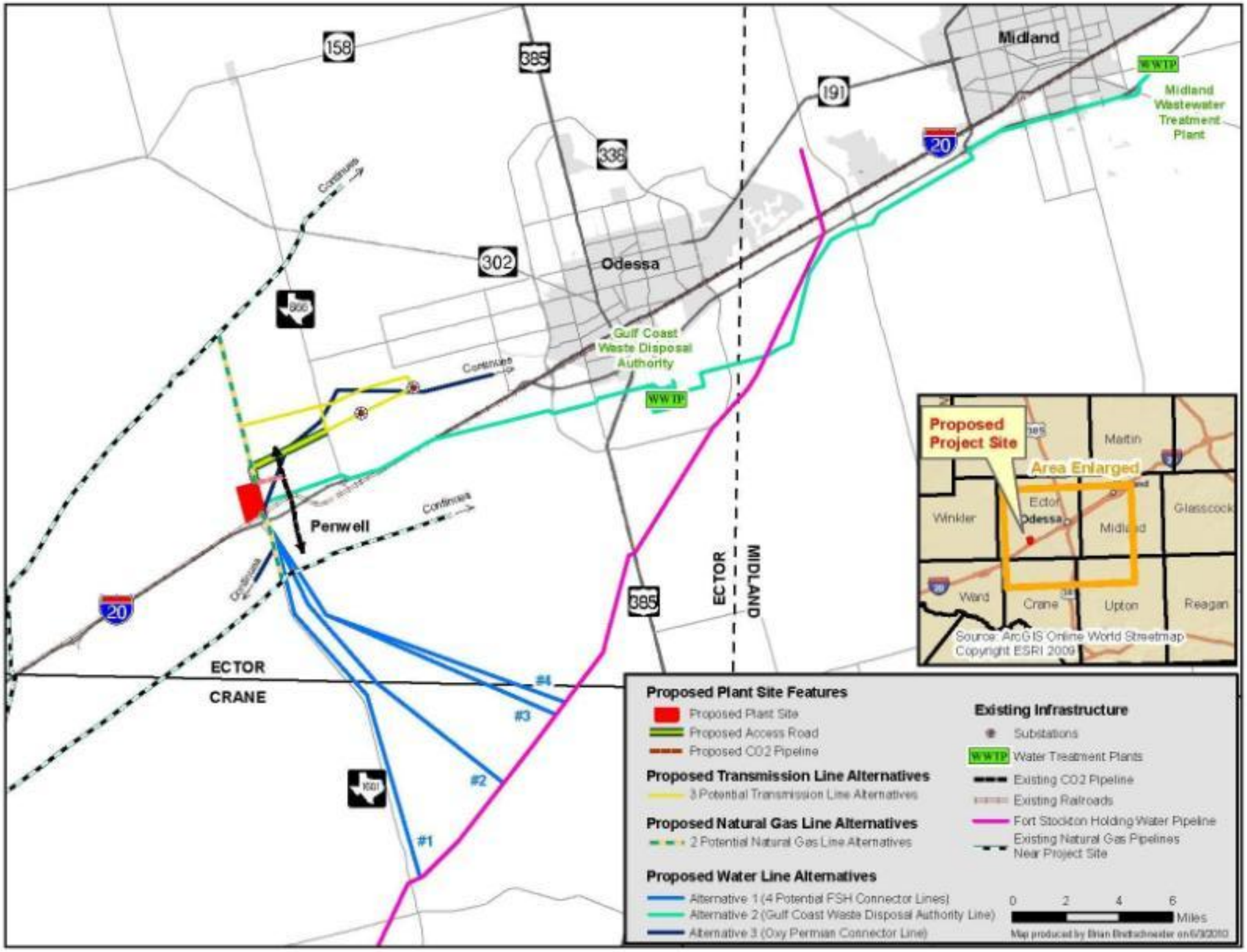
___ Yes, we wish to continue to receive information and participate in the consultation process.

___ No, we do not wish to continue to receive information or participate in the consultation process.

By:______________________________

Title:_____________________________

Date:_____________________________



Midland
Midland Wastewater Treatment Plant
WWTP
Odessa
Gulf Coast Waste Disposal Authority
WWTP
Penwell
MIDLAND
ECTOR
ECTOR
CRANE
Continues
#1
#2
#3
#4
Proposed Project Site
Area Enlarged
Martin
Glasscock
Winkler
Ector
Odessa
Midland
Ward
Crane
Upton
Reagan
Source: ArcGIS Online World Streetmap
Copyright ESRI 2009
Proposed Plant Site Features
Proposed Plant Site
Proposed Access Road
Proposed CO2 Pipeline
Proposed Transmission Line Alternatives
3 Potential Transmission Line Alternatives
Proposed Natural Gas Line Alternatives
2 Potential Natural Gas Line Alternatives
Proposed Water Line Alternatives
Alternative 1 (4 Potential FSH Connector Lines)
Alternative 2 (Gulf Coast Waste Disposal Authority Line)
Alternative 3 (Oxy Permian Connector Line)
Existing Infrastructure
Substations
Water Treatment Plants
Existing CO2 Pipeline
Existing Railroads
Fort Stockton Holding Water Pipeline
Existing Natural Gas Pipelines Near Project Site
0 2 4 6 Miles

Tribal Responses

Ysleta del Sur Pueblo

Tribal Council – Javier Loera – (War Captain/Tribal Historic and Preservation Officer)

117 South Old Pueblo Road * P.O. Box 17579 * El Paso, Texas 79917 * (915) 859-8053 * Fax: (915) 859-4252

August 31, 2010

Mr. Mark L. Mckoy
Environmental Manager
U.S. Department of Energy
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507

Dear Mr. Mckoy:

This letter is in response to the correspondence received in our office in which you provide the Ysleta del Sur Pueblo the opportunity to comment on the U.S. Department of Energy's (DOE) preparation of an Environmental Impact Statement (EIS) for the proposed action of providing Federal funding for the proposed Texas Clean Energy Project (TCEP) located in Crane, Hector, and Midland Counties, Texas.

While we do not have any comments on the proposed (EIS) and believe that this project will not adversely affect traditional, religious or culturally significant sites of our Pueblo and have no opposition to it; we would like consultation should any human remains or artifacts unearthed during this project be determined to fall under Native American Graves Protection and Repatriation Act (NAGPRA) guidelines. Copies of our Pueblo's Cultural Affiliation Position Paper and Consultation Policy are available upon request.

Thank you for allowing us the opportunity to comment on the proposed project.

Sincerely,

Javier Loera

Javier Loera
War Captain/Tribal Historic and Preservation Officer
Ysleta del Sur Pueblo
E-mail: jloera@ydsp-nsn.gov

August 20, 2010

Mr. Arturo Senclair
Governor
Ysleta del Sur Pueblo Tribe
P.O. Box 17579-Ysleta Station
El Paso, TX 79917

Dear Mr. Senclair:

The U. S. Department of Energy (DOE) is preparing an Environmental Impact Statement (EIS) for the proposed action of providing Federal funding for the proposed Texas Clean Energy Project (TCEP). The project would involve planning, design, construction, and operation, by Summit Texas Clean Energy, LLC, of a coal-fueled electric power and chemicals production plant integrated with carbon dioxide (CO_2) capture and geologic sequestration. The TCEP will consist of a 600-acre power plant facility and approximately 85 miles of associated linear utility features located in Crane, Ector, and Midland Counties, Texas.

The DOE would like to solicit your input on the project to determine if your tribe has any concerns or issues about the project. In particular, we are interested in learning whether or not this project has the potential to impact any significant archaeological, religious, or cultural sites. DOE is requesting that you (or your designated representative) submit to my office any concerns or issues you may have or notify my office if you are aware of any significant archaeological, religious, or cultural sites within the areas of potential impact.

To assist in your review, the enclosed maps illustrate the potential areas where construction impacts may occur. Impacts to archaeological resources (if present) could occur as a result of site development and other land-disturbing activities from the project. Please also take into account any traditional properties in the vicinity that may be visually impacted by the proposed project.

received
8·23·2010
original: Javier Lara

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Albany, OR • Morgantown, WV • Pittsburgh, PA
U.S. DEPARTMENT OF ENERGY

RESPONSE REQUESTED:

___ Yes, we wish to continue to receive information and participate in the consultation process.

✓ No, we do not wish to continue to receive information or participate in the consultation process. - See Attached Letter

By: Javier Loera (JAVIER LOERA)

Title: THPO/WAR CAPTAIN of Tribe (NAGPRA Rep.)

Date: August 31, 2010

Appendix B. Environmental Synopsis CCPI Round 3

ENVIRONMENTAL SYNOPSIS
CCPI Round 3
DE-PS26-08NT43181
DE-FOA-0000042

October 2010

National Energy Technology Laboratory
U.S. Department of Energy
Morgantown, West Virginia

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CONTENTS

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INTRODUCTION

The U.S. Department of Energy (DOE or the Department) prepared this Environmental Synopsis pursuant to the Department's responsibilities under section 1021.216 of DOE's National Environmental Policy Act (NEPA) Implementing Procedures set forth in 10 CFR Part 1021. This synopsis summarizes the consideration given to environmental factors and records that the relevant environmental consequences of reasonable alternatives were evaluated in the process of selecting projects seeking financial assistance under Round 3 of the Clean Coal Power Initiative (CCPI). DOE selected five applicants seeking financial assistance under CCPI Round 3 during its merit review process. In addition to financial and technical elements, DOE considered relevant environmental factors and consequences of the projects proposed to DOE in response to the funding opportunity announcements. As required by section 1021.216, this synopsis does not contain business, confidential, trade secret or other information that statutes or regulations would prohibit DOE from disclosing. It also does not contain data or other information that may in any way reveal the identity of the offerors.[1]

BACKGROUND

Coal is an abundant and indigenous energy resource and supplies almost 50 percent of the United States' electric power. Demand for electricity is projected to increase by more than 30 percent by 2030. Based on analyses conducted by the EIA, it is projected that this power increase can only be achieved if coal use is also increased. Furthermore, nearly half of the nation's electric power generating infrastructure is more than 30 years old, with a significant portion in service for twice as long. These aging facilities are - or soon will be - in need of substantial refurbishment or replacement. Additional capacity must also be put in service to keep pace with the nation's ever-growing demand for electricity. Therefore, DOE expects that nearly half of the nation's electricity needs will continue to be served by coal for at least the next several decades. Given heightened awareness of environmental stewardship, while at the same time meeting the demand for a reliable and cost-effective electric power supply, it is clearly in the public interest for the nation's energy infrastructure to be upgraded with the latest and most advanced commercially viable technologies to achieve greater efficiencies, environmental performance, and cost-competitiveness. However, to realize acceptance and replication of these advanced technologies into the electric power generation sector, the technologies must first be demonstrated (i.e., designed and constructed to industrial standards and operated at significant scale under industrial conditions).

Public Law 107-63, enacted in November 2001, first provided funding for the Clean Coal Power Initiative, or CCPI. The CCPI is a multi-year federal program tasked with accelerating the commercial readiness of advanced multi-pollutant emissions control, combustion, gasification, and efficiency improvement technologies to retrofit or repower existing coal-based power plants and for deployment in new coal-based generating facilities. The CCPI encompasses a broad spectrum of commercial-scale demonstrations that target environmental challenges, including reducing greenhouse gas (GHG) emissions, by boosting the efficiency at which coal is converted to electricity or other energy forms. The CCPI is closely linked with DOE's research and development activities directed toward creating ultra-clean, fossil fuel-based energy complexes in the 21st century. When integrated with other DOE initiatives, the CCPI will help the nation successfully commercialize advanced power systems that will produce electricity at greater efficiencies, produce almost no emissions, and create clean fuels. Improving power plant efficiency is a potentially significant way to reduce carbon dioxide (CO_2) emissions in the near- and midterm. In the longer term, the most recent future funding opportunity announcements targeted CCPI technologies employing CO_2 capture and storage, or beneficial reuse. Accelerating

[1] The five projects selected for awards are identified in this synopsis and information on these projects is available on the DOE National Energy Technology Laboratory web site at http://www.netl.doe.gov/technologies/coalpower/cctc/ccpi/index.html.

commercialization of clean coal technologies also positions the United States to supply these technologies to a rapidly expanding world market.

Congress provided for competitively awarded federal cost-shared funding for CCPI demonstration projects. In contrast to other federally funded activities, CCPI projects are not federal projects seeking private investment; instead, they are private projects seeking federal financial assistance. Under the CCPI funding opportunities, industry proposes projects that meet its needs and those of its customers while furthering the national goals and objectives of DOE's CCPI. Demonstration projects selected by the CCPI program become private-public partnerships that satisfy a wide set of industry and government needs. Through the CCPI program, industry may satisfy its short-term need to retrofit or repower a facility, develop new power generating capacity, or obtain critical economic or technical evaluation of emerging commercial-scale technologies, all for the benefit of its customers. By providing financial incentives to the energy sector that reduce risks associated with project financing and technical challenges for emerging clean coal technologies, the government: (a) supports the verification of commercial readiness leading toward the long-term objective of transitioning the nation's existing fleet of electric power plants to more efficient, environmentally sound, and cost-competitive facilities; and (b) facilitates the adoption of technologies that can meet more stringent environmental regulation through more efficient power generation, advanced environmental controls, and production of environmentally attractive energy carriers and byproduct utilization.

DOE selects projects for CCPI funding in a series of rounds, each of which starts with a Funding Opportunity Announcement (FOA) that asks project proponents to submit applications for federal cost-sharing for their demonstration projects. DOE issued the first CCPI FOA (Round 1) in March 2002 and a second FOA (Round 2) in February 2004. These funding opportunities focused on projects involving advanced coal-based power generation, including gasification, efficiency improvements, optimization through neural networking, environmental and economic improvements, and mercury control. For Round 3, DOE issued a Financial Assistance FOA on August 11, 2008 (DE-PS26-08NT43181) to solicit applications and subsequently issued Amendment 005 (as DE-FOA-0000042) on June 9, 2009, to reopen the FOA and provide a second closing date (August 24, 2009) for additional applications. Projects receiving awards under the amended FOA could be funded, in whole or in part, with funds appropriated by the American Recovery and Reinvestment Act of 2009, Public Law 111-5.

Applications for demonstrations under CCPI Round 3 were evaluated against specific programmatic criteria:

- Technology merit, technical plan, and site suitability;
- Project organization and project management plan;
- Commercialization potential;
- Funding plan;
- Financial business plan.

Evaluations against these criteria represented the total evaluation scoring. However, the selection official also considered the results of the environmental evaluation and the applicant's budget information and financial management system, as well as program policy factors, in making final selections.

As a Federal agency, DOE must comply with NEPA (42 U.S.C. §§ 4321 et seq.) by considering potential environmental issues associated with its actions prior to deciding whether to undertake these actions. The environmental review of applications received in response to the CCPI Round 3 FOA was conducted pursuant to Council on Environmental Quality Regulations (40 Code of Federal Regulations (CFR) Parts 1500 - 1508) and DOE's NEPA Implementing Procedures (10 CFR Part 1021), which provide directions specific to procurement actions that DOE may undertake or fund before completing the NEPA process.

PURPOSE AND NEED

The purpose and need for DOE's selections of projects under the CCPI Program are to satisfy the responsibility Congress imposed on the Department to demonstrate advanced coal-based technologies that can generate clean, reliable, and affordable electricity in the United States.

The specific objectives of the Round 3 FOAs were:

- The CO_2 capture process must operate at a CO_2 capture efficiency of at least 90 percent;
- Progress is made toward carbon capture and sequestration (CCS) at less than a 10 percent increase in the cost of electricity for gasification systems and less than 35 percent increase for combustion and oxy-combustion systems;
- Progress is made toward CCS of 50 percent of plant CO_2 output at a scale sufficient to evaluate the full impact of the carbon capture technology on plant operations, economics, and performance; and
- At least 300,000 tons per year of CO_2 emissions from the demonstration plant must be captured and sequestered or put to beneficial use.

ALTERNATIVES

DOE received eleven (11) applications in response to the initial FOA (issued August 11, 2008) for CCPI-3, all of which were determined to have met the mandatory eligibility requirements listed in the FOA. The applications covered a wide geographic range, including sites in fourteen different states representing nearly every region of the country. In response to the reopened FOA (issued June 9, 2009), DOE received thirty eight (38) applications, of which twenty five (25)were determined to have met the mandatory eligibility requirements listed in the FOA. The requirements for the reopened FOA were the same as for the initial. The twenty five applications offered projects involving sites in nineteen different states representing nearly all geographic regions of the country. Several applicants in the initial FOA also resubmitted modified applications in response to the reopened FOA. The applications were evaluated against technical, financial and environmental factors. The criteria for evaluating applications received under CCPI-3 were published in the FOA. The technical and financial evaluations resulted in separate numerical scores; the environmental evaluation, while not scored, was considered in making selections. Each applicant was required to complete and submit a standard environmental questionnaire for each site proposed in its application.

The evaluations focused on the technical description of the proposed project, financial plans and budgets, potential environmental impacts, and other information that the applicants submitted. Following reviews by technical, environmental and financial panels and a comprehensive assessment by a merit review board, a DOE official selected those projects that best met the CCPI program's purpose and need. By broadly soliciting proposals to meet the programmatic purpose and need for DOE action and by evaluating the potential environmental impacts associated with each proposal before selecting projects, DOE considered a reasonable range of alternatives for meeting the purpose and need of the CCPI Round 3 solicitation.

For the initial FOA, applications were divided into three broad categories:

- Retrofit of CCS to an existing integrated gasification combined cycle (IGCC) facility or to an IGCC facility under construction;
- Retrofit of CCS to an existing pulverized coal (PC)-fired facility; and
- Construction and operation of new IGCC or Fluidized Bed Combustion (FBC) facilities with integrated CCS.

DOE received no less than two applications in each of the above groupings, which provided DOE with a range of reasonable alternatives for meetings the Department's need to demonstrate, at a commercial scale, new technologies that capture CO_2 emissions from coal-based power plants and either sequester the CO_2 or put it to beneficial reuse. The applications included demonstration of CCS integrated into new facilities using advanced technologies for power generation, as well as retrofits of CCS to existing facilities or ones already under construction, including both advanced and conventional technologies for power generation.

For the reopened FOA, DOE divided the applications into four groups, because of the larger number of submissions received:

- Retrofit of CCS to an existing plant (already permitted and operating);
- Retrofit of CCS to a planned or authorized power plant (but not yet constructed or operating);
- Construction and operation of a new power plant with CCS on an existing industrial site; and
- Construction and operation of a new power plant with CCS on an undeveloped site.

DOE received no less than four applications in each of the above groupings.

ENVIRONMENTAL REVIEW

DOE assembled environmental review teams to assess all applications that met the mandatory requirements. The review teams considered twenty (20) resource areas that could potentially be impacted by the projects proposed under CCPI-3. These resource areas consisted of:

Aesthetics	Floodplains	Soils
Air Quality	Geology	Surface Water
Biological Resources	Ground Water	Transportation and Traffic
Climate	Human Health and Safety	Utilities
Community Services	Land Use	Wastes and Materials
Cultural Resources	Noise	Wetlands
Environmental Justice	Socioeconomics	

The review teams were composed of environmental professionals with experience evaluating the impacts of power plants and energy-related projects, and with expertise in the resource areas considered by DOE. The review teams considered the information provided as part of each application, which included narrative text, worksheets, and the environmental questionnaire(s) for the site(s) proposed by the applicant. In addition, reviewers independently verified the information provided to the extent practicable using available sources commonly consulted in the preparation of NEPA documents, and conducted preliminary analyses to identify the potential range of impacts associated with each application. Reviewers identified both direct and indirect, as well as short-term impacts, which might occur during construction and start-up, and long-term impacts, which might occur over the expected operational life of the proposed project and beyond. The reviewers also considered any mitigation measures proposed by the applicant and any reasonably available mitigation measures that may not have been proposed.

Reviewers assessed the potential for environmental issues and impacts using the following characterizations:

- **Beneficial** – Expected to have a net beneficial effect on the resource in comparison to baseline conditions.

- **None (negligible)** – Immeasurable or negligible in consequence (not expected to change baseline conditions).
- **Low** – Measurable or noticeable but of minimal consequence (barely discernable change in baseline conditions).
- **Moderate** – Adverse and considerable in consequence but moderate and not expected to reach a level of significance (discernable, but not drastic, alteration of baseline conditions).
- **High** – Adverse and potentially significant in severity (anticipated substantial changes or effects on baseline conditions that might not be mitigable).

Applications in Response to the Initial FOA

Based on the technologies and sites proposed, none of the applications for the initial FOA were deemed to have a high potential for adverse impacts in nineteen of the twenty resource areas. However, four applications could have a potential for high adverse impacts to biological resources. The following impacts by resource area were considered in the selection of candidates for award:

Aesthetics – No impacts would be expected for one project at an existing power plant. Low to moderate impacts would be expected for other existing facilities or facilities to be constructed. Impacts ranged from temporary impacts during construction to new construction within the line-of-sight of public property, including nearby roads and highways.

Air Quality – Low to moderate impacts would be expected from emissions of criteria pollutants from new sources and fugitive emissions of dust. Compliance with Prevention of Significant Deterioration increments would be required for three projects; and new source reviews would be required for four projects. Increased emissions of volatile organic compounds (VOCs) and ammonia would be expected for more than half of the projects. Some increase in cooling tower drift could be expected for two projects.

Biological Resources – Four applications could potentially impact threatened or endangered species or their critical habitat, waterfowl and other migratory bird flyways or their crucial habitat, or wildlife refuges either because of new plant construction or installation of pipelines for CO_2 transport. No impacts were expected for two projects at existing plants. Low to moderate potential impacts would be expected for five applications.

Climate – No impacts would be expected for four projects at existing power plants. Low to moderate impacts would be expected for other existing facilities or facilities to be constructed. Impacts ranged from potential operational impacts from severe weather to localized increases in fogging or icing. Successful demonstration of CCS could contribute to reduced carbon footprints of fossil-fuel power plants.

Community Services – No impacts would be expected at the sites of two existing plants. Low to moderate impacts would be expected for the remaining applications. Generally, projects anticipating a larger temporary workforce during construction would be expected to place a higher demand on community services – particularly in smaller, more rural communities where currently existing community services are more limited.

Cultural Resources – No impacts would be expected at three existing facilities. Low to moderate impacts would be expected for the remaining applications. Potential impacts include tribal concerns over pipeline routes. Impacts would vary with the extent of known tribal claims and their proximity to the proposed project or pipeline route.

Environmental Justice – No impacts would be expected for five applications with no environmental justice populations present. There is a moderate potential for environmental justice issues at all but one of the remaining sites either because of environmental justice populations near the proposed site or along a proposed pipeline route. Potential impacts at the remaining site are expected to be low because of more limited environmental justice populations in the project area.

Floodplains – No impacts would be expected for two proposed projects. Low to moderate potential impacts during construction or pipeline routing would be expected for the remaining proposed projects.

Geology – The potential for low to moderate impacts exists for all applications either from CO_2 injection into saline aquifers or use for enhanced oil recovery. Some impacts could be expected from increased demand for coal if such demand contributes to opening new coal mines or expanding existing mines.

Ground Water – No impacts would be expected for one application involving an existing facility. Low to moderate impacts could be expected for the other applications. Impacts could include displacement of saline waters in reservoirs targeted for CO_2 injection or loss of CO_2 containment should injection pressures be too high.

Human Health and Safety – Potential impacts would be low to moderate and consist mainly of hazards associated with construction. The level of risk is generally related to the size and complexity of the planned construction. There could also be risk to human health and safety from loss of containment of CO_2 during transport and injection. This risk is present for all applications and generally varies from low to moderate with distance and population density along the CO_2 transport route where shorter routes through sparsely populated areas would have a lower risk than longer routes through regions of higher population.

Land Use – No impacts were identified for applications at existing facilities where the proposed project would not increase the footprint of the existing plant. Low to moderate impacts would be expected for applications proposing new construction. The level of potential impacts would generally be higher for new facilities on land currently used for other than industrial purposes. The assessment of impacts included both the plant site, sequestration site, and required pipeline routes for CO_2 transport.

Noise – No impacts would be expected for one project at an existing power plant. Low to moderate impacts could result from increases to ambient noise during construction and operation. Impacts would generally vary with distance and population density.

Socioeconomics – Expected impacts would be low for all applications. All applications would provide some additional employment during construction and operations. Most employment opportunities would be in the local area.

Soils – No impacts would be expected for one project at an existing power plant. Low impacts related to increased erosion during construction would be expected for other existing facilities requiring new pipelines or new facilities to be constructed.

Surface Water – Low to moderate impacts, including increased demand for cooling water and discharges to surface waters, would be expected for most of the applications. Some applications offered plans to maximize on-site reuse of water. Sediment control during construction was also considered.

Transportation and Traffic – Low to moderate impacts to traffic flow would be expected for all applications. Impacts would generally be higher during construction. Impacts expected during operations vary depending on increased rail or truck traffic. Projects in more rural areas would generally have lower impacts than new or existing facilities in more urban areas, where some increases in travel time could be expected during periods of peak construction.

Utilities – Low to moderate impacts would be expected for all applications. These would include an energy penalty for CCS retrofitted to existing power plants and increased demand for natural gas, potable water and wastewater treatment and disposal. Expected impacts would be higher for new plants proposed at sites not previously serviced by public utilities.

Wastes and Materials – Low to moderate impacts would be expected for all applications. Applications for projects that would include associated construction and operation of a new power plant would generally involve more material and waste impacts than would retrofits to existing plants.

Wetlands – No wetlands are located on the preferred site for one application. The potential for low to moderate impacts could be expected to small jurisdictional wetlands located on the proposed site or near proposed pipeline routes.

Applications in Response to the Reopened FOA

Based on the technologies and sites proposed, none of the applications for the reopened FOA were deemed to have a high potential for adverse impacts in sixteen of the twenty resource areas. All applications that would involve construction and operation of a new power plant were considered to have potentially high air quality impacts based on the need for new source permitting. Four applications were determined to have high potential for adverse impacts on biological resources; three applications were determined to have high potential for adverse impacts on surface waters; and one was determined to have high potential for adverse impacts on floodplains. The following impacts by resource area were considered in the selection of candidates for award:

Aesthetics – Impacts would be negligible for six projects that would involve retrofit or new construction at existing power plants or industrial sites. Low to moderate impacts would be expected for other retrofits to existing facilities or new facilities to be constructed. Moderate adverse impacts would result in the case of four applications involving construction of new power plants that would introduce line-of-sight impacts from superstructure and exhaust stacks where similar structures do not exist.

Air Quality – Impacts would result from emissions of criteria pollutants from new sources and fugitive emissions of dust. Twelve projects would have potentially high adverse impacts relating to emissions from proposed new plants. Lowest potential impacts would result from retrofits to existing or already-planned power plants.

Biological Resources – Four applications could potentially impact threatened or endangered species or their critical habitat, waterfowl and other migratory bird flyways, crucial habitat, or wildlife refuges either because of new plant construction or installation of pipelines for CO_2 transport. Moderate potential impacts would be expected for seven applications based on the locations of pipelines and other features. Low potential impacts would be expected for fourteen applications.

Climate – All applications were considered to present net beneficial effects on climate, because successful demonstration of CCS could contribute to reduced carbon footprints for fossil-fuel power plants. Potential adverse climate effects on plant operations were considered more from the perspective of engineering and design challenges to plant construction and maintenance.

Community Services – Negligible to low impacts would be expected for twenty applications. Five applications were determined to have potential for moderate impacts based on the size of the proposed projects to be located in smaller, more rural communities where existing community services are more limited.

Cultural Resources – Low potential for impacts would be expected for seventeen applications, including most retrofit projects. Moderate impacts would be expected for eight applications that could involve construction of structures or pipelines in proximity to tribal areas or historic sites.

Environmental Justice – Negligible to low potential for impacts would be expected for twenty three applications involving locations where environmental justice populations are not present. There is a moderate potential for environmental justice issues relating to the two remaining applications because of low-income or minority populations near the proposed site or along a proposed pipeline route.

Floodplains – One application would involve construction of structures within a 100-year floodplain with high potential for adverse impacts. Four applications were determined to have moderate potential impacts during construction of structures or pipelines. Negligible to low potential for impacts would be expected for twenty applications that do not directly involve actions in floodplains.

Geology – Negligible to low potential for impacts would be expected for twenty two applications based on CO_2 injection into saline aquifers or use for enhanced oil recovery. Three applications would have potential for moderate impacts based on limited information and uncertainties relating to target formations for proposed CO_2 injection.

Ground Water – Negligible to low potential for impacts would be expected for eighteen applications. Moderate impacts could be expected for the seven other applications relating to limited information about groundwater capacity to supply plant operations or the potential effects on groundwater sources from required dewatering operations.

Human Health and Safety – Moderate potential for impacts would be expected for seventeen applications; low potential would be expected for eight. The level of risk is generally related to the size and complexity of the planned construction. There could also be risk to human health and safety from loss of containment of CO_2 during transport and injection. This risk is present for all applications and generally varies from low to moderate with distance and population density along the CO_2 transport route.

Land Use – Negligible to low potential for impacts would be expected for twenty applications, mainly including projects involving retrofit at existing facilities or new construction on industrial sites. Moderate potential for impacts would be expected for five applications particularly requiring new construction on land currently used for other than industrial purposes.

Noise – Negligible to low potential for impacts from increases to ambient noise during construction and operation for all applications. Moderate potential for impacts could occur in the cases of five applications if coal would be transported by truck instead of by rail.

Socioeconomics – All applications were determined to provide beneficial impacts to the respective host areas based on economic multipliers associated with project spending as well as additional employment during construction and operations.

Soils – Low potential for impacts would be expected for twenty applications, mainly including projects involving retrofit at existing facilities or new construction on industrial sites. Moderate potential for impacts would relate to increased erosion during construction of structures or pipelines for five applications.

Surface Water – Three applications could have high potential for impacts attributable to substantial planned withdrawals from surface waters for plant operations, construction of pipelines along impaired surface waters, or planned discharges to surface waters. Moderate potential for impacts would be expected for eight applications; low potential would be expected for fourteen, including most retrofit projects.

Transportation and Traffic – Negligible to low potential for impacts could result from increases in traffic during construction and operation for all applications. Moderate potential for impacts could occur in the cases of five applications if coal would be transported by truck instead of by rail.

Utilities – Low potential for impacts would be expected for twelve applications that would not require extensive new pipelines and transmission lines. Thirteen applications would have potential for moderate impacts based on the need for longer pipeline and/or transmission line construction.

Wastes and Materials – Low potential for impacts would be expected for nine applications, including most projects proposing retrofits. Sixteen applications would have potential for moderate impacts based on the development of new facilities or new processes at existing facilities that would increase demands for management of materials and wastes.

Wetlands – The potential for negligible to low impacts could be expected for nineteen applications. Six applications would have potential for moderate impacts based on the lengths and routing of utility features and the potential for encountering wetlands along corridors.

CONCLUSION

The applications received in response to the CCPI-3 FOAs provided reasonable alternatives for accomplishing the Department's purpose and need to satisfy the responsibility Congress imposed on DOE to demonstrate advanced coal-based technologies that can generate clean, reliable and affordable electricity in the United States. The alternatives available to DOE would also meet the Department's goal of accelerating the deployment of carbon capture and storage. An environmental review was part of the evaluation process of these applications. DOE prepared a critique containing information from this environmental review. That critique, summarized here, contained summary as well as project-specific environmental information. The critique was made available to, and considered by, the selection official before selections for financial assistance were made.

DOE determined that selecting two applications in response to the initial FOA, and three applications in response to the reopened FOA, would meet its purpose and need. The following provides a list of the projects selected, their locations, brief descriptions of the projects, and the anticipated level of NEPA review:

CCPI-3 initial FOA:

- Hydrogen Energy California Project (Kern County, CA). Hydrogen Energy International LLC, a joint venture owned by BP Alternative Energy and Rio Tinto, would design, construct, and operate an IGCC power plant that would take blends of coal and petroleum coke, combined with non-potable water, and convert them into hydrogen and CO_2. The CO_2 would be separated from the hydrogen using the methanol-based Rectisol process. The hydrogen gas would be used to fuel a power station, and the CO_2 would be transported by pipeline to nearby oil reservoirs where it would be injected for storage and used for enhanced oil recovery. The project, which would be located in Kern County, California, would capture more than 2,000,000 tons per year of CO_2. The anticipated level of NEPA review for this project is an EIS.
- Basin Electric Power Cooperative - Post Combustion CO_2 Capture Project - Basin Electric Power Cooperative proposed to add CO_2 capture and sequestration (CCS) to Basin Electric's existing Antelope Valley Station, located near Beulah, N.D. Negotiations are still ongoing to define the project scope and schedule.

CCPI-3 reopened FOA:

- Mountaineer Carbon Dioxide Capture and Storage Demonstration (New Haven, WV). American Electric Power (AEP) would design, construct, and operate a chilled ammonia process that is expected to effectively capture at least 90 percent of the CO_2 (1.5 million metric tons per year) in a 235 megawatt (MW) flue gas stream at the existing 1,300 MW Appalachian Power Company (APCo) Mountaineer Power Plant near New Haven, WV. The captured CO_2 would be treated, compressed, and then transported by pipeline to proposed injection sites located near the capture facility. During the operation phase, AEP proposed to permanently store the entire amount of captured CO_2 in two separate saline formations located approximately 1.5 miles below the surface. The project team includes AEP, APCo, Schlumberger Carbon Services, Battelle Memorial Institute, CONSOL Energy, Alstom, and an advisory team of geologic experts. The anticipated level of NEPA review for this project is an EIS.
- The Texas Clean Energy Project. Summit Texas Clean Energy, LLC (Bainbridge Island, WA) would integrate Siemens gasification and power generating technology with carbon capture technologies to effectively capture 90% of the carbon dioxide (2.7 million metric tons per year) at a 400 MW plant to

be built near Midland-Odessa, TX. The captured CO_2 would be treated, compressed and then transported by CO_2 pipeline to oilfields in the Permian Basin of West Texas, for use in enhanced oil recovery (EOR) operations. The Bureau of Economic Geology (BEG) at the University of Texas would design and assure compliance with a state-of-the-art CO_2 sequestration monitoring, verification, and accounting program. The anticipated level of NEPA review for this project is an EIS.

- The Parish Post-Combustion CO_2 Capture and Sequestration Project (Thompsons, Texas). NRG Energy, Inc. (NRG) would design, construct, and operate a system that would capture and store approximately 400,000 tons of carbon CO_2 per year. The system would employ Fluor's Econamine FG Plus technology to capture at least 90 percent of the CO_2 from a 60 MW flue gas stream of the 617-MW Unit 7 at the W.A. Parish Generating Station located in Thompsons, Texas. Fluor's Econamine FG Plus CO_2 capture system features advanced process design and techniques, which lower the energy consumption of existing amine-based CO_2 capture processes by more than 20 percent. The captured CO_2 would be compressed and transported by pipeline to a mature oil field for injection into geologic formations for permanent storage through an enhanced oil recovery operation. The site would be monitored to track the migration of the CO_2 underground and to establish the permanence of sequestration. DOE is in the process of evaluating the appropriate level of NEPA documentation for this project.

Appendix C. Preliminary Quantitative Risk Analysis of the Texas Clean Energy Project

PRELIMINARY
QUANTITATIVE RISK ANALYSIS (QRA)
OF THE TEXAS CLEAN ENERGY PROJECT

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PRELIMINARY QUANTITATIVE RISK ANALYSIS (QRA) OF THE TEXAS CLEAN ENERGY PROJECT

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SECTION 1
INTRODUCTION

Quest Consultants Inc. was retained by CH2MHill to perform a preliminary quantitative risk analysis (QRA) of the proposed Texas Clean Energy Project and associated pipelines and anhydrous ammonia storage operations to be located near the town of Penwell, Texas. The primary objectives of the QRA were to identify the potential risk to persons outside of the TCEP and to compare those risks to internationally accepted risk criteria. With this objective in mind, the TCEP process units and associated pipelines included in the study were limited to those that transport or process flammable, acutely toxic, or asphyxiant materials. The primary TCEP process units, associated pipelines, and storage facilities handling these materials included in this study can be identified as follows.

- Ammonia synthesis unit
- Mercury removal and acid gas removal unit
- Sulfuric acid plant
- Carbon dioxide compression and drying unit
- Gasification unit
- Sour shift and gas cooling units
- Blowdown and sour water system
- Urea synthesis
- Air separation unit
- Gas turbine unit
- Anhydrous ammonia storage
- Carbon dioxide pipeline
- Natural gas pipeline

The QRA was divided into three primary tasks. First, determine potential releases that could result in significant hazardous conditions along the pipelines and near the TCEP. Second, for those potential releases identified, derive an annual probability of release. Third, using consistent, accepted methodology, combine the potential release consequences with the annual release probabilities to arrive at a measure of the risk posed to the public. Figure 1-1 illustrates the steps in the QRA procedure required to complete the three primary tasks.

1.1 Hazards Identification

The potential hazards associated with the TCEP process units, pipelines, and ammonia storage options are common to similar processes worldwide, and are a function of the materials being processed, processing systems, procedures used for operating and maintaining the equipment, and hazard detection and mitigation systems provided. The hazards that are likely to exist are identified by the physical and chemical properties of the materials being handled, and the process conditions. For facilities handling flammable, toxic, and asphyxiant fluids, the common hazards are:

- torch fires
- flash fires
- vapor cloud explosions
- toxic gas clouds (e.g., fluids containing hydrogen sulfide)
- asphyxiant gas clouds (e.g., fluids containing an asphyxiant such as carbon dioxide)

The hazards identification step is discussed in Sections 2 and 3.

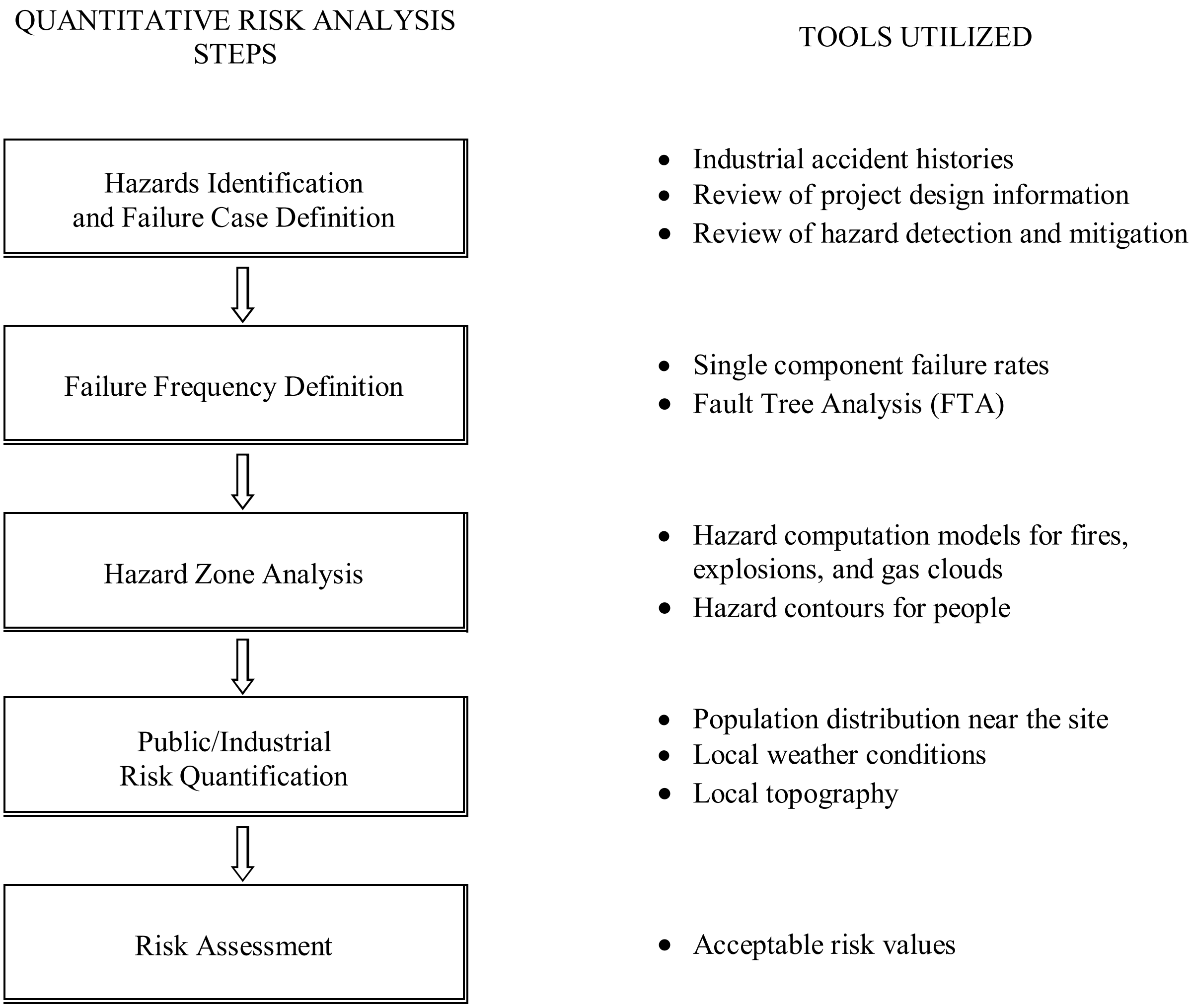

Figure 1-1 Overview of Risk Analysis Methodology

1.2 Failure Case Definition

The potential release sources of process materials or working fluids are determined from a combination of past history of releases from similar facilities and facility-specific information, including Process Flow Diagrams (PFDs), Piping and Instrumentation Diagrams (P&IDs), accident data, and engineering analysis by system safety engineers. Other methods that may be used in selected instances include Failure Modes and Effects Analysis (FMEA) and Hazards and Operability (HAZOP) studies.

This step in the analysis defines the various release sources and conditions of release for each failure case. The release conditions include:

- fluid composition, temperature, and pressure
- release rate and duration

- location and orientation of the release
- type of surface over which released liquid (if any) spreads

The failure case definition step is included in Section 3.

1.3 Failure Frequency Definition

The frequency with which a given failure case is expected to occur can be estimated by using a combination of:

- historical experience
- failure rate data on similar types of equipment
- service factors
- engineering judgment

For single component failures (e.g., pipe rupture), the failure frequency can be determined from industrial failure rate data bases. For multiple component failures (e.g., failure of a high pressure alarm and shut-down of a compressor discharge line), Fault Tree Analysis (FTA) techniques can be used. The single component failure rates used in constructing the fault tree are obtained from industrial failure rate data bases. The failure frequency step is included in Section 4.

1.4 Hazard Zone Analysis

The release conditions (pressure, composition, temperature, hole size, inventory, etc.) from the failure case definitions are then processed, using the best available hazard quantification technology, to produce a set of hazard zones for each failure case. The CANARY by Quest® computer software hazards analysis package is used to produce profiles for the fire, explosion, toxic, and asphyxiant hazards associated with the failure case. The models that are used account for:

- release conditions
- ambient weather conditions (wind speed, air temperature, humidity, atmospheric stability)
- effects of the local terrain (diking, vegetation)
- mixture thermodynamics

The hazard zone analysis step is included in Section 3.

1.5 Public/Industrial Risk Quantification

The methodology used in this study follows internationally accepted guidelines and has been successfully employed in QRA studies that have undergone regulatory review in countries worldwide. This methodology is described in Section 5.

The result of the analysis is a prediction of the risk posed by the TCEP process units, pipelines, and anhydrous ammonia storage options. Risk may be expressed in several forms (risk contours, average individual risk, societal risk, etc.). For this analysis, the focus was on the prediction of risk contours.

1.6 Risk Assessment

Risk indicators enable decision makers (corporate risk managers or regulatory authorities) to evaluate the potential risks associated with the TCEP and ancillary operations. Risk contours for the TCEP process components and associated pipelines can be compared to internationally accepted risk criteria which can assist decision makers in making judgments about the acceptability of the risk associated with the project. Results of the risk analysis and conclusions drawn from this study are presented in Section 6.

SECTION 2
FACILITY LOCATION, PIPELINE ROUTES, PIPELINE DATA, AND WELL DATA

2.1 TCEP Facility Location

The Texas Clean Energy Plant (TCEP) is located just north of the town of Penwell, Texas. The portions of the project to be evaluated include the coal gasification plant, power generation block, ammonia and urea production facilities, the pipelines that consist of one incoming natural gas pipeline from the south and one carbon dioxide pipeline leaving the north end of the site, and anhydrous ammonia storage. A preliminary plot plan of the site is presented in Figure 2-1.

2.2 TCEP Process Description

A brief summary of the TCEP process is presented in this section. This summary is drawn from an extensive process description presented in CH2MHill's report titled *Texas Clean Energy Project Initial Conceptual Design Report* [CH2MHill, 2010].

Coal, which has been dried and ground, is gasified by combusting coal with purified oxygen in a gasifier to produce raw syngas (primarily carbon monoxide) and molten slag. The syngas and molten slag are cooled by contact with quench water. The slag and excess quench water form "black water" and are removed for further dewatering and slag disposal. The cooled raw syngas is further processed to remove fine ash, chlorides and soot. The remaining syngas is converted to a hydrogen rich syngas using a water gas shift reaction. During the water shift process, carbonyl sulfides are converted into hydrogen sulfide. The resultant hot sour syngas containing hydrogen, carbon dioxide, and hydrogen sulfide is cooled and passed through a mercury removal unit to remove up to 95 percent of the mercury in the gas. After mercury removal, the sour syngas is processed in the Acid Gas Removal (AGR) unit to remove carbon dioxide and hydrogen sulfide. The recovered carbon dioxide is further cleaned, compressed and piped to locations for enhanced oil recovery operations. The hydrogen sulfide is processed to produce a saleable molten sulfur product.

The high hydrogen content syngas can be used as a fuel for power generation or a raw feedstock for production of urea. To produce power, the syngas is combusted in a turbine generator to produce electricity. The syngas feed to the turbine is diluted with nitrogen before combustion to reduce formation of nitrous oxides. The exhaust gas from the turbine generator contains water, carbon monoxide and hydrogen sulfide with trace amounts of carbonyl sulfide and ammonia.

Urea is produced by first converting the syngas into ammonia and then converting the ammonia to urea. Syngas is purified to remove trace impurities such as carbon monoxide, methane, and argon using a liquid nitrogen wash. Nitrogen is added to the syngas (now mostly hydrogen) to produce a stoichiometric nitrogen to hydrogen ratio for ammonia production. The hydrogen-nitrogen mixture is compressed, cooled, and reacted in a multi-bed catalytic reactor to produce ammonia. The reactor product, ammonia, is cooled and liquefied. The liquid ammonia product is temporarily stored prior to conversion to urea. Urea is produced by reacting ammonia with carbon dioxide to form ammonium carbamate, which slowly decomposes into urea and water. The concentrated urea solution is sprayed into a fluidized bed (granulator) to produce urea particles of the desired size. The urea is stored prior to shipping out in rail cars.

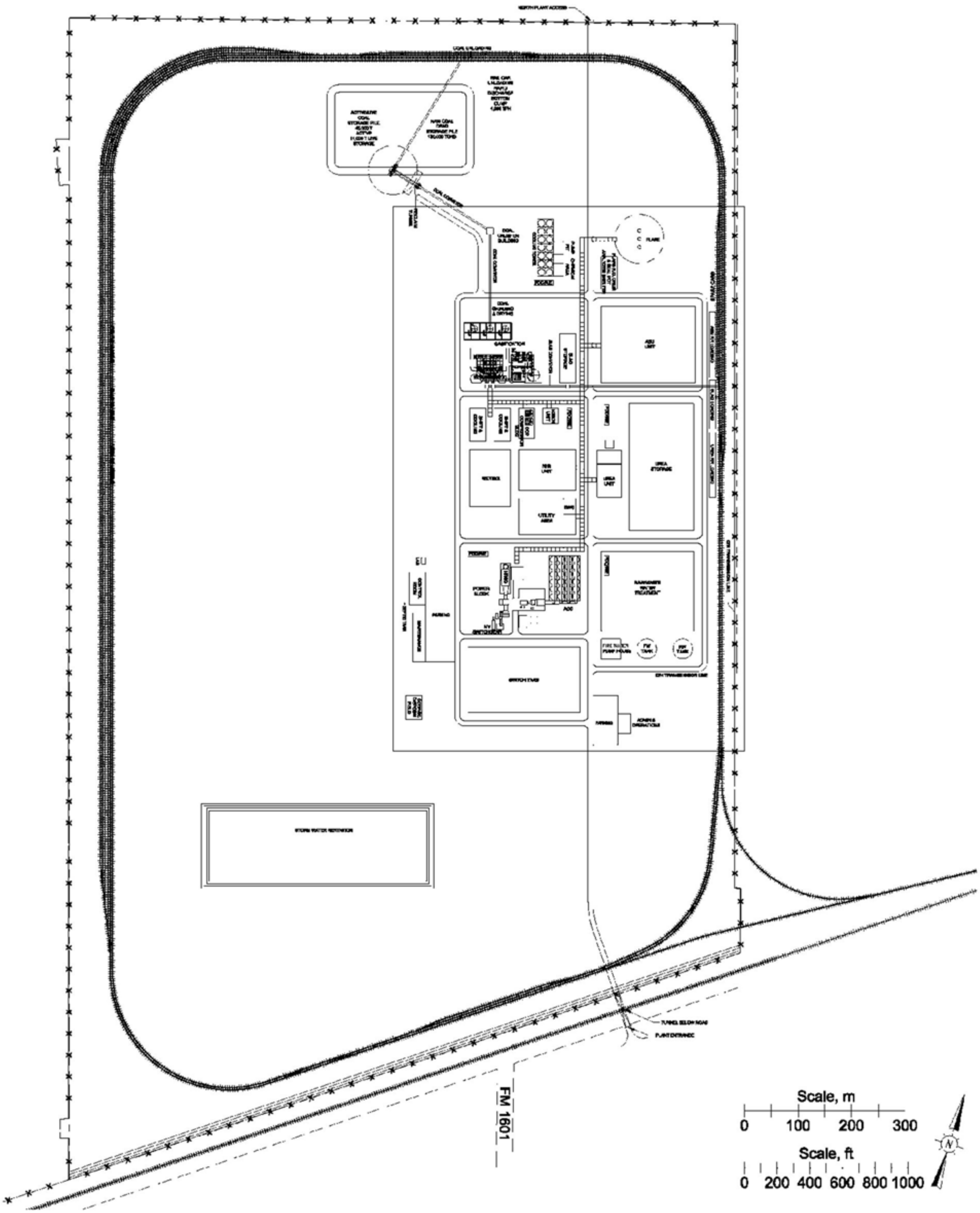

Figure 2-1
Plot Plan and Property Line for TCEP

Oxygen and nitrogen for the facility are provided by an Air Separation Unit (ASU). The ASU will produce 99.5 percent pure oxygen and 99 percent pure nitrogen by cryogenic distillation of air. Oxygen will be used in the gasifier to produce raw syngas while nitrogen will be used for ammonia synthesis and to dilute the purified syngas before combustion in the power generation turbines.

Black water from the gasifier is flashed, treated with chemicals to enhance precipitation and flocculation, and allowed to settle in a settling basin. The thickened liquid will be dewatered using a fabric filter. Filter cake from the filter will be dried and transported to a disposal location.

Two types of cooling systems are provided. For the combined cycle power block, an air-cooled condenser will be used. For cooling in other systems, water cooling using a wet cooling tower will be used. Utility systems will also be provided for flaring and auxiliary steam production.

There are three primary hazardous material import and export activities associated with the TCEP. One is a natural gas fuel pipeline entering the TCEP from the south. A second is a CO_2 export pipeline. The CO_2 pipeline travels approximately one mile to the east where it connects to an existing CO_2 pipeline. The third hazardous material exported is anhydrous ammonia. The ammonia is exported by tank truck intermittently.

An overall block diagram presenting the major flowlines between the individual units is presented in Figure 2-2. The major lines transferring material from one unit to another that contain significant amounts or concentrations of flammable, toxic, or asphyxiant material are highlighted in yellow in Figure 2-3. The layout of the major units within TCEP is presented in Figure 2-4. The entering natural gas pipeline and the export carbon dioxide pipeline routes are presented in Figure 2-5. A summary of pipeline data is presented in Table 2-1.

Table 2-1
Summary of Pipeline Data

Pipeline	Pipe Diameter [inches]	Approximate Pressure at Plant Inlet [psia]	Temperature [°F]	Approximate Flow Rate [mmscfd]
Natural Gas	4	1,200	59	5
Carbon Dioxide	10	2,315	100	148

2.3 Population Data

The TCEP and the CO_2 export pipeline are located in rural areas that are sparsely populated. None of the individual units associated with the TCEP or the proposed CO_2 export pipeline have any residential or business structures within 1,000 meters (3,280 feet). Because of these factors, the potential for the public to be exposed to an accidental release of hazardous materials originating in the TCEP or the CO_2 pipeline is low. The incoming natural gas pipeline passes through the town of Penwell. Since this is an existing natural gas line, the risk to the people of Penwell due to the natural gas line is already in place.

2.4 Meteorological Data

Meteorological data for wind speed, wind direction, and Pasquill-Gifford atmospheric stability class used in this study were gathered from the Midland, Texas, airport for the years 1995 through 2004. This was the nearest available reporting station with a complete data set and is approximately 30 miles northeast of Penwell, Texas. Figure 2-6 presents the annual wind rose data for all stability classes. The length and width of a particular arm of the rose define the frequency and speed at which the wind blows from the direction the arm is pointing. As an example, reviewing Figure 2-6 shows that the most common wind blows from south to north.

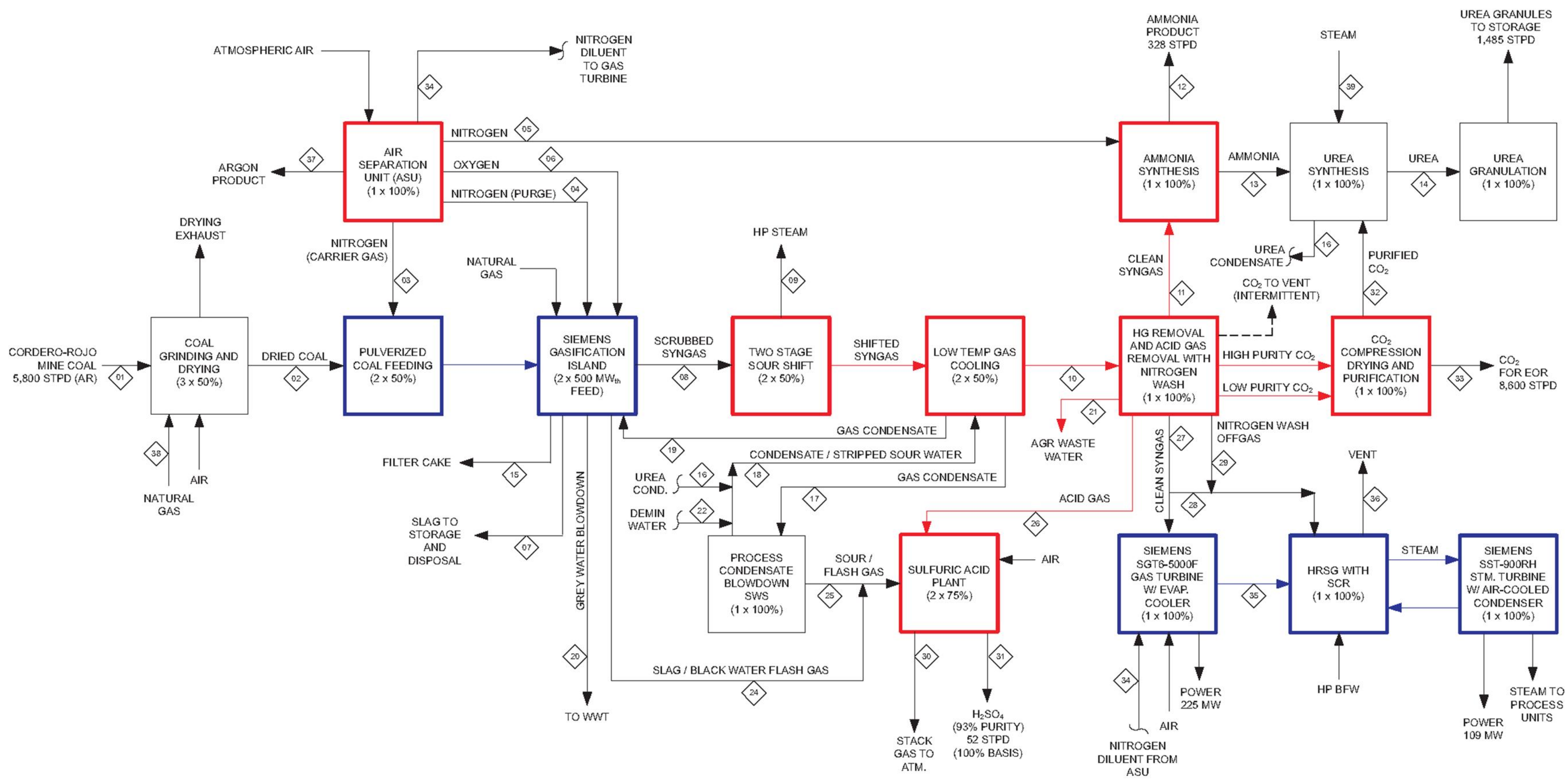

Figure 2-2
Block Flow Diagram for TCEP

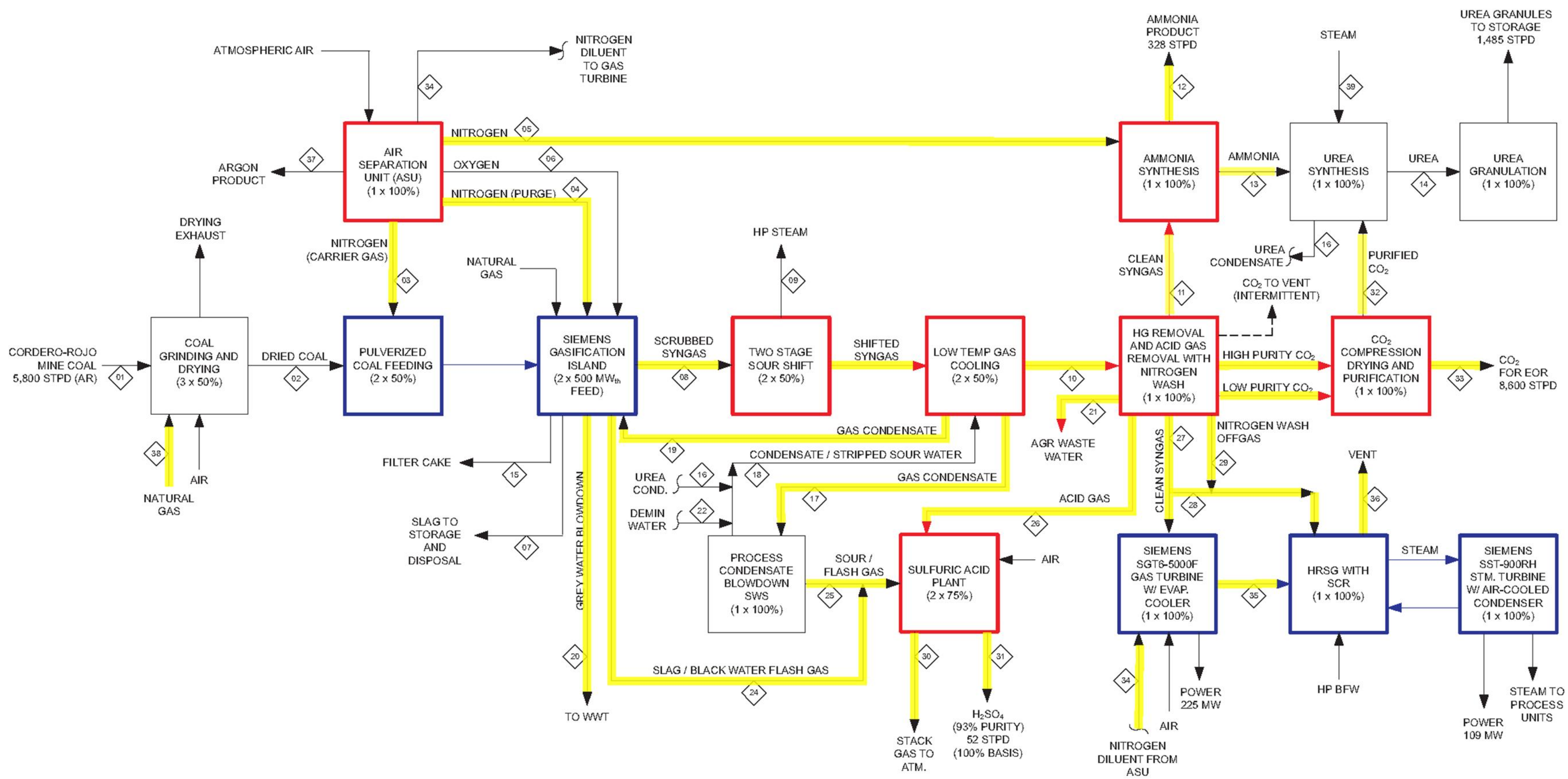

Figure 2-3
Block Flow Diagram Identifying Major Lines Containing Hazardous Materials in TCEP

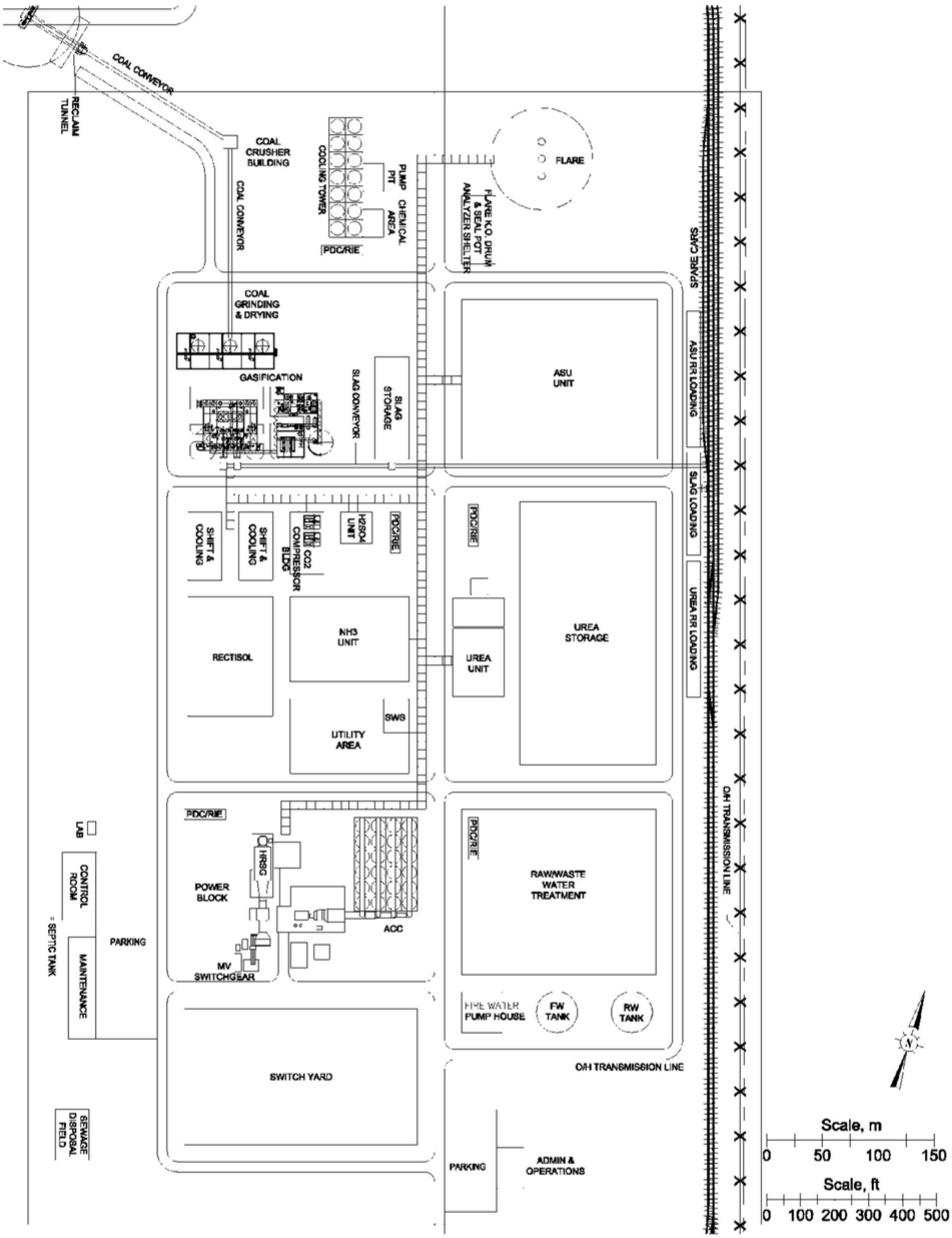

Figure 2-4
Process Unit Layout for TCEP

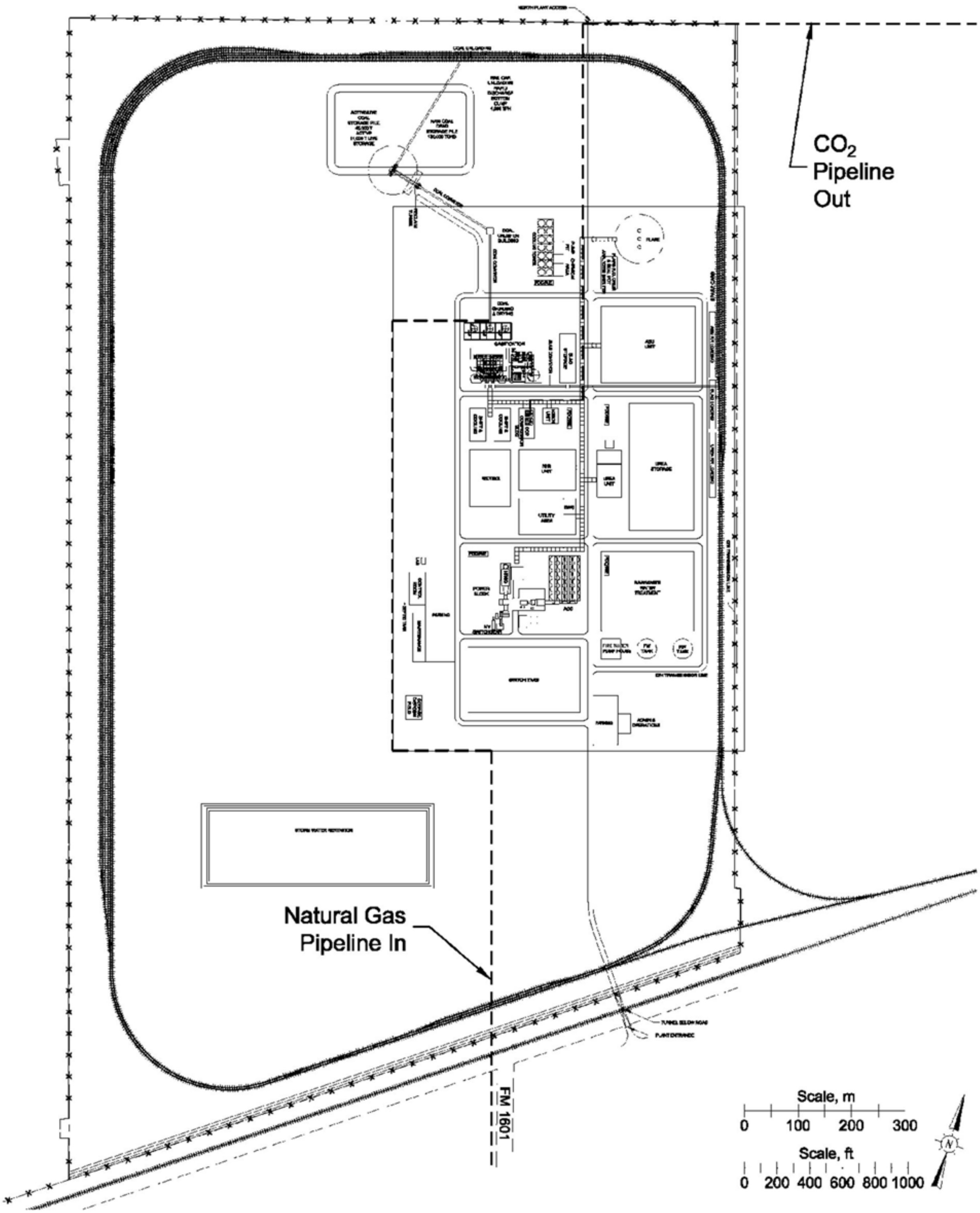

Figure 2-5
Pipeline Routes for TCEP

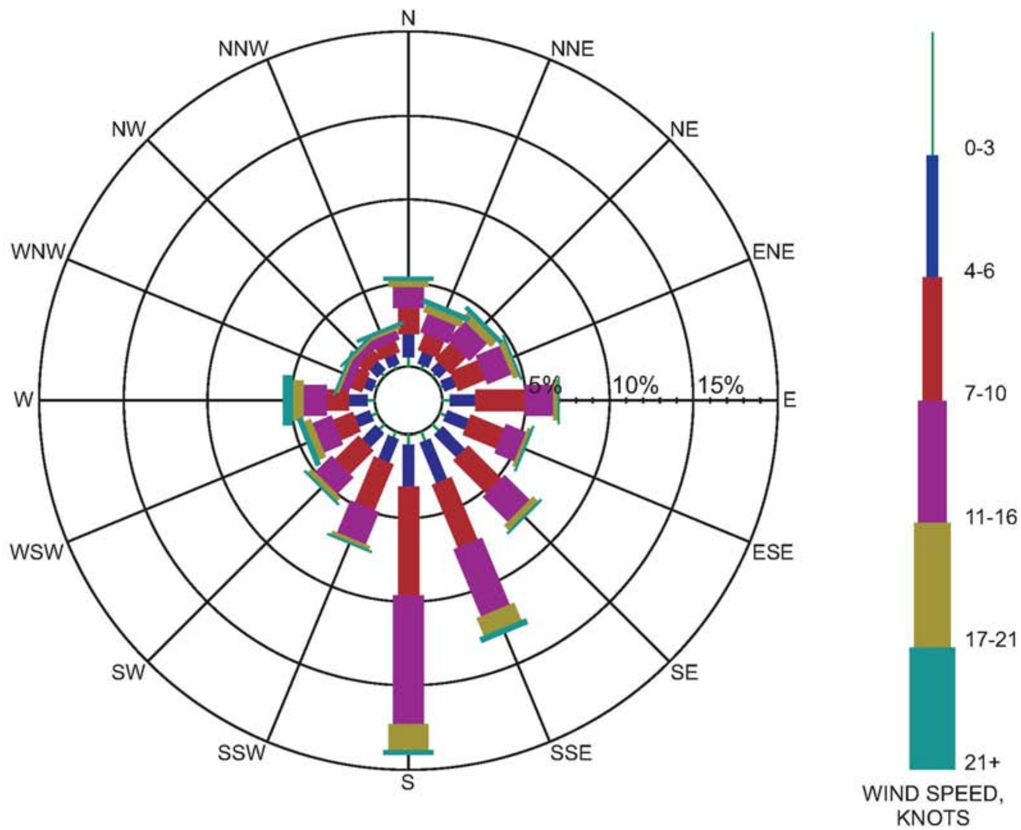

Figure 2-6
Wind Rose for Midland, TX

SECTION 3
POTENTIAL HAZARDS

Quest reviewed the TCEP preliminary process design and proposed pipeline routes in order to determine credible hazardous release events involving flammable and toxic fluids. As a result of this review, the following potential releases were selected for evaluation.

TCEP Process Units

(1) Full rupture of the piping or associated equipment, resulting in rapid depressurization of an individual system.
(2) A 1-inch hole (2.54 cm) in the piping or associated equipment. This hole could be the result of material defect or puncture.
(3) A 1/4-inch hole (0.635 cm) in the piping or associated equipment. This release would simulate a corrosion hole or a damaged fitting on the equipment.

Anhydrous Ammonia Storage

(1) Full rupture of the piping or associated equipment, resulting in a release from storage.
(2) A 1-inch hole (2.54 cm) in the piping or associated equipment. This hole could be the result of material defect or puncture.
(3) A 1/4-inch hole (0.635 cm) in associated equipment. This release would simulate a corrosion hole or a damaged fitting on the equipment.

Natural Gas and Carbon Dioxide Pipeline Releases

(1) Full rupture of the pipeline or associated equipment, resulting in rapid depressurization of the line. This is considered the maximum credible release that might occur along a pipeline.
(2) A 2-inch hole (5.08 cm) in one of the pipelines or associated equipment. This hole could be the result of material defect or puncture.
(3) A 1/4-inch hole (0.635 cm) in one of the pipelines or associated equipment. This release would simulate a corrosion hole in the pipeline.

Hazards Created by Releases

The release scenarios described above define the range of credible releases that might occur within or between the TCEP process units and along the pipeline routes. Each of these releases may create one or more of the following hazards.

(1) Exposure to gas containing a toxic compound (e.g., hydrogen sulfide)
(2) Exposure to asphyxiant levels caused by the presence of a non-toxic gas (e.g., carbon dioxide)
(3) Exposure to flammable gas that could result in a flash fire or torch fire
(4) Exposure to explosion overpressure following the ignition of a flammable cloud

The remainder of Section 3 defines the techniques used to quantify the hazards, while Section 4 quantifies the frequencies at which these releases might occur.

3.1 Physiological Effects of Hydrogen Sulfide

Hydrogen Sulfide (H_2S) is a colorless, flammable gas with a strong, irritating odor. H_2S has a low threshold limit value (TLV) and is detectable by odor at concentrations significantly lower than those necessary to cause physical harm or impairment (odor detectable from 0.13 – 1 ppm). The most serious hazard presented by H_2S is exposure to a large release from which escape is impossible. Table 3-1 describes various physiological effects of H_2S.

The physiological effects of airborne toxic materials depend on the concentration of the toxic vapor in the air being inhaled, and the length of time an individual is exposed to this concentration. The combination of concentration and time is referred to as "dosage." In risk studies that involve toxic gases, probit equations are commonly used to quantify the expected rate of fatalities for the exposed population. Probit equations are based on experimental dose-response data and take the following form.

$$Pr = a + b \ln(C^n \bullet t)$$

where:

	Pr	=	probit
	C	=	concentration of toxic vapor in the air being inhaled (ppm)
	t	=	time of exposure (minutes) to concentration C
	a, b, and n	=	constants

The product $C^n \bullet t$ is often referred to as the dose factor. According to probit equations, all combinations of concentration (C) and time (t) that result in equal dose factors also result in equal values for the probit (Pr) and therefore produce equal expected mortality rates for the exposed population.

3.1.1 H_2S Probit Relation from Perry and Articola

A probit equation for H_2S has been presented by Perry and Articola [1980]. This probit uses the values of -31.42, 3.008, and 1.43 for the constants a, b, and n, respectively. Substituting these values into the general probit equation yields the following probit equation for H_2S.

$$Pr = -31.42 + 3.008 \ln(C^{1.43} \bullet t)$$

Dispersion calculations are often performed assuming a 60-minute exposure to the gas. This is particularly true when dealing with air pollution studies since they are typically concerned with long-term exposures to low concentration levels. For accidental releases of toxic gases, shorter exposure times are warranted since the durations of many accidental releases are less than an hour. In this study, calculations were performed for various exposure times and concentration levels, dependent on the duration and nature of the release.

When using a probit equation, the value of the probit (Pr) that corresponds to a specific dose factor must be compared to a statistical table to determine the expected mortality rate. If the value of the probit is 2.67, the expected mortality rate is one percent. Using this probit equation, the H_2S concentration that equates to a one percent mortality rate is 157 ppm for 60 minutes exposure, 256 ppm for 30 minutes exposure, or 416 ppm for 15 minutes exposure, etc. Table 3-2 presents the probit values, mortality rates, and H_2S concentrations for various exposure times, while Figure 3-1 presents the same information in graphical form.

Table 3-1
Physiological Response to Various Concentrations of Hydrogen Sulfide (H_2S)

H_2S Concentration (ppm)	Duration of Exposure						
	0-2 min	2-15 min	15-30 min	30 min to 1 hr	1-4 hr	4-8 hr	8-48 hr
5-100				Mild conjunctivitis, respiratory tract irritation.			
100-150		Coughing, irritation of eyes, loss of sense of smell.	Disturbed respiration, pain in eyes, sleepiness.	Throat irritation.	Salivation and mucous discharge, sharp pain in eyes, coughing.	Increased symptoms.*	Hemorrhage and death.*
150-200		Loss of sense of smell.	Throat and eye irritation.	Throat and eye irritation.	Difficult breathing, blurred vision, light shy.	Serious irritating effect.*	Hemorrhage and death.*
250-350	Irritation of eyes, loss of sense of smell.	Irritation of eyes.	Painful secretion of tears, weariness.	Light shy, pain in eyes, difficult breathing.	Hemorrhage and death.*		
340-450		Irritation of eyes, loss of sense of smell.	Difficult respiration, coughing, irritation of eyes.	Increased irritation of eyes and nasal tract, dull pain in head, weariness, light shy.	Dizziness, weakness, increased irritation, death.	Death.*	
500-600	Coughing, collapse, and unconscio-usness.	Respiratory disturbances, irritation of eyes, collapse.*	Serious eye irritation, light shy, palpitation of heart, a few cases of death.	Severe pain in eyes and head, dizziness, trembling of extremities, great weakness and death.*			
600 or greater	Collapse, unconscio-usness, death.*						

*Data secured from experience on dogs that have a susceptibility similar to man.
Source: National Safety Council data sheet D-chem 15.

Table 3-2
Hazardous H_2S Concentration Levels for Various Exposure Times
Using the Perry and Articola[1980] H_2S Probit

Exposure Time (minutes)	Probit Value	Mortality Rate* (percent)	H_2S Concentration (ppm)
5	2.67 5.00 7.33	1 50 99	897 1,542 2,652
15	2.67 5.00 7.33	1 50 99	416 715 1,230
30	2.67 5.00 7.33	1 50 99	256 440 758
60	2.67 5.00 7.33	1 50 99	157 271 467

* Percent of population fatally affected.

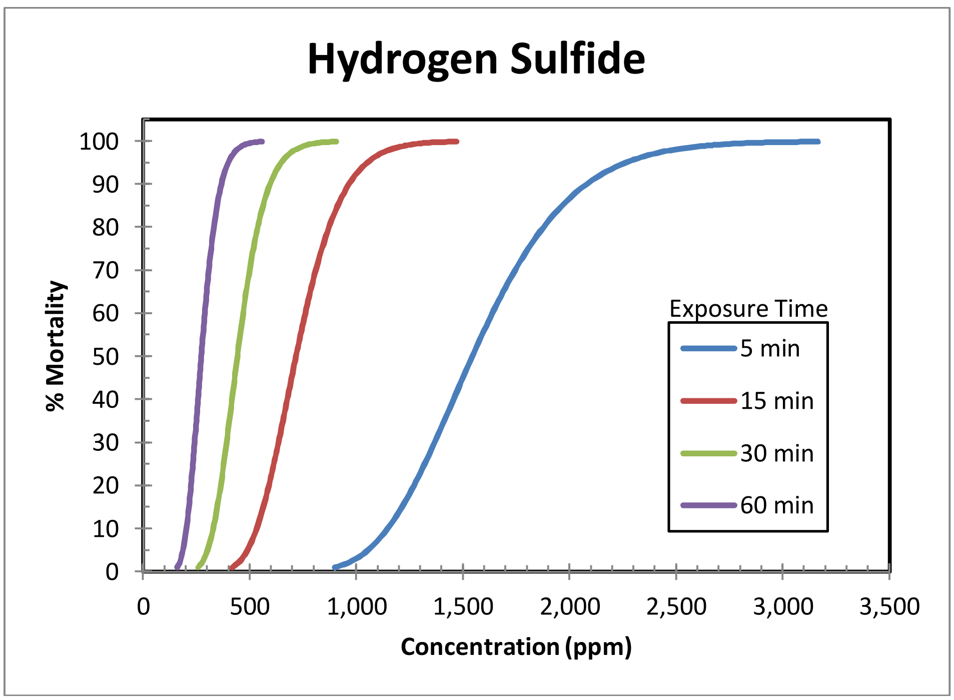

Figure 3-1
Hydrogen Sulfide Probit Functions

3.2 Physiological Effects of Ammonia

Ammonia (NH_3) is a colorless, toxic gas with a low threshold limit value (TLV). NH_3 is detectable by odor at concentrations much less than those necessary to cause harm. This allows persons who smell the gas to escape. The most serious hazard presented by NH_3 is from a large release from which escape is not possible. Table 3-3 describes various physiological effects of NH_3.

Table 3-3
Effects of Different Concentrations of Ammonia

Description	Concentration (ppmv)	Reference
TLV (Threshold Limit Value)	25	ACGIH
IDLH – This level represents a maximum concentration from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.	300	NIOSH
Concentration causing severe irritation of throat, nasal passages, and upper nasal tract.	400	Matheson
Concentration causing severe eye irritation.	700	Matheson
Concentration causing coughing and bronchial spasms. Possibly fatal for exposure of less than one-half hour.	1,700	Matheson
Minimum concentration for the onset of lethality after 30-minute exposure (fatal to 1% of exposed population).	1,883	Perry and Articola
Minimum concentration for 50% lethality after 30-minute exposure (fatal to 50% of exposed population).	4,005	Perry and Articola
Minimum concentration for 99% lethality after 30-minute exposure (fatal to 99% of exposed population).	8,519	Perry and Articola

ACGIH - Threshold Limit Values for 1976 (HSE, 1977 EH 15).
Matheson – *Matheson Gas Data Book* (Matheson Company, 1961).
NIOSH - "Pocket Guide to Chemical Hazards." Publication No. 94-116, 1994, Superintendent of Documents, Washington, D.C.
Perry, W. W., and W. P. Articola - "Study to Modify the Vulnerability Model of the Risk Management System." U.S. Coast Guard, Report CG-D-22-80, February, 1980.

A probit equation for NH_3 uses the values of -28.33, 2.27, and 1.36 for the constants *a*, *b*, and *n*, respectively [Perry and Articola, 1980]. Substituting these values into the general probit equation yields the following probit equation for NH_3.

$$Pr = -28.33 + 2.27 \ln(C^{1.36} \bullet t)$$

Using this probit equation, the NH_3 concentration that equates to a one percent mortality rate is 1,131 ppm for 60 minutes exposure, 1,883 ppm for 30 minutes exposure, or 3,135 ppm for 15 minutes exposure, etc., as shown in Table 3-4. Table 3-4 presents the mortality rates, dosage levels, and NH_3 concentrations for various exposure times, while Figure 3-2 presents the same information in graphical form.

Table 3-4
Hazardous NH_3 Concentration Levels for Various Exposure Times
Using the Perry and Articola [1980] NH_3 Probit

Exposure Time (minutes)	Probit Value	Mortality Rate* (percent)	NH_3 Concentration (ppm)
5	2.67 5.00 7.33	1 50 99	7,031 14,955 31,809
15	2.67 5.00 7.33	1 50 99	3,135 6,667 14,182
30	2.67 5.00 7.33	1 50 99	1,883 4,005 8,519
60	2.67 5.00 7.33	1 50 99	1,131 2,406 5,117

* Percent of population fatally affected.

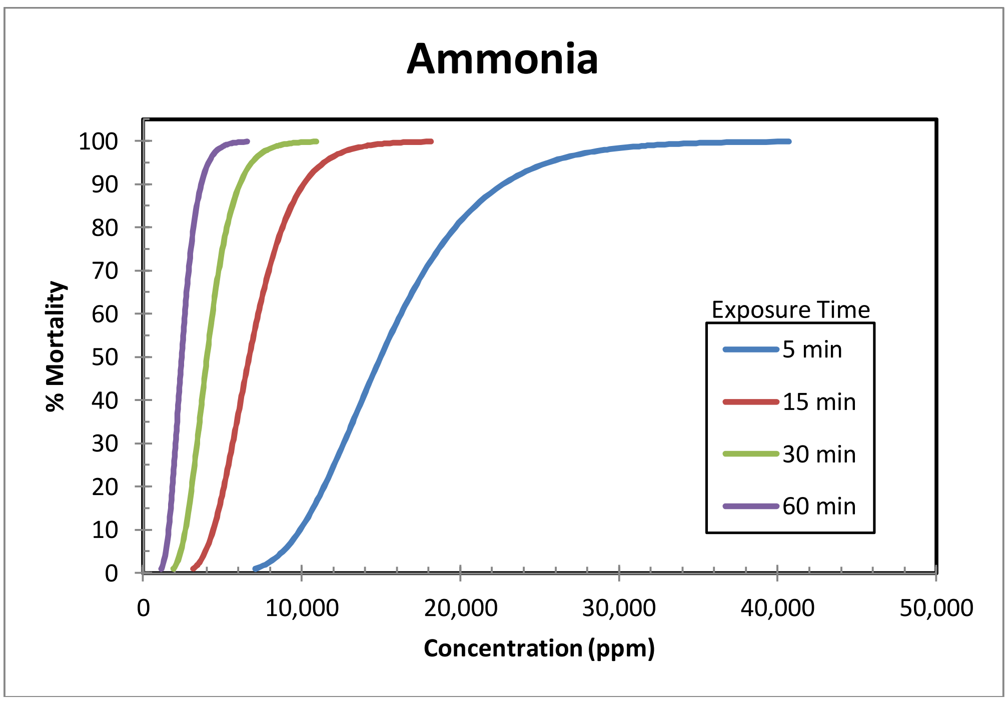

Figure 3-2
Ammonia Probit Functions

3.3 Physiological Effects of Hydrogen Cyanide

Hydrogen Cyanide (HCN) is a colorless, flammable, toxic gas. It is extremely poisonous and can cause fatality before a person is aware of its presence. HCN is said to have an odor similar to bitter almonds. It is extremely poisonous because it binds irreversibly to the iron atom in hemoglobin. This process reduces the ability of hemoglobin to transport oxygen to the body's cells and tissues. At relatively low concentrations, HCN can cause impaired vision, vomiting, nausea, or even death.

The effect of HCN exposure can vary greatly from person to person depending on their age and health, and the concentration and length of exposure. Many people cannot detect HCN, hence odor does not provide adequate warning of hazardous concentrations.

A probit equation for HCN has been presented by Perry and Articola [1980]. This probit uses the values of -29.4224, 3.008 and 1.43 for the constants *a*, *b*, and *n*, respectively. Substituting these values into the general probit equation yields the following probit equation for HCN.

$$Pr = -29.4224 + 3.008 \ln(C^{1.43} \bullet t)$$

Using this probit equation, the HCN concentration that equates to a one percent mortality rate is 99 ppm for 60 minutes exposure, 161 ppm for 30 minutes exposure, or 262 ppm for 15 minutes exposure, etc., as shown in Table 3-5. Table 3-5 presents the probit values, mortality rates, and HCN concentration for various exposure times, while Figure 3-3 presents the same information in graphical form.

Table 3-5
Hazardous HCN Concentration Levels for Various Exposure Times
Using the Perry and Articola [1980] HCN Probit

Exposure Time (minutes)	Probit Value	Mortality Rate* (percent)	HCN Concentration (ppm)
5	2.67 5.00 7.33	1 50 99	564 970 1,667
15	2.67 5.00 7.33	1 50 99	262 450 773
30	2.67 5.00 7.33	1 50 99	161 277 476
60	2.67 5.00 7.33	1 50 99	99 171 293

* Percent of population fatally affected.

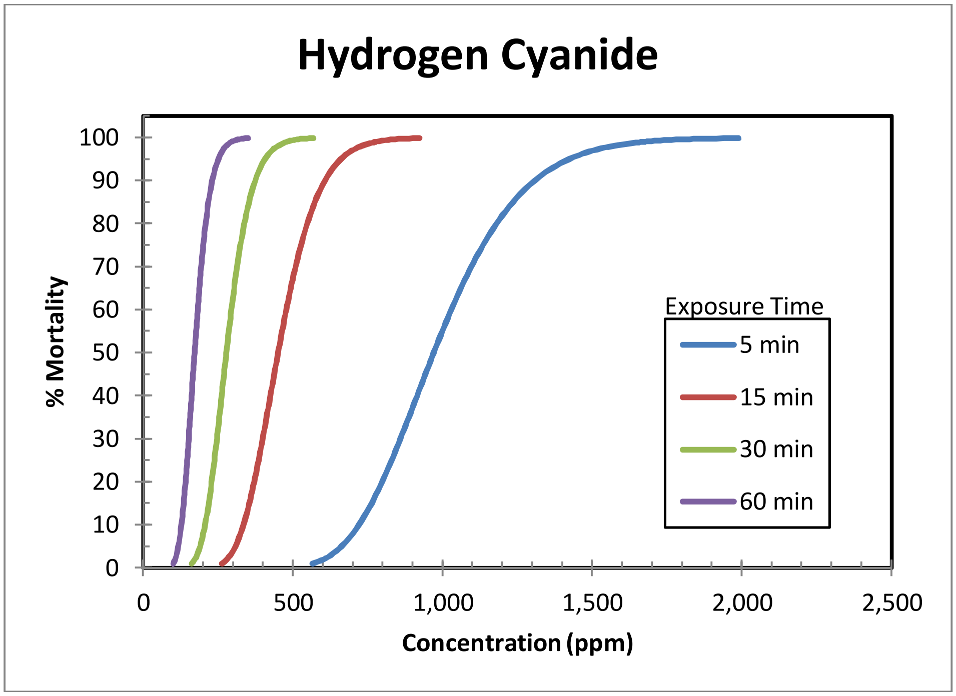

Figure 3-3
Hydrogen Cyanide Probit Functions

3.4 Physiological Effects of Sulfuric Acid

Sulfuric acid (H_2SO_4) normally exists as a colorless, oily liquid that is odorless. The most serious hazard presented by H_2SO_4 is exposure to a large release from which an acid mist is formed and escape is impossible. Table 3-6 describes various physiological effects of H_2SO_4 mist.

A probit equation for H_2SO_4 uses the values of -34.214, 4.178, and 1.00 for the constants *a*, *b*, and *n*, respectively [Mudan, 1990]. Substituting these values into the general probit equation yields the following probit equation for H_2SO_4.

$$Pr = -34.214 + 4.178 \ln(C^{1.00} \bullet t)$$

Using this probit equation, the H_2SO_4 concentration that equates to a one percent mortality rate is 114 ppm for 60 minutes exposure, 227 ppm for 30 minutes exposure, or 455 ppm for 15 minutes exposure, etc., as shown in Table 3-7. Table 3-7 presents the mortality rates and H_2SO_4 concentrations for various exposure times, while Figure 3-4 presents the same information in graphical form.

Table 3-6
Effects of Different Concentrations of Sulfuric Acid

Description	Concentration (mg/m^3) [ppm]	Reference
TLV-TWA. The time-weighted average concentration for a normal 8-hour work day and a 40-hour work week, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.	1.0 [0.25]	ACGIH
ERPG-1. The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing other than mild, transient adverse health effects or without perceiving a clearly defined objectionable odor.	2.0 [0.50]	AIHA
TEL-STEL. The concentration to which workers can be exposed continuously for a short period of time without suffering from 1) irritation, 2) chronic or irreversible tissue damage, or 3) narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue, or materially reduce work efficiency, and provided that the daily TLV-TWA is not exceeded. A STEL is defined as a 15-minute TWA exposure which should not be exceeded at any time during a work day, even if the 8-hour TWA is within the TLV-TWA.	3.0 [0.75]	ACGIH
ERPG-2. The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.	10.0 [2.5]	AIHA
Minimum concentration for the onset of lethality after 30-minute exposure (fatal to 1% of exposed population).	[3.53]	Mudan
Minimum concentration for the onset of lethality after 30-minute exposure (fatal to 50% of exposed population).	[6.16]	Mudan
ERPG-3. The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.	30.0 [7.5]	AIHA
Minimum concentration for the onset of lethality after 30-minute exposure (fatal to 99% of exposed population).	[10.76]	Mudan
IDLH. This level represents a maximum concentration from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.	80.0 [20.0]	NIOSH

ACGIH - "TLV's - Threshold Limit Values and Biological Exposure Indices for 1986-1987." American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, 1986: p. 21.

AIHA - "Emergency Response Planning Guidelines." American Industrial Hygiene Association, 1988.

Mudan, K. S. - *Quantitative Risk Assessment of Generic Hydrofluoric Acid and Sulfuric Acid Alkylation for Phillips Petroleum Company* (Appendix D, "Toxicology"). Technica Inc., 355 East Campus Boulevard, Suite 170, Columbus, Ohio 43235, 1990: p. D.19.

NIOSH - "Pocket Guide to Chemical Hazards." Publication No. 78-210, Superintendent of Documents, Washington, D.C.

Table 3-7
Hazardous H_2SO_4 Concentration Levels for Various Exposure Times
Using the Mudan [1990] H_2SO_4 Probit

Exposure Time (minutes)	Probit Value	Mortality Rate* (percent)	H_2SO_4 Concentration (ppm)
5	2.67 5.00 7.33	1 50 99	1,364 2,383 4,162
15	2.67 5.00 7.33	1 50 99	455 794 1,387
30	2.67 5.00 7.33	1 50 99	227 397 694
60	2.67 5.00 7.33	1 50 99	114 199 347

* Percent of population fatally affected.

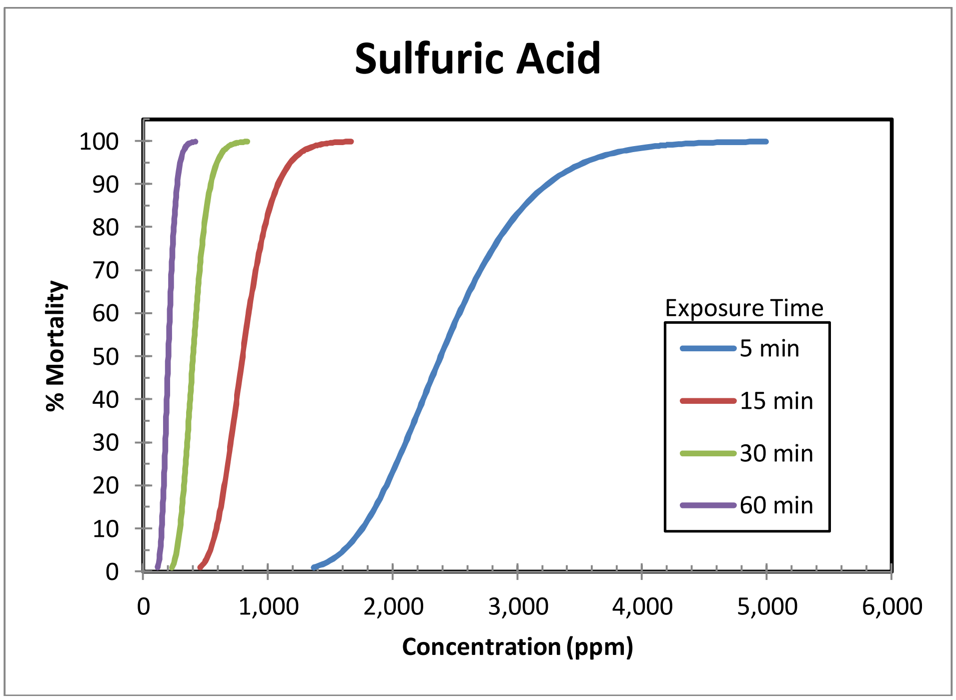

Figure 3-4
Sulfuric Acid Probit Functions

3.5 Physiological Effects of Sulfur Dioxide

Sulfur Dioxide (SO_2) is a colorless, nonflammable, toxic gas with a strong, irritating odor. SO_2 is so irritating that it provides its own warning of toxic concentration (odor detectable from 0.3 – 1 ppm). Similar to H_2S, the most serious hazard presented by SO_2 is exposure to a large release from which escape is impossible. The principle toxic effects of SO_2 are due to the formation of sulfurous acid when SO_2 comes into contact with water in bodily fluids.

A probit equation for SO_2 has been presented by Perry and Articola [1980]. This probit uses the values of -15.67, 2.100, and 1.00 for the constants *a*, *b*, and *n*, respectively. Substituting these values into the general probit equation yields the following probit equation for SO_2.

$$Pr = -15.67 + 2.100 \ \ln\ (C^{1.00} \bullet t)$$

Using this probit equation, the SO_2 concentration that equates to a one percent mortality rate is 103 ppm for 60 minutes exposure, 207 ppm for 30 minutes exposure, or 414 ppm for 15 minutes exposure, etc., as shown in Table 3-8. Table 3-8 presents the probit values, mortality rates, and SO_2 concentrations for various exposure times, while Figure 3-5 presents the same information in graphical form.

Table 3-8
Hazardous SO_2 Concentration Levels for Various Exposure Times
Using the Perry and Articola [1980] SO_2 Probit

Exposure Time [minutes]	Probit Value	Mortality Rate* [percent]	SO_2 Concentration [ppm]
5	2.67	1	1,241
	5.00	50	3,765
	7.33	99	11,418
15	2.67	1	414
	5.00	50	1,255
	7.33	99	3,806
30	2.67	1	207
	5.00	50	628
	7.33	99	1,903
60	2.67	1	103
	5.00	50	314
	7.33	99	952

*Percent of exposed population fatally affected.

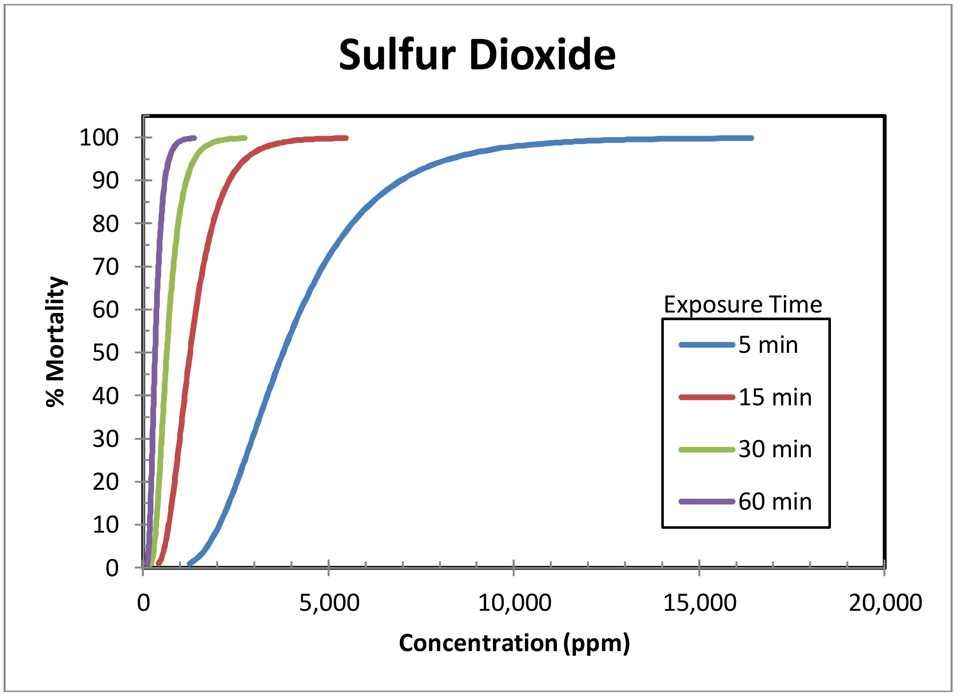

Figure 3-5
Sulfur Dioxide Probit Functions

3.6 Physiological Effects of Hydrogen Chloride

Hydrogen chloride (HCl) is a colorless, corrosive, toxic gas with a pungent, irritating odor. HCl is miscible in water. HCl is an irritant to eyes, skin, and mucous membranes. HCl has a low threshold limit value (TLV) and is detectable by odor at concentrations lower than those necessary to cause physical harm or impairment. The most serious hazard presented by HCl is exposure to a large release from which escape is impossible. Table 3-9 describes various effects of HCl.

A probit equation for HCl uses the values of -16.85, 2.00, and 1.00 for the constants *a*, *b*, and *n*, respectively [Perry and Articola, 1980]. Substituting these values into the general probit equation yields the following probit equation for HCl.

$$Pr = -16.85 + 2.00 \ln(C^{1.00} \bullet t)$$

Using this probit equation, the HCl concentration that equates to a one percent mortality rate is 289 ppm for 60 minutes exposure, 578 ppm for 30 minutes exposure, or 1,155 ppm for 15 minutes exposure, etc., as shown in Table 3-10. Table 3-10 presents the mortality rates, dosage levels, and HCl concentrations for various exposure times, while Figure 3-6 presents the same information in graphical form.

Table 3-9
Effects of Different Concentrations of Hydrogen Chloride

Description	Concentration (ppm)	Reference
TLV (Threshold Limit Value).	5	ACGIH
IDLH. This level represents a maximum concentration from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.	50	NIOSH
ERPG-3. The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.	100	AIHA
Minimum concentration for the onset of lethality after 30-minute exposure (fatal to 1% of exposed population).	578	Perry and Articola
Minimum concentration for 50% lethality after 30-minute exposure (fatal to 50% of exposed population).	1,852	Perry and Articola
Minimum concentration for 99% lethality after 30-minute exposure (fatal to 99% of exposed population).	5,936	Perry and Articola

ACGIH - "TLV's - Threshold Limit Values and Biological Exposure Indices for 1986-1987." American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, 1986: p. 21.
AIHA - "Emergency Response Planning Guidelines." American Industrial Hygiene Association, 1988.
NIOSH - "Pocket Guide to Chemical Hazards." Publication No. 94-116, 1994, Superintendent of Documents, Washington, D.C.
Perry, W. W., and W. P. Articola - "Study to Modify the Vulnerability Model of the Risk Management System." U.S. Coast Guard, Report CG-D-22-80, February, 1980.

Table 3-10
Hazardous HCl Concentration Levels for Various Exposure Times
Using the Perry and Articola [1980] HCl Probit

Exposure Time [minutes]	Probit Value	Mortality Rate* [percent]	HCl Concentration [ppm]
5	2.67	1	3,465
	5.00	50	11,110
	7.33	99	35,616
15	2.67	1	1,155
	5.00	50	3,703
	7.33	99	11,872
30	2.67	1	578
	5.00	50	1,852
	7.33	99	5,936
60	2.67	1	289
	5.00	50	926
	7.33	99	2,968

*Percent of exposed population fatally affected.

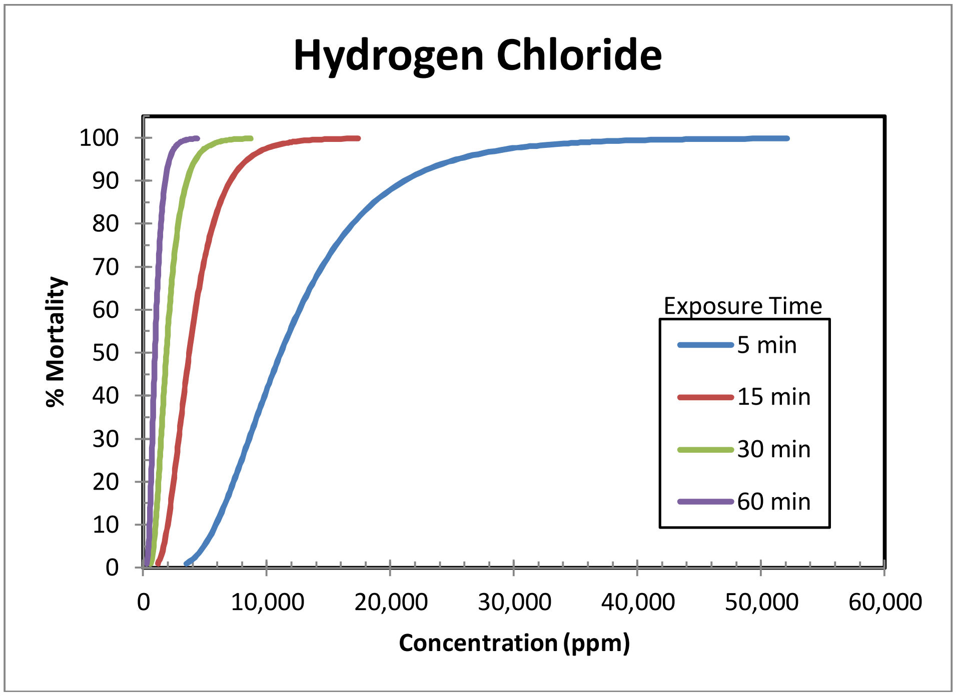

Figure 3-6
Hydrogen Chloride Probit Functions

3.7 Physiological Effects of Carbon Monoxide

Carbon Monoxide (CO) is a colorless, odorless, flammable, toxic gas. Due to these properties, CO can cause fatality before a person is aware of its presence. At low concentrations or exposures, CO may have only a mild impact, and may be mistaken for the flu. At higher concentrations, CO can cause impaired vision, nausea, or even death. Acute effects are due to the formation of carboxyhemoglobin in the blood, which limits oxygen intake. The effect of CO exposure can vary greatly from person to person depending on their age and health, and the concentration and length of exposure.

A probit equation for CO has been presented by TNO [1989]. This probit uses the values of -7.265, 1.000, and 1.00 for the constants *a*, *b*, and *n*, respectively. Substituting these values into the general probit equation yields the following probit equation for CO.

$$Pr = -7.265 + 1.000 \ln(C^{1.00} \bullet t)$$

Using this probit equation, the CO concentration that equates to a one percent mortality rate is 344 ppm for 60 minutes exposure, 688 ppm for 30 minutes exposure, or 1,376 ppm for 15 minutes exposure, etc., as shown in Table 3-11. Table 3-11 presents the probit values, mortality rates, and CO concentrations for various exposure times, while Figure 3-7 presents the same information in graphical form.

Table 3-11
Hazardous CO Concentration Levels for Various Exposure Times
Using the TNO [1989] CO Probit

Exposure Time [minutes]	Probit Value	Mortality Rate* [percent]	CO Concentration [ppm]
5	2.67 5.00 7.33	1 50 99	4,128 42,428 436,072
15	2.67 5.00 7.33	1 50 99	1,376 14,143 145,357
30	2.67 5.00 7.33	1 50 99	688 7,071 72,679
60	2.67 5.00 7.33	1 50 99	344 3,536 36,339

*Percent of exposed population fatally affected.

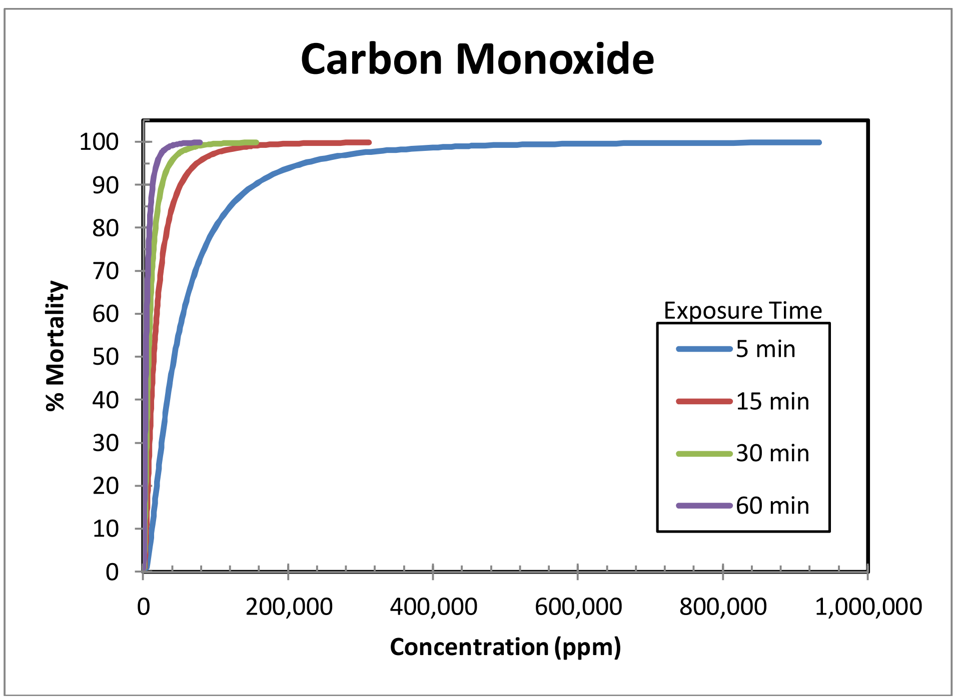

Figure 3-7
Carbon Monoxide Probit Functions

3.8 Physiological Effects of Carbonyl Sulfide

Carbonyl Sulfide (COS) is a colorless, flammable gas with an odor. Pure COS has no odor, but commercial grade has a typical sulfur odor and is detectable by odor at concentrations significantly lower than those necessary to cause physical harm or impairment, odor threshold of 0.1 ppm [U.S. EPA, 1992].

The most serious hazards presented by COS are exposure to a large release from which escape is impossible. Table 3-12 describes various physiological effects of COS.

A probit equation for COS has not been developed. A review of Table 3-12 would allow for the use of 190 ppm of COS to be conservatively used as the 1%, 50%, and 100% mortality level for exposure to COS for exposure time ranging from 10 to 30 minutes.

Table 3-12
Hazardous COS Concentration Levels for Various Exposure Times
According to NAC/AEGL Committee

AEGL	Exposure Time = 10 min	Exposure Time = 30 min	Exposure Time = 1 hr
AEGL-1 is the airborne concentration (expressed as parts per million or milligrams per cubic meter [ppm or mg/m3]) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.	NR	NR	NR
AEGL-2 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.	69 ppm (170 mg/m^3)	69 ppm (170 mg/m^3)	55 ppm (130 mg/m^3)
AEGL-3 is the airborne concentration (expressed as ppm or mg/m3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.	190 ppm (470 mg/m^3)	190 ppm (470 mg/m^3)	150 ppm (370 mg/m^3)

NR: Not Recommended due to insufficient data. The absence of AEGL-1 values does not imply that concentrations below AEGL-2 are without effect. Carbonyl sulfide has poor warning properties; it may cause serious effects or lethality at concentrations causing no signs or symptoms.

3.9 Physiological Effects of Carbon Dioxide

Carbon Dioxide (CO_2) is a colorless, odorless gas. The major hazard associated with CO_2 is asphyxiation. At low concentrations CO_2 may only have mild effects. At high concentrations, CO_2 can cause nausea, vomiting, asphyxiation and even death. The acute effects are due to displacement of oxygen by CO_2 resulting in reduced oxygen. Table 3-13 describes in detail the various effects of CO_2 concentrations.

A probit equation for CO_2 uses the values of -90.80, 1.01, and 8 for the constants *a*, *b*, and *n*, respectively [HSE, 2009]. Substituting these values into the general probit equation yields the following probit equation for CO_2.

$$Pr = -90.80 + 1.01 \ln(C^8 \bullet t)$$

Table 3-13
Effects of Different Concentrations of Carbon Dioxide

Oxygen Concentration	Effects and Symptoms (Due to Depleted Oxygen Content in Air [1])	Required Carbon Dioxide Concentration
15 - 19 %	Decreased ability to perform tasks. May impair coordination and may induce early symptoms in persons with head, lung, or circulatory problems.	28.6 - 9.5 % 286,000 - 95,000 ppmv
12 -14 %	Breathing increases, especially in exertion. Pulse up. Impaired coordination, perception, and judgment.	42.9 - 33.3 % 524,000 - 333,333 ppmv
10 - 12 %	Breathing further increases in rate and depth, poor coordination and judgment, lips slightly blue.	52.4 - 42.9 % 524,000 - 429,000 ppmv
8 - 10 %	Mental failure, fainting, unconsciousness, ashen face, blueness of lips, nausea (upset stomach), and vomiting.	61.9 - 52.4 % 619,000 - 524,000 ppmv
6 - 8 %	8 minutes, may be fatal in 50 to 100% of cases; 6 minutes, may be fatal in 25 to 50% of cases; 4-5 minutes, recovery with treatment.	71.4 - 61.9 % 714,000 - 619,000 ppmv
4 - 6 %	Coma in 40 seconds, followed by convulsions, breathing failure, death.	80.9 - 71.4 % 809,000 - 714,000 ppmv

[1] Compressed Gas Association Safety Bulletin [SB-2 - 1992]

Using this probit equation, the CO_2 concentration that equates to a one percent mortality rate is 63,340 ppm for 60 minutes exposure, 69,073 ppm for 30 minutes exposure, or 75,325 ppm for 15 minutes exposure, etc., as shown in Table 3-14. Table 3-14 presents the mortality rates, dosage levels, and CO_2 concentrations for various exposure times, while Figure 3-8 presents the same information in graphical form.

Table 3-14
Hazardous CO_2 Concentration Levels for Various Exposure Times
Using the HSE [2009] CO_2 Probit

Exposure Time [minutes]	Probit Value	Mortality Rate* [percent]	CO_2 Concentration [ppm]
5	2.67	1	86,413
	5.00	50	115,296
	7.33	99	153,833
15	2.67	1	75,325
	5.00	50	100,502
	7.33	99	134,094
30	2.67	1	69,073
	5.00	50	92,160
	7.33	99	122,965
60	2.67	1	63,340
	5.00	50	84,511
	7.33	99	112,759

*Percent of exposed population fatally affected.

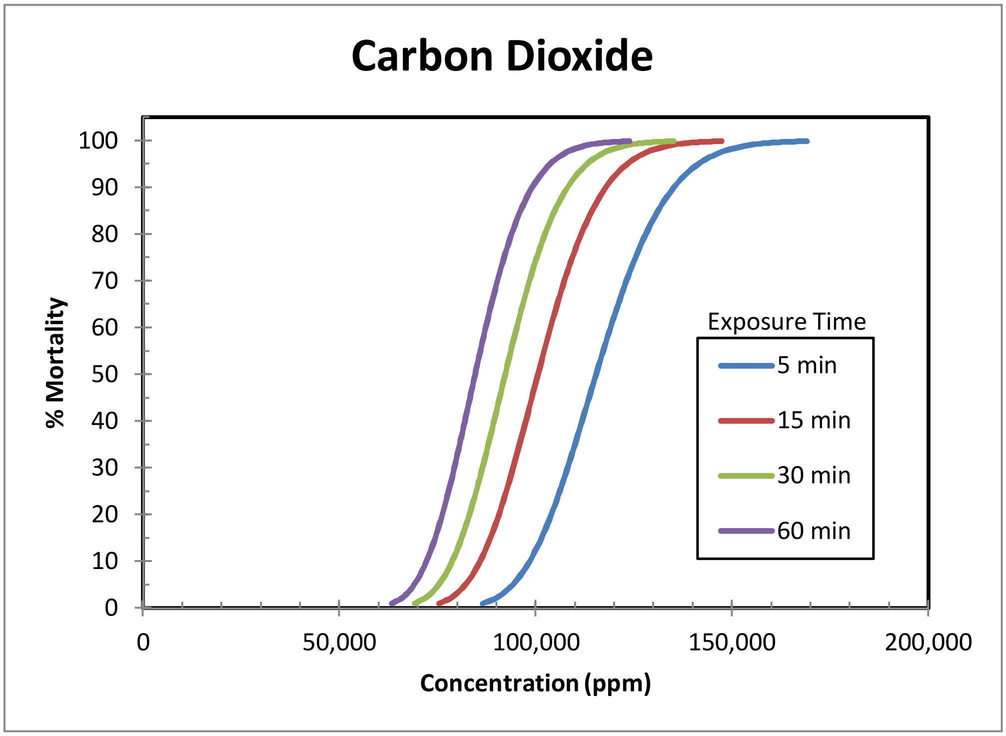

Figure 3-8
Carbon Dioxide Probit Functions

3.10 Physiological Effects of Exposure to Thermal Radiation from Fires

The physiological effect of fire on humans depends on the rate at which heat is transferred from the fire to the person, and the time the person is exposed to the fire. Even short-term exposure to high heat flux levels may be fatal. This situation could occur when persons wearing ordinary clothes are inside a flammable vapor cloud (defined by the lower flammable limit) when it is ignited. Persons located outside a flammable cloud when it is ignited will be exposed to much lower heat flux levels. If the person is far enough from the edge of the flammable cloud, the heat flux will be incapable of causing fatal injuries, regardless of exposure time. Persons closer to the cloud, but not within it, will be able to take action to protect themselves (e.g., moving farther away as the flames approach, or seeking shelter inside structures or behind solid objects).

In the event of a continuous torch fire during the release of flammable gas or gas/aerosol, or a pool fire, the thermal radiation levels necessary to cause fatal injuries to the public must be defined as a function of exposure time. This is typically accomplished through the use of probit equations, which are based on experimental dose-response data.

$$Pr = a + b \ln(t \bullet K^n)$$

where:

where:	Pr	=	probit
	K	=	intensity of the hazard
	t	=	time of exposure to the hazard
	a, b, and n	=	constants

The product $(t \bullet K^n)$ is often referred to as the "dose factor." According to probit equations, all combinations of intensity (*K*) and time (*t*) that result in equal dose factors also result in equal values for the probit (*Pr*) and therefore produce equal expected mortality rates for the exposed population.

Work sponsored by the U.S. Coast Guard [Tsao and Perry, 1979] developed the following probit relationship between exposure time and incident heat flux.

$$Pr = -38.479 + 2.56 \ln\left(t \bullet I^{4/3}\right)$$

where: t = exposure time, sec
I = effective thermal radiation intensity, kW/m^2

Table 3-15 presents the probit results for several exposure times that would be applicable for torch and pool fires. The mortality rates and corresponding thermal radiation levels are listed. The graphical form of the thermal radiation probit equation for different exposure times is presented in Figure 3-9.

The choice of thermal radiation flux levels is influenced by the duration of the fire and potential time of exposure to the flame by an individual. All combinations of incident heat flux (*I*) and exposure time (*t*) that result in equal values of "radiant dosage" $\left(t \bullet I^{4/3}\right)$ produce equal expected mortality rates. An exposure time of 30 seconds was chosen for this analysis for torch fires and pool fires. This is considered conservative (i.e., too long) as people who are exposed to radiant hazards are aware of the hazards and know in which direction to move in a very short period of time.

Table 3-15
Hazardous Thermal Radiation Levels for Various Exposure Times
Using the Tsao and Perry [1979] Thermal Radiation Probit

Exposure Time [seconds]	Probit Value	Mortality Rate* [percent]	Thermal Radiation [kW/m^2]
5	2.67	1	52
	5.00	50	102
	7.33	99	202
15	2.67	1	23
	5.00	50	45
	7.33	99	89
30	2.67	1	13
	5.00	50	27
	7.33	99	53
60	2.67	1	8
	5.00	50	16
	7.33	99	31

*Percent of exposed population fatally affected.

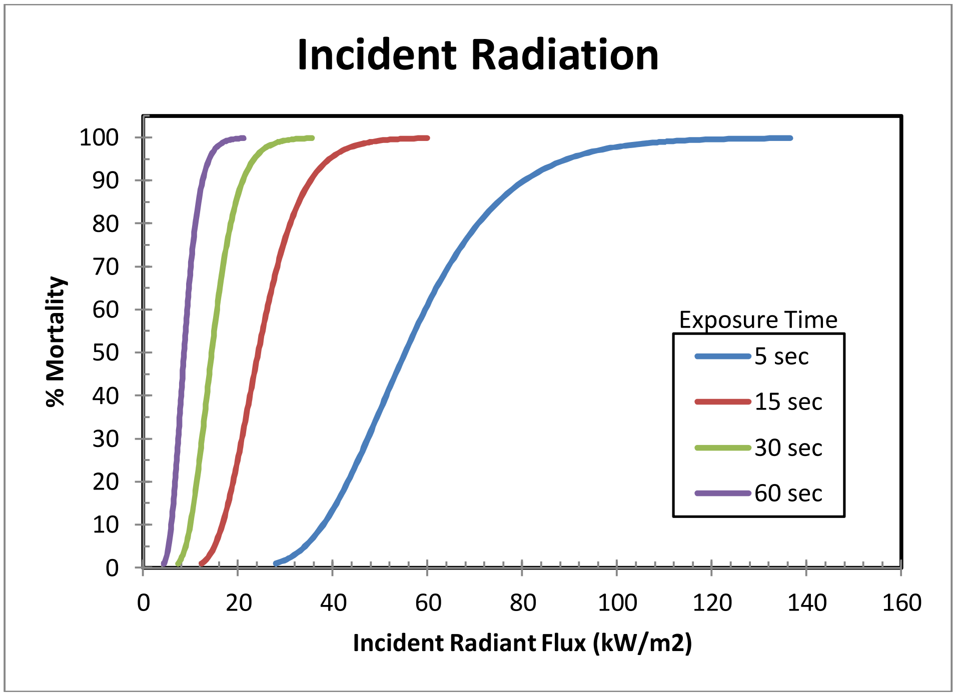

Figure 3-9
Incident Radiation Probit Functions

3.11 Physiological Effects of Overpressure

The damaging effect of overpressure on buildings depends on the peak overpressure that reaches a given structure, and the method of construction of that structure, as illustrated by Table 3-16. Similarly, the physiological effects of overpressure depend on the peak overpressure that reaches the person. Exposure to high overpressure levels may be fatal. If the person is far enough from the source of the explosion, the overpressure is incapable of causing fatal injuries.

The vapor cloud explosion (VCE) calculations in this analysis were made with the Baker-Strehlow-Tang model. This model is based on the premise that the strength of the blast wave generated by a VCE is dependent on the reactivity of the flammable gas involved; the presence (or absence) of structures such as walls or ceilings that partially confine the vapor cloud; and the spatial density of obstructions within the flammable cloud [Baker, et al., 1994, 1998]. This model reflects the results of several international research programs on vapor cloud explosions and deflagrations, which show that the strength of the blast wave generated by a VCE increases as the degree of confinement and/or obstruction of the cloud increases. The following quotations illustrate this point.

> "On the evidence of the trials performed at Maplin Sands, the deflagration [explosion] of truly unconfined flat clouds of natural gas or propane does not constitute a blast hazard." [Hirst and Eyre, 1982] (Tests conducted by Shell Research Ltd. in the United Kingdom.)

> "Both in two- and three-dimensional geometries, a continuous accelerating flame was observed in the presence of repeated obstacles. A positive feedback mechanism between the flame front and a disturbed flow field generated by the flame is responsible for this.

The disturbances in the flow field mainly concern flow velocity gradients. Without repeated obstacles, the flame front velocities reached are low both in two-dimensional and three-dimensional geometry." [van Wingerdan and Zeeuwen, 1983] (Tests conducted by TNO in the Netherlands.)

"The current understanding of vapor cloud explosions involving natural gas is that combustion only of that part of the cloud which engulfs a severely congested region, formed by repeated obstacles, will contribute to the generation of pressure." [Johnson, Sutton, and Wickens, 1991] (Tests conducted by British Gas in the United Kingdom.)

Researchers who have studied case histories of accidental vapor cloud explosions have reached similar conclusions.

"It is a necessary condition that obstacles or other forms of semi-confinement are present within the explosive region at the moment of ignition in order to generate an explosion." [Wiekema, 1984]

"A common feature of vapor cloud explosions is that they have all involved ignition of vapor clouds, at least part of which have engulfed regions of repeated obstacles." [Harris and Wickens, 1989]

In the event of an ignition and deflagration of a flammable gas or gas/aerosol cloud, the overpressure levels necessary to cause injury to the public are often defined as a function of peak overpressure. Unlike potential fire hazards, persons who are exposed to overpressure have no time to react or take shelter; thus, time does not enter into the hazard relationship. Work by the Health and Safety Executive, United Kingdom [HSE, 1991], has produced a probit relationship based on peak overpressure. This probit equation has the following form.

$$Pr = -23.8 + 2.92\ln(p)$$

where: p = peak overpressure, psig

Table 3-17 presents the probit results for exposure time that would be applicable for a vapor cloud explosion. The mortality rates and corresponding overpressure levels are listed. The graphical form of the overpressure probit equation for exposure time is presented in Figure 3-10.

Table 3-16
Damage Produced by Blast Waves [Clancey, 1972]

Overpressure		Damage
psig	kPag	
0.02	0.14	Annoying noise
0.04	0.28	Loud noise (143 dB)
0.15	1.0	Typical pressure for glass breakage
0.3	2.0	10% window glass broken
0.5 - 1.0	3.45-6.9	Large and small windows usually shattered; occasional damage to window frames
0.7	4.8	Minor damage to house structures
1.0	6.9	Partial demolition of houses, made uninhabitable
1.3	9.0	Steel frame of clad building slightly distorted
2.0	13.8	Partial collapse of walls and roofs of houses
2.3	15.8	Lower limit of serious structural damage
2.5	17.2	50% destruction of brickwork of houses
3.0	20.7	Steel frame building distorted and pulled away from foundations
3 - 4	20.7-27.6	Frameless, self-framing steel panel building demolished
4.0	27.6	Cladding of light industrial buildings ruptured
5.0	34.5	Wooden utility poles snapped
5.0 - 7.0	34.5-48.2	Nearly complete destruction of houses
7.0	48.3	Loaded railcars overturned
7.0 - 8.0	48.3-55.2	Brick panels, 8-12 inches (203-305 mm) thick, not reinforced, fail by shearing or flexure
9.0	62.1	Loaded train boxcars completely demolished
10.0	69.0	Probable total destruction of buildings

Table 3-17
Hazardous Overpressure Levels for Various Exposure Times
Using the HSE [1991] Overpressure Probit

Exposure Time [minutes]	Probit Value	Mortality Rate* [percent]	Overpressure psi [kPa]
Instantaneous	2.67	1	2.4 [16.6]
	5.00	50	13.2 [9.07]
	7.33	99	72.1 [496.9]

*Percent of exposed population fatally affected.

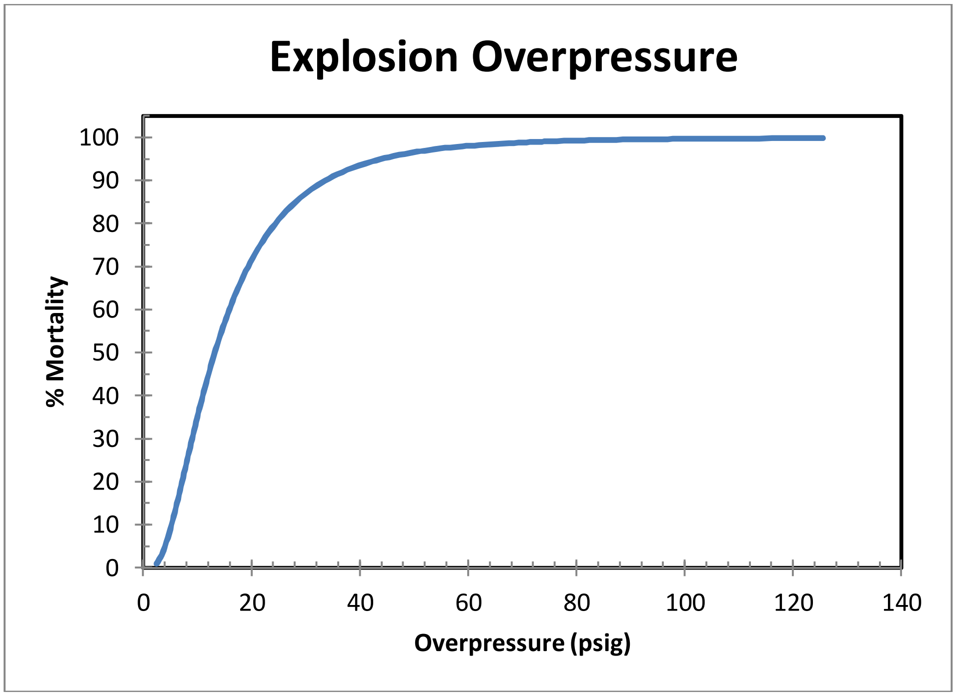

Figure 3-10
Explosion Overpressure Probit Function

3.12 Consequence Analysis

When performing site-specific consequence analysis studies, the ability to accurately model the release, dilution, and dispersion of gases and aerosols is important if an accurate assessment of potential exposure is to be attained. For this reason, Quest uses a modeling package, CANARY by Quest®, that contains a set of complex models that calculate release conditions, initial dilution of the vapor (dependent upon the release characteristics), and the subsequent dispersion of the vapor introduced into the atmosphere. The models contain algorithms that account for thermodynamics, mixture behavior, transient release rates, gas cloud density relative to air, initial velocity of the released gas, and heat transfer effects from the surrounding atmosphere and the substrate. The release and dispersion models contained in the QuestFOCUS package (the predecessor to CANARY by Quest) were reviewed in a United States Environmental Protection Agency (EPA) sponsored study [TRC, 1991] and an American Petroleum Institute (API) study [Hanna, Strimaitis, and Chang, 1991]. In both studies, the QuestFOCUS software was evaluated on technical merit (appropriateness of models for specific applications) and on model predictions for specific releases. One conclusion drawn by both studies was that the dispersion software tended to overpredict the extent of the gas cloud travel, thus resulting in too large a cloud when compared to the test data (i.e., a conservative approach).

A study prepared for the Minerals Management Service [Chang, et al.,1998] reviewed models for use in modeling routine and accidental releases of flammable and toxic gases. CANARY by Quest received the highest possible ranking in the science and credibility areas. In addition, the report recommends CANARY by Quest for use when evaluating toxic and flammable gas releases. The specific models (e.g., SLAB) contained in the CANARY by Quest software package have also been extensively reviewed.

Technical descriptions of the CANARY models used in this study are presented in Appendix A.

3.12.1 Toxic Concentration Limits for Process Streams Containing More Than One Toxic Compound

In many of the TCEP process streams, the fluid being transported or processed contains more than one toxic component. In some cases, the concentration of one of the toxic components is so much larger than the other toxic component(s), that the decision to model the impact from the dominant single component is easy to justify. This is because the hazard zone produced by the dominant toxic component will be large enough to completely engulf the hazard zone(s) produce by the other toxic component(s) in the fluid release.

For some process streams, identifying the toxic component that dominates or defines the impact zone is not as straight-forward. In the absence of data on the combined effect of these toxic gases on humans, the toxic hazards of each gas must be determined individually. In these cases, multiple runs of the consequence modeling software were conducted, using the component-specific probit concentration endpoints in order to identify the dominant toxic hazard.

3.12.2 Example Consequence Analysis Results

This section presents two sets of consequence analysis results for two of the process streams in TCEP. The first set of calculations describes how the toxic impacts are derived and the second set describes how the flammable (flash fire, torch fire, and explosion overpressure) impacts are defined.

3.12.2.1 Toxic Release and Dispersion Calculations for the Ammonia Production Line

Dispersion analyses were performed to determine the extent of ammonia gas clouds resulting from the ammonia line leaving the ammonia synthesis plant going to storage. The calculations were performed when ammonia was being produced at the maximum rate (328 STPD). The release scenario involves a rupture or hole in the piping. All releases are assumed to last until ammonia inventory is depleted. For this study, sixty minutes is considered the upper time limit within which a release begins, detection occurs, and corrective action is taken to stop the release. In light of the uncertainties in the available experimental data and probit equations in general, a minimum exposure time of five minutes is used in this study. Thus, even if the duration of a particular release is less than five minutes, the time a person may be exposed is assumed to be five minutes.

Mathematical models are used to calculate the time-varying release rates from the break or leak source. Most of the NH_3 releases modeled in this study are liquid releases in which part of the liquid flashes to vapor upon release. This behavior produces an aerosol of vapor, air, and small liquid drops that remain suspended; and larger liquid drops that fall to the ground (i.e., the “rainout” from the atmosphere). The ratio of vapor to aerosol to rainout varies according to the pressure, temperature, and composition of the liquid being released. The rainout portion forms a pool on the ground, and the pool is assumed to spread unconfined. The rate of vapor evolution from this pool is also modeled.

Release rate and liquid vaporization calculations are completed first, then dispersion calculations are performed. A momentum jet model is used to predict the dispersion of the gas and aerosol-laden vapor clouds because gas and aerosol releases have high velocities relative to the surrounding atmosphere and quickly entrain air into the plume. The entrainment of air is due to the momentum exchange and results in initial rapid dilution of the cloud. For aerosol releases, the rapid expansion of the plume and entrainment of air into the aerosol cloud cause the temperature of the plume to decrease as the liquid droplets are evaporating. These pressurized releases are described by the momentum jet aerosol model employed in this study.

For releases that result in a significant liquid portion reaching the ground (rainout), a second vapor cloud will be created. Dispersion of the second cloud is modeled using the SLAB dense gas dispersion model. Dense gas models are specifically designed to calculate the rate of dispersion of negatively buoyant gases in the atmosphere. In all cases where a second cloud developed, the downwind extent of the second cloud was markedly shorter than the extent of the aerosol-laden momentum jet cloud.

Tables 3-18, 3-19, and 3-20 illustrate how the dispersion results vary with atmospheric conditions and hole size. These tables provide the dispersion results from calculations performed for a full line rupture, one-inch puncture, and 1/4-inch leak in the piping associated with the ammonia production line leaving the ammonia synthesis unit. These tables contain the maximum downwind travel distances to the three NH_3 concentrations of interest for each cloud, using an accident duration of five minutes (time to deinventory the NH_3 from piping and terminate the release for a full line rupture) to 60 minutes for the 1/4-inch leak.

For the full line rupture, these concentrations represent exposures to 7,031 ppm (exposure time (Δt) = 5 min = 1% mortality); 14,955 ppm (Δt = 5 min = 50% mortality); and 31,809 ppm (Δt = 5 min = 99% mortality), respectively. As can be seen in Tables 3-18, 3-19, and 3-20, the maximum downwind extent of a vapor cloud occurs when the atmosphere is stable and the wind speed is low (i.e., F stability and a wind speed of 1 to 3 m/s). A summary of the maximum distances achieved by the 19 releases evaluated under low wind and average wind conditions is presented in Table 3-25.

A graphical example drawn from the dispersion results is presented in Figure 3-11. Figure 3-11 presents a plan view of the momentum jet cloud under moderate winds (4.63 m/s) and D stability following a rupture of the ammonia line leaving the ammonia synthesis unit. The outlines of the 7,031 ppm (1% mortality), 14,955 ppm (50% mortality), and 31,809 ppm (99% mortality) concentration levels within the cloud are presented.

In all cases, when two clouds were formed during a release, the maximum extent of the aerosol-laden (momentum jet) cloud was much greater than the extent of the cloud evolving from the liquid pool; therefore, the results from the momentum jet model dominate the analysis.

3.12.2.2 Flammable Release Calculations for the Clean Syngas Line Entering the Ammonia Synthesis Unit

In addition to the toxic dispersion calculations made, dispersion analyses were performed to determine the extent of flammable gas clouds resulting from the releases selected. These release scenarios involve holes in vessels and piping, seal failures, gasket failures, etc., in all areas of TCEP.

Release rate and liquid vaporization calculations are completed first, then dispersion calculations are performed to identify the size of the flash fire zone and the source terms for the torch fire, pool fire, and vapor cloud explosion scenarios.

Tables 3-21 and 3-22 illustrate how the flammable dispersion results vary with atmospheric conditions and hole size. These tables give the dispersion results from calculations performed for a line rupture and 1-inch puncture in the clean syngas line (99+% hydrogen) leaving the mercury and acid gas removal unit on its way to the ammonia synthesis unit. The leak scenarios produced impact zones less than 3 meters and not presented. These tables contain the maximum downwind travel distances to lower flammable limit (LFL) for each cloud.

3.12.2.3 Torch Fire Radiation Hazards Following Flammable Fluid Release

The extent of the potential torch fire hazards following a release from the clean syngas line is determined by many of the same parameters that define the flash fire for dispersion analysis. For torch fire calculations, the atmospheric stability is not an important parameter; thus, for each hole size, fewer thermal radiation calculations need to be made (one for each combination of hole size, wind speed, and release rate). A maximum of 36 torch fire radiation calculations are made for each release location (3 hole sizes x 6 wind speeds x 2 rates [immediate and delayed ignition]).

The distinction between immediate and delayed torch fires is based upon when the flammable cloud ignites following release. In general, the immediate torch fire will create a larger hazard because of the high mass flow during the initial seconds of a release. If a flammable fluid is ignited at some time after the release begins, the mass flow rate that feeds the torch fire is generally less. Thus, two torch fire outcomes are evaluated for each flammable gas/aerosol release scenario and each hole size. If a pool is created during the release, the opposite is true. The longer the ignition of the flammable vapors is delayed, the larger the pool may be, resulting in a larger radiant impact once ignited.

Results of the torch fire radiation calculations for the release of syngas feeding the ammonia synthesis unit are summarized in Tables 3-23 and 3-24 for the rupture and puncture scenarios. Since the fire radiation calculations are not a function of atmospheric stability, the matrix is defined differently. The rupture and puncture results for immediate torch fires are represented in Table 3-23. Delayed torch fire results are shown in Table 3-24.

Thermal radiation endpoints defined by the probit analysis for 30-second exposure are listed in Tables 3-23 and 3-24 as 7.27 kW/m^2 (1% mortality), 14.39 kW/m^2 (50% mortality), and 28.47 kW/m^2 (99% mortality). The ¼-inch leak fires are so small relative to the ruptures and punctures, they are not presented.

3.12.2.4 <u>Vapor Cloud Explosion Overpressure Hazards</u>

The extent of a potential explosion overpressure hazard zone is initially influenced by the same parameters as the flash fire hazard zones. Once a flammable cloud develops, it then requires an ignition source and some degree of confinement or congestion in order to develop significant overpressure. Areas within TCEP that provide this congestion or confinement are associated with the process equipment, piping and piperacks, and infrastructure components. As part of the analysis, potential areas of congestion were identified as those where sufficient confinement of a flammable cloud might be possible and the vapor cloud explosion calculations were performed accordingly. The results of the vapor cloud explosion calculations, for the vapor cloud ignitions that could result in overpressures high enough to cause a fatality, are listed in Table 3-25.

3.13 Summary of Consequence Analysis Results

Table 3-25 presents a summary of the largest impacts from each of the major process lines transporting flammable or toxic materials from one process unit to another. Incoming and outgoing pipeline releases as well as anhydrous ammonia storage releases are also used in Table 3-25. In each table, the maximum ground level distances to the specified mortality endpoints are listed for ruptures, punctures, and leaks from project equipment.

Table 3-18
NH_3 Dispersion Results – Aerosol Jet Model
Rupture of Line Leaving Ammonia Synthesis Unit

Momentum jet:
Title: Maximum downwind distances
Case name: Rupture of line leaving ammonia synthesis unit
Concentrations: 12vtxr

C low C medium C high	C low C medium C high	7,031 ppm NH_3 (Δt = 5 min) 14,955 ppm NH_3 (Δt = 5 min) 31,809 ppm NH_3 (Δt = 5 min)

Downwind Distance in Meters to Concentration Level

11.32 m/s wind speed			13 9 <5	25 16 <5		
10.36 m/s wind speed			14 9 <5	26 17 <5		
7.20 m/s wind speed			17 12 <5	73 27 <5		
4.63 m/s wind speed		14 10 6	38 15 9	142 78 33	164 100 56	
2.83 m/s wind speed	12 8 6	51 13 9	130 77 30	150 101 61	177 118 74	190 126 81
1.03 m/s wind speed	96 75 34	113 78 51	128 94 66	148 108 77		177 128 90
	A stability	B stability	C Stability	D stability	E stability	F stability

Table 3-19
NH_3 Dispersion Results – Aerosol Jet Model
1-Inch Hole in Line Leaving Ammonia Synthesis Unit

Momentum jet:	
Title:	Maximum downwind distances
Case name:	1-inch hole in line leaving ammonia synthesis unit
Concentrations:	12vtxp

C low	C low	3,983 ppm NH_3 (Δt = 11 min)
C medium	C medium	8,472 ppm NH_3 (Δt = 11 min)
C high	C high	18,020 ppm NH_3 (Δt = 11 min)

Downwind Distance in Meters to Concentration Level

11.32 m/s wind speed			18 12 8	67 24 15		
10.36 m/s wind speed			19 13 9	93 46 16		
7.20 m/s wind speed			23 16 11	158 96 53		
4.63 m/s wind speed		18 13 9	179 106 51	203 131 82	217 140 89	
2.83 m/s wind speed	73 11 8	167 106 63	198 140 93	233 161 109	266 180 118	290 194 126
1.03 m/s wind speed	167 142 82	172 146 120	195 151 124	220 163 120		266 192 138
	A stability	B stability	C stability	D stability	E stability	F stability

Table 3-20
NH_3 Dispersion Results – Aerosol Jet Model
1/4-Inch Hole In Line Leaving Ammonia Synthesis Unit

Momentum jet:	
Title:	Maximum downwind distances
Case name:	1/4-inch hole in line leaving ammonia synthesis unit
Concentrations:	12vtxq

C low	C low	1,883 ppm NH_3 (Δt = 30 min)
C medium	C medium	4,005 ppm NH_3 (Δt = 30 min)
C high	C high	8,519 ppm NH_3 (Δt = 30 min)

Downwind Distance in Meters to Concentration Level

11.32 m/s wind speed			11 7 <5	22 14 <5		
10.36 m/s wind speed			12 8 <5	23 15 <5		
7.20 m/s wind speed			14 10 6	89 48 20		
4.63 m/s wind speed		11 8 5	19 13 9	158 103 65	167 110 72	
2.83 m/s wind speed	9 6 5	92 42 8	169 118 75	188 130 86	212 142 92	237 158 100
1.03 m/s wind speed	120 86 61	139 107 82	161 119 93	183 135 100		224 159 111
	A stability	B stability	C stability	D stability	E stability	F stability

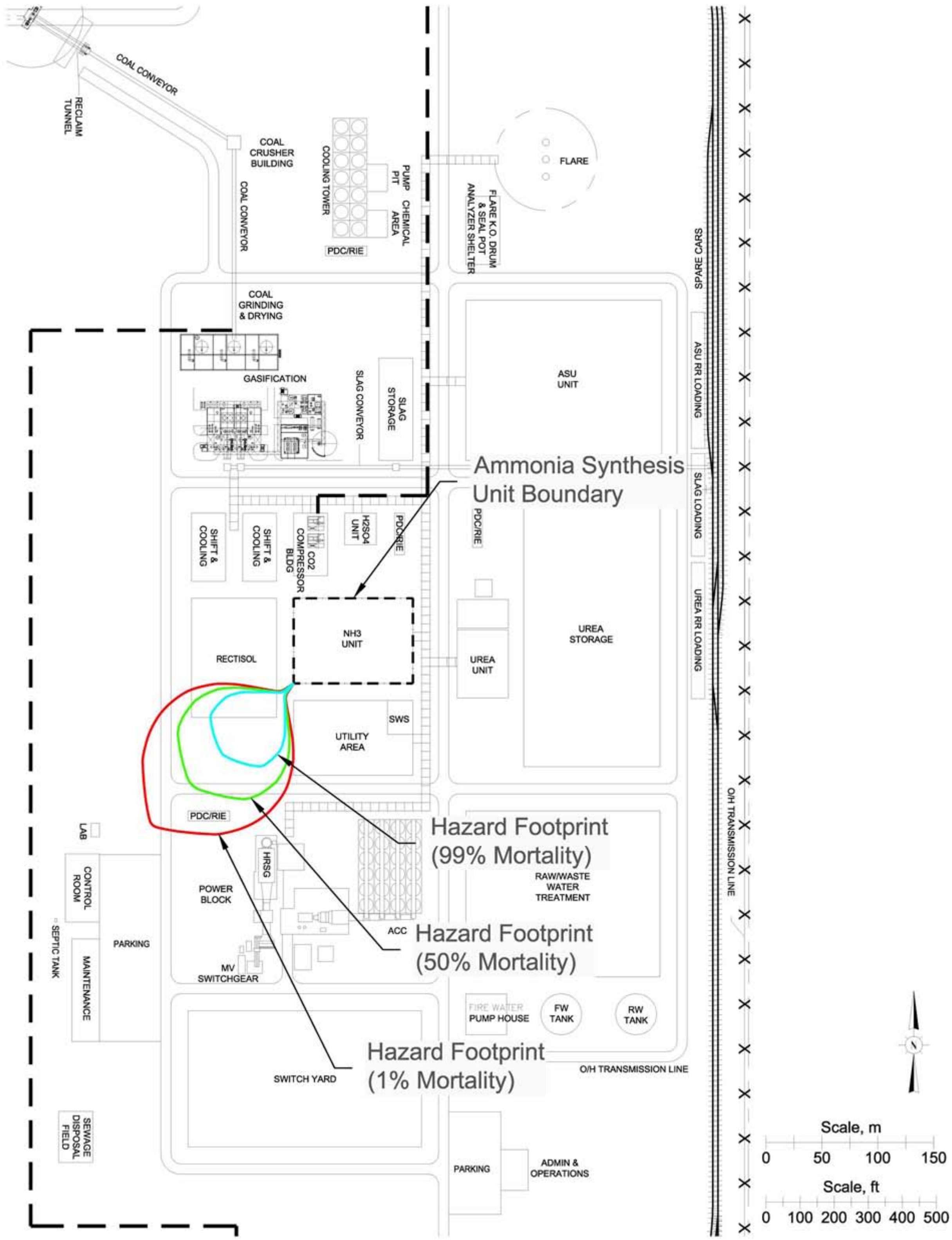

Figure 3-11
Overhead View of Toxic Vapor Dispersion Cloud

Table 3-21
Flammable Dispersion Results – Momentum Jet Model
Rupture of Syngas Line Entering Ammonia Synthesis Unit

Momentum jet: Maximum downwind distances
Title: Rupture of syngas line entering ammonia synthesis unit
Case name: 11vfxr
Concentrations:

C	C	LFL (4.0 mol %)

Downwind Distance in Meters to Concentration Level

11.32 m/s wind speed			13	20		
10.36 m/s wind speed			14	21		
7.20 m/s wind speed			17	23		
4.63 m/s wind speed		16	20	26	30	
2.83 m/s wind speed	15	20	24	29	32	34
1.03 m/s wind speed	23	27	30	33		35
	A stability	B stability	C stability	D stability	E stability	F stability

Table 3-22
Flammable Dispersion Results – Momentum Jet Model
1-Inch Hole in Syngas Line Entering Ammonia Synthesis Unit

Momentum jet: Maximum downwind distances
Title: 1-inch hole in syngas line entering ammonia synthesis unt
Case name: 11vfxp
Concentrations:

C	C	LFL (4.0 mol %)

Downwind Distance in Meters to Concentration Level

11.32 m/s wind speed			<5	<5		
10.36 m/s wind speed			<5	<5		
7.20 m/s wind speed			<5	<5		
4.63 m/s wind speed		<5	<5	<5	<5	
2.83 m/s wind speed	<5	<5	<5	<5	<5	<5
1.03 m/s wind speed	<5	<5	<5	<5		<5
	A stability	B stability	C stability	D stability	E stability	F stability

Table 3-23
Summary of Immediate Torch Fire Impacts
for a Release from Syngas Line Entering the Ammonia Synthesis Unit

Endpoints:

RAD low	7.27 kW/m^2	(2,304 Btu/hr · ft^2)	1% mortality
RAD middle	14.39 kW/m^2	(4,561 Btu/hr · ft^2)	50% mortality
RAD high	28.47 kW/m^2	(9,025 Btu/hr · ft^2)	99% mortality

Downwind Distance in Metres to Thermal Radiation Level

11.32 m/s wind speed	27 24 21	13 13 13
10.36 m/s wind speed	27 24 21	13 13 13
7.21 m/s wind speed	27 23 20	13 13 13
4.63 m/s wind speed	27 23 18	13 13 13
2.83 m/s wind speed	26 22 16	13 13 13
1.03 m/s wind speed	25 19 9	13 13 13
	Rupture	**Puncture**

Table 3-24
Summary of Delayed Torch Fire Impacts
for a Release from Syngas Line Entering the Ammonia Synthesis Unit

Endpoints:

RAD low	7.27 kW/m^2	(2,304 $Btu/hr \cdot ft^2$)	1% mortality
RAD middle	14.39 kW/m^2	(4,561 $Btu/hr \cdot ft^2$)	50% mortality
RAD high	28.47 kW/m^2	(9,025 $Btu/hr \cdot ft^2$)	99% mortality

Downwind Distance in Metres to Thermal Radiation Level

11.32 m/s wind speed	23 20 18	13 13 13
10.36 m/s wind speed	23 20 18	13 13 13
7.21 m/s wind speed	23 20 17	13 13 13
4.63 m/s wind speed	23 19 15	13 13 13
2.83 m/s wind speed	22 18 12	13 13 13
1.03 m/s wind speed	21 16 7	13 13 13
	Rupture	**Puncture**

Table 3-25
Summary of Consequence Modeling Results for
"Worst Case" and "Average" Meteorological Conditions

Release Location [Toxic/Asphyxiant]	Hole Size (Effective Diameter)	Weather (Wind Speed (m/s)/ Stability)	Grade Level Impact Distance (m) to Flash Fire Endpoint	Grade Level Impact Distance (m) to Toxic or Asphyxiant Probit Endpoints			Grade Level Impact Distance (m) to Overpressure Probit Endpoints			Grade Level Impact Distance (m) to Radiation Probit Endpoints		
			Mortality Level	Mortality Level			Mortality Level			Mortality Level		
			100%	1%	50%	99%	1%	50%	99%	1%	50%	99%
Scrubbed syngas to shift [Carbon Monoxide]	32"	1.03/F	< 5	199	0	0	22	5	3	90	88	85
		4.63/D	< 5	155	0	0	21	5	3	90	88	85
	1"	1.03/F	< 5	101	0	0	2	2	0	12	12	12
		4.63/D	< 5	45	0	0	2	2	0	12	12	12
	1/4"	1.03/F	< 5	29	0	0	1	1	1	0	0	0
		4.63/D	< 5	0	0	0	1	1	1	0	0	0
Shifted syngas to acid gas removal	30"	1.03/F	63	0	0	0	51	12	6	99	96	91
		4.63/D	48	0	0	0	45	11	6	99	96	91
	1"	1.03/F	< 5	0	0	0	6	1	1	16	15	0
		4.63/D	< 5	0	0	0	5	1	1	16	15	0
	1/4"	1.03/F	< 5	0	0	0	1	1	1	0	0	0
		4.63/D	< 5	0	0	0	1	1	1	0	0	0
Clean syngas to ammonia synthesis	12"	1.03/F	35	0	0	0	34	8	4	25	19	9
		4.63/D	26	0	0	0	29	7	4	27	23	18
	1"	1.03/F	< 5	0	0	0	10	2	1	13	13	13
		4.63/D	< 5	0	0	0	9	2	1	13	13	13
	1/4"	1.03/F	< 5	0	0	0	2	2	0	5	0	0
		4.63/D	< 5	0	0	0	2	2	0	5	0	0

Table 3-25 (continued)
Summary of Consequence Modeling Results for
"Worst Case" and "Average" Meteorological Conditions

Release Location [Toxic/Asphyxiant]	Hole Size (Effective Diameter)	Weather (Wind Speed (m/s)/ Stability)	Grade Level Impact Distance (m) to Flash Fire Endpoint	Grade Level Impact Distance (m) to Toxic or Asphyxiant Probit Endpoints			Grade Level Impact Distance (m) to Overpressure Probit Endpoints			Grade Level Impact Distance (m) to Radiation Probit Endpoints		
			Mortality Level	Mortality Level			Mortality Level			Mortality Level		
			100%	1%	50%	99%	1%	50%	99%	1%	50%	99%
Ammonia product [Ammonia]	3"	1.03/F	0	177	128	90	0	0	0	0	0	0
		4.63/D	0	142	78	33	0	0	0	0	0	0
	1"	1.03/F	0	266	192	138	0	0	0	0	0	0
		4.63/D	0	203	131	82	0	0	0	0	0	0
	1/4"	1.03/F	0	224	159	111	0	0	0	0	0	0
		4.63/D	0	158	103	65	0	0	0	0	0	0
Ammonia to urea synthesis [Ammonia]	6"	1.03/F	0	324	252	195	0	0	0	0	0	0
		4.63/D	0	258	194	145	0	0	0	0	0	0
	1"	1.03/F	0	401	324	253	0	0	0	0	0	0
		4.63/D	0	329	233	166	0	0	0	0	0	0
	1/4"	1.03/F	0	228	167	123	0	0	0	0	0	0
		4.63/D	0	154	103	68	0	0	0	0	0	0
Slag/black water flash gas	3"	1.03/F	0	0	0	0	2	2	0	0	0	0
		4.63/D	0	0	0	0	2	2	1	0	0	0
	1"	1.03/F	0	0	0	0	1	1	1	0	0	0
		4.63/D	0	0	0	0	1	1	1	0	0	0
	1/4"	1.03/F	0	0	0	0	1	1	1	0	0	0
		4.63/D	0	0	0	0	1	1	1	0	0	0

Table 3-25 (continued)
Summary of Consequence Modeling Results for
"Worst Case" and "Average" Meteorological Conditions

Release Location [Toxic/Asphyxiant]	Hole Size (Effective Diameter)	Weather (Wind Speed (m/s)/ Stability)	Grade Level Impact Distance (m) to Flash Fire Endpoint	Grade Level Impact Distance (m) to Toxic or Asphyxiant Probit Endpoints			Grade Level Impact Distance (m) to Overpressure Probit Endpoints			Grade Level Impact Distance (m) to Radiation Probit Endpoints		
			Mortality Level	Mortality Level			Mortality Level			Mortality Level		
			100%	1%	50%	99%	1%	50%	99%	1%	50%	99%
Acid gas to sulfuric acid [Hydrogen Sulfide]	8"	1.03/F	14	112	90	72	8	2	1	6	0	0
		4.63/D	< 5	84	59	38	4	2	1	7	0	0
	1"	1.03/F	< 5	74	51	32	1	1	1	0	0	0
		4.63/D	< 5	0	0	0	1	1	1	0	0	0
	1/4"	1.03/F	< 5	0	0	0	1	1	1	0	0	0
		4.63/D	<5	0	0	0	1	1	1	0	0	0
Clean syngas to power block	18"	1.03/F	50	0	0	0	45	11	6	46	38	12
		4.63/D	39	0	0	0	38	9	5	48	42	34
	1"	1.03/F	< 5	0	0	0	9	2	1	16	16	16
		4.63/D	< 5	0	0	0	8	2	1	16	16	16
	1/4"	1.03/F	< 5	0	0	0	2	2	0	5	0	0
		4.63/D	<5	0	0	0	2	2	0	5	0	0
Clean syngas to duct firing	3"	1.03/F	< 5	0	0	0	8	2	1	8	0	0
		4.63/D	< 5	0	0	0	7	2	1	9	0	0
	1"	1.03/F	< 5	0	0	0	6	1	1	10	9	0
		4.63/D	< 5	0	0	0	5	1	1	10	9	0
	1/4"	1.03/F	< 5	0	0	0	2	2	0	5	0	0
		4.63/D	< 5	0	0	0	2	2	0	5	0	0

Table 3-25 (continued)
Summary of Consequence Modeling Results for
“Worst Case” and “Average” Meteorological Conditions

Release Location [Toxic/Asphyxiant]	Hole Size (Effective Diameter)	Weather (Wind Speed (m/s)/ Stability)	Grade Level Impact Distance (m) to Flash Fire Endpoint	Grade Level Impact Distance (m) to Toxic or Asphyxiant Probit Endpoints			Grade Level Impact Distance (m) to Overpressure Probit Endpoints			Grade Level Impact Distance (m) to Radiation Probit Endpoints		
			Mortality Level	Mortality Level			Mortality Level			Mortality Level		
			100%	1%	50%	99%	1%	50%	99%	1%	50%	99%
Nitrogen wash offgas [Carbon Monoxide]	10"	1.03/F	< 5	46	0	0	5	1	1	10	8	6
		4.63/D	< 5	23	0	0	4	2	1	10	8	7
	1"	1.03/F	< 5	30	0	0	1	1	1	4	0	0
		4.63/D	< 5	0	0	0	1	1	1	4	0	0
	1/4"	1.03/F	< 5	0	0	0	1	1	1	0	0	0
		4.63/D	< 5	0	0	0	1	1	1	0	0	0
Stack gas to atmosphere [Nitrogen]	20"	1.03/F	0	69	62	55	0	0	0	0	0	0
		4.63/D	0	31	27	23	0	0	0	0	0	0
	1"	1.03/F	0	9	7	6	0	0	0	0	0	0
		4.63/D	0	0	0	0	0	0	0	0	0	0
	1/4"	1.03/F	0	0	0	0	0	0	0	0	0	0
		4.63/D	0	0	0	0	0	0	0	0	0	0
Purified CO_2 to urea system [Carbon Dioxide]	3"	1.03/F	0	64	56	48	0	0	0	0	0	0
		4.63/D	0	29	24	20	0	0	0	0	0	0
	1"	1.03/F	0	51	37	26	0	0	0	0	0	0
		4.63/D	0	0	0	0	0	0	0	0	0	0
	1/4"	1.03/F	0	0	0	0	0	0	0	0	0	0
		4.63/D	0	0	0	0	0	0	0	0	0	0

Table 3-25 (continued)
Summary of Consequence Modeling Results for
"Worst Case" and "Average" Meteorological Conditions

Release Location [Toxic/Asphyxiant]	Hole Size (Effective Diameter)	Weather (Wind Speed (m/s)/ Stability)	Grade Level Impact Distance (m) to Flash Fire Endpoint	Grade Level Impact Distance (m) to Toxic or Asphyxiant Probit Endpoints			Grade Level Impact Distance (m) to Overpressure Probit Endpoints			Grade Level Impact Distance (m) to Radiation Probit Endpoints		
			Mortality Level	Mortality Level			Mortality Level			Mortality Level		
			100%	1%	50%	99%	1%	50%	99%	1%	50%	99%
CO_2 to EOR [Carbon Dioxide]	10"	1.03/F	0	139	101	77	0	0	0	0	0	0
		4.63/D	0	131	114	97	0	0	0	0	0	0
	1"	1.03/F	0	110	79	29	0	0	0	0	0	0
		4.63/D	0	66	54	43	0	0	0	0	0	0
	1/4"	1.03/F	0	31	24	0	0	0	0	0	0	0
		4.63/D	0	0	0	0	0	0	0	0	0	0
Nitrogen diluents to gas turbine [Nitrogen]	60"	1.03/F	0	9	7	4	0	0	0	0	0	0
		4.63/D	0	13	10	7	0	0	0	0	0	0
	1"	1.03/F	0	0	0	0	0	0	0	0	0	0
		4.63/D	0	0	0	0	0	0	0	0	0	0
	1/4"	1.03/F	0	0	0	0	0	0	0	0	0	0
		4.63/D	0	0	0	0	0	0	0	0	0	0
Gas turbine exhaust to HRSG [Nitrogen]	198"	1.03/F	0	10	9	9	0	0	0	0	0	0
		4.63/D	0	13	12	10	0	0	0	0	0	0
	1"	1.03/F	0	0	0	0	0	0	0	0	0	0
		4.63/D	0	0	0	0	0	0	0	0	0	0
	1/4"	1.03/F	0	0	0	0	0	0	0	0	0	0
		4.63/D	0	0	0	0	0	0	0	0	0	0

Table 3-25 (continued)
Summary of Consequence Modeling Results for
"Worst Case" and "Average" Meteorological Conditions

Release Location [Toxic/Asphyxiant]	Hole Size (Effective Diameter)	Weather (Wind Speed (m/s)/ Stability)	Grade Level Impact Distance (m) to Flash Fire Endpoint	Grade Level Impact Distance (m) to Toxic or Asphyxiant Probit Endpoints			Grade Level Impact Distance (m) to Overpressure Probit Endpoints			Grade Level Impact Distance (m) to Radiation Probit Endpoints		
			Mortality Level	Mortality Level			Mortality Level			Mortality Level		
			100%	1%	50%	99%	1%	50%	99%	1%	50%	99%
HRSG vent [Nitrogen]	132"	1.03/F	0	19	17	16	0	0	0	0	0	0
		4.63/D	0	27	23	20	0	0	0	0	0	0
	1"	1.03/F	0	0	0	0	0	0	0	0	0	0
		4.63/D	0	0	0	0	0	0	0	0	0	0
	1/4"	1.03/F	0	0	0	0	0	0	0	0	0	0
		4.63/D	0	0	0	0	0	0	0	0	0	0
Natural gas to coal grinding and drying	4"	1.03/F	< 5	0	0	0	6	0	0	17	15	15
		4.63/D	< 5	0	0	0	5	0	0	17	15	15
	1"	1.03/F	< 5	0	0	0	6	0	0	16	16	16
		4.63/D	< 5	0	0	0	5	0	0	16	16	16
	1/4"	1.03/F	< 5	0	0	0	3	0	0	10	9	9
		4.63/D	<5	0	0	0	2	0	0	10	9	9
Pressurized ammonia storage [Ammonia]	6"	1.03/F	74	1415	972	750	86	21	11	96	95	94
		4.63/D	133	1174	845	622	236	56	30	96	95	94
	1"	1.03/F	0	498	419	294	20	5	3	22	22	21
		4.63/D	0	435	310	215	16	4	2	22	22	21
	1/4"	1.03/F	0	204	147	102	0	0	0	0	0	0
		4.63/D	0	130	81	47	0	0	0	0	0	0

SECTION 4
ACCIDENT FREQUENCY

The likelihood of a particular accident occurring within some specific time period can be expressed in different ways. One way is to state the statistical probability that the accident will occur during a one-year period. This annual probability of occurrence can be derived from failure frequency data bases of similar accidents that have occurred with similar systems or components in the past.

Most data bases (e.g., CCPS [1989], OREDA [1984]) that are used in this type of analysis contain failure frequency data (e.g., on the average, there has been one failure of this type of equipment for 347,000 hours of service). By using the following equation, the annual probability of occurrence of an event can be calculated if the frequency of occurrence of the event is known.

$$p = 1 - e^{(-\lambda t)}$$

where: p = annual probability of occurrence (dimensionless)
λ = annual failure frequency (failures per year)
t = time period (one year)

If an event has occurred once in 347,000 hours of use, its annual failure frequency is computed as follows.

$$\lambda = \frac{1\,event}{347{,}000\,hours} x \frac{8{,}760\,hours}{year} = 0.0252\,events\,/\,year$$

The annual probability of occurrence of the event is then calculated as follows.

$$p = 1 - e^{(-0.0252 \cdot 1)} = 0.0249$$

Note that the frequency of occurrence and the probability of occurrence are nearly identical. (This is always true when the frequency is low.) An annual probability of occurrence of 0.0249 is approximately the same as saying there will probably be one event per forty years of use.

Due to the scarcity of accident frequency data bases, it is not always possible to derive an exact probability of occurrence for a particular accident. Also, variations from one system to another (e.g., differences in design, operation, maintenance, or mitigation measures) can alter the probability of occurrence for a specific system. Therefore, variations in accident probabilities are usually not significant unless the variation approaches one order of magnitude (i.e., the two values differ by a factor of ten).

The following subsections describe the basis and origin of failure frequency rates used in this analysis.

4.1 <u>Piping Failure Rates</u>

4.1.1 Welded Piping

WASH-1400 [USNRC, 1975] lists the failure rates for piping as 1.0 x 10^{-10}/hour for pipes greater than three inches in diameter, and 1.0 x 10^{-9}/hour for smaller pipes. These rates are based on a "section" of pipe, i.e., 1.0 x 10^{-10} failures per section of >three-inch pipe/hour. A section of pipe is defined as any straight portion of pipe of welded construction between any two fittings (such as flanges, valves, strainers, elbows, etc.). CCPS [1989] gives a mean pipe failure rate of 2.68 x 10^{-8}/mile/hour (4.45 x 10^{-8}/foot/year). This would be approximately the same as the WASH-1400 rate, 1.0 x 10^{-9}/section/hour (8.76 x 10^{-6}/section/year), if the average section of pipe were about 200 feet in length.

Most data bases of pipe failure rates are not sufficiently detailed to allow a determination of the failure frequency as a function of the size of the release (i.e., size of the hole in the pipe). However, British Gas has gathered such data on their gas pipelines [Fearnehough, 1985]. Their data show that well over 90% of all failures are less than a one-inch diameter hole, and only 3% are greater than a three-inch diameter hole. Since most full ruptures of piping systems are caused by outside forces, full ruptures are expected to occur more frequently on small-diameter pipes.

Based on the above discussion, the expected failure rates for aboveground, metallic piping with no threaded connections are assumed to be as follows.

For pipes from one inch to three inches in diameter:

Hole size	≤ 1/4 inch	1/4 to 2 inch	2 inch to full rupture
Expected failure rate	2.25 x 10^{-8}/foot/year	1.8 x 10^{-8}/foot/year	4.5 x 10^{-9}/foot/year

For pipes from four inches to ten inches in diameter:

Hole size	≤ 1/4 inch	1/4 to 2 inch	2 inch to full rupture
Expected failure rate	2.25 x 10^{-8}/foot/year	2.0 x 10^{-8}/foot/year	2.5 x 10^{-9}/foot/year

4.1.2 Screwed Piping

CCPS [1989] also gives a value of 5.7 x 10^{-7}/hour for the failure rate of metal piping connections. The specific types of connections are not listed, but threaded connections are implied since failures in welded piping systems with flanged connections are either classified as piping failures or gasket failures. Failure rates for piping in aboveground, metallic piping systems with screwed connections are assumed to be the same as the failure rates listed in Section 4.1.1 for welded piping systems. For screwed fittings, the expected failure rates are as follows.

Hole size	0 to 1/4 inch	1/4 inch to full rupture
Expected failure rate	4.0 x 10^{-3}/fitting/year	1.0 x 10^{-3}/fitting/year

4.2 Gaskets

According to WASH-1400 [USNRC, 1975], the median failure rate (leak or rupture) for gaskets at flanged connections is 3.0 x 10^{-7}/hour. Green and Bourne [1972] reported 5.0 x 10^{-7}/hour as the failure rate for gaskets. The data from both sources are thought to include small leaks that would not create significant hazards.

Unfortunately, the data are not broken down by gasket type. It is generally believed that spiral-wound, metallic-reinforced gaskets are less prone to major leaks than ordinary composition gaskets. Also, it is nearly impossible to "blow out" all, or even a section, of a metallic-reinforced gasket. In consideration of these factors, a failure rate of 3.0 x 10^{-8}/hour is thought to be conservative for loss of 1/4 of a metallic-reinforced gasket. Based on continuous service, the annual expected failure rate for metallic-reinforced gaskets is 2.6 x 10^{-4} failures/year/gasket. For ordinary composition gaskets, the expected failure rate is 2.6 x 10^{-3} failures/year/gasket.

4.3 Valves

WASH-1400 [USNRC, 1975] lists a failure rate of 1.0 x 10^{-8} failures/hour for external leakage or rupture of valves. Assuming continuous service, the annual leakage/rupture rate is approximately 8.8 x 10^{-5}/year. Unfortunately, this number includes very small leaks as well as valve body ruptures. This reduces the usefulness of this failure rate since the probability of a small leak from a valve bonnet gasket is obviously much greater than the probability of a two-inch hole in the valve body. To overcome this difficulty, the valve body can be considered similar to pipe, and the valve bonnet gasket can be treated like other gaskets. To be conservative, each flanged valve is considered to have a failure rate equal to a ten-foot section of pipe and one gasket. Similarly, a threaded valve is treated like ten feet of pipe, one gasket, and one screwed fitting.

4.3.1 Check Valve failures

The CCPS [1989] lists a value for the failure of a check valve to prevent reverse flow upon demand. This value is 2.2 failures per 1,000 demands, or 2.2 x 10^{-3}/d.

4.4 Pressure Vessel Failure Rates

4.4.1 Leaks

CCPS [1989] reports a failure rate of 1.09 x 10^{-8}/hour for pressure vessels. For continuous service, the annual expected failure rate for pressure vessels would be 9.5 x 10^{-5} failures/year. Bush [1975] made an in-depth study of pressure vessels of many types, including boilers. In Bush's study, the rate of "disruptive" failures of pressure vessels was 1.0 x 10^{-5}/year, i.e., a factor of ten less than the CCPS value. The explanation for this difference lies in the definition of "failure." Bush's number is based on "disruptive" failures which are assumed to be failures of such magnitude that the affected vessel would need to be taken out of service immediately for repair or replacement. The data base reported by the CCPS most likely includes smaller leaks that Bush categorized as "noncritical."

Smith and Warwick [1981] analyzed the failure history of a large number of pressure vessels (about 20,000) in the United Kingdom. They present a short description of each failure, thus allowing the failures to be categorized by size. Most of the failures were small leaks (approximately half can be categorized as smaller than a one-inch diameter hole).

Based on the previous discussion, the following failure rates are proposed for pressurized process vessels.

Equivalent hole diameter	≤1/4 inch	1/4 to 2 inch	>2 inch
Expected failure rate	3.0 x 10^{-5}/year	4.0 x 10^{-5}/year	5.0 x 10^{-6}/year

4.4.2 Catastrophic Failures

For this study, a catastrophic failure is defined as the sudden, nearly instantaneous rupture of a pressure vessel, resulting in nearly instantaneous release of the vessel's contents. Catastrophic failures of pressure vessels can be roughly divided into two types—cold catastrophic failures and BLEVE's.

If a pressure vessel ruptures when the contents of the vessel are at, or near, ambient temperature, the failure is a cold catastrophic failure. Such failures might occur as the result of improper metallurgy, defective welds, overpressurization, etc. Most products that are stored at ambient temperature in pressure vessel storage tanks are superheated liquefied gases. If the contents of the tank are released into the atmosphere nearly instantaneously, an aerosol cloud will be formed as some of the liquid flashes to vapor. If the material is flammable, the cloud might be ignited (either instantaneously or after some delay) or will dissipate without being ignited.

Sooby and Tolchard [1993] conducted an analysis of cold catastrophic failures of pressurized LPG storage tanks in Europe. They found that no such failure had ever been recorded during more than twenty-five million tank-years of service. From this data, they derived a frequency of 2.7×10^{-8} cold catastrophic failures per vessel per year for pressurized storage tanks.

4.5 Heat Exchanger Failure Rates

Failure rate data for shell-and-tube heat exchangers that are designed and constructed much like other pressurized process vessels are sometimes reported with the data for pressure vessels. However, shell-and-tube heat exchangers are expected to have higher failure rates than simple pressure vessels because they are more complex than pressure vessels and are subject to additional stresses caused by temperature-induced expansion and contraction. To account for the additional complexity and stresses, the failure rates of the reboilers are assumed to be twice the rates listed previously for pressure vessels.

Based on this discussion, the following failure rates are proposed.

Equivalent hole diameter	≤1/4 inch	1/4 to 2 inch	>2 inch
Expected failure rate	6.0×10^{-5}/year	8.0×10^{-5}/year	1.0×10^{-5}/year

4.6 Pump Failure Rates

Green and Bourne [1972] list the failure rate for “rotating seals” as 7.0×10^{-6}/hour. Assuming continuous operation (i.e., 8,760 hours/year), the annual expected failure rate is 6.0×10^{-2} failures/year/seal.

For pumps fitted with double mechanical seals, a major seal leak occurs only if both seals fail. If the two seal failures were always caused by independent events, the failure rate for a double seal configuration would be the square of the single seal failure rate, i.e., about 3.6×10^{-3} failures/year. However, some causes of seal failure can result in the simultaneous failure of both seals (e.g., bearing failures, excessive vibration, improper installation, etc.). Thus, the failure rate is somewhere between 6.0×10^{-2}/year and 3.6×10^{-3}/year. In the absence of hard data, we have assumed the failure rate for double mechanical seals is 5.0×10^{-3}/year.

Rotating seal failures do not occur with sealless pumps because such pumps do not have rotating seals. However, sealless pumps are still subject to many of the non-seal types of failures that can occur with any pump (e.g., cracks in the pump housing).

The common sources of failure rate data (OREDA, WASH-1400, CCPS) do not present data for failures of pump housings, although such failures have occurred. In the absence of such data, we assume the failure rate for a pump housing is equal to the failure rate of a ten-foot section of pipe of similar diameter.

4.7 Compressor Failure Rates

Data on the frequency of releases from compressors are very rare, and contain little detailed information. A report from The Oil Industry International Exploration and Production Forum (E&P Forum) includes data from four sources, but the total sample size of all four data bases is only 1,875 compressor years of service [E&P, 1992]. The number of reported releases was 119, which translates to a release frequency of 6.35×10^{-2}/compressor/year. Only seven of the 119 releases were classified as "major."
Based on this limited data, the expected failure rates are as follows.

Hole size	<1/4 inch	1/4 to 1 inch	1 inch to full rupture
Expected failure rate	6.0×10^{-2}/compr/yr	3.2×10^{-3}/compr/yr	5.3×10^{-4}/compr/yr

4.8 Pipeline Failure Rates

4.8.1 Steel Pipelines

Department of Transportation (DOT) data for underground liquid pipelines in the United States indicate a failure rate of 1.35×10^{-3} failures/mile/year [DOT 1988]. Data compiled from DOT statistics on failures of gas pipelines show a failure rate of 1.21×10^{-3} failures/mile/year for steel pipelines in the United States [Jones, et al., 1986]. In addition to failures of buried pipe, these data include failures of buried pipeline components, such as block valves and check valves, when the failure resulted in a release of fluid from the pipeline.

Data gathered by operators of gas transmission pipelines in Europe indicate a failure rate of 1.13×10^{-3} failures/mile/year [EGPIDG, 1988].

These data sets are not sufficiently detailed to allow a determination of the failure frequency as a function of the size of the release (i.e., the size of hole in the pipeline). However, British Gas has gathered such data on their gas pipelines [Fearnehough, 1985]. These data indicate that well over 90% of all failures are less than a one-inch diameter hole, and only 3% are greater than a three-inch diameter hole.

Data compiled from DOT data on gas pipelines in the United States show a trend toward higher failure rates as pipe diameter decreases [Jones, et al., 1986]. (Smaller diameter pipes have thinner walls; thus, they are more prone to failure by corrosion and by mechanical damage from outside forces.)

Based on the data sets described above, the expected failure rates for steel pipelines are assumed to be as follows.

For pipelines from six to twelve inches in diameter:

Hole size	<1/4 inch	1/4 to 1 inch	1 inch to full rupture
Expected failure rate	0.76×10^{-3}/mile/year	0.61×10^{-3}/mile/year	0.15×10^{-3}/mile/year

For pipelines from fourteen to twenty-two inches in diameter:

Hole size	<1/4 inch	1/4 to 1 inch	1 inch to full rupture
Expected failure rate	0.65 x 10^{-3}/mile/year	0.52 x 10^{-3}/mile/year	0.13 x 10^{-3}/mile/year

For pipelines from twenty-four to twenty-eight inches in diameter:

Hole size	<1/4 inch	1/4 to 1 inch	1 inch to full rupture
Expected failure rate	0.28 x 10^{-3}/mile/year	0.224 x 10^{-3}/mile/year	0.056 x 10^{-3}/mile/year

For pipelines from thirty to thirty-six inches in diameter:

Hole size	<1/4 inch	1/4 to 1 inch	1 inch to full rupture
Expected failure rate	0.10 x 10^{-3}/mile/year	0.08 x 10^{-3}/mile/year	0.02 x 10^{-3}/mile/year

In the absence of applicable data, the injection pipelines in this study were assumed to have failure rates similar to the ones presented above for gas transmission pipelines. In addition, failure rates for the 4-inch pipeline were assumed to be similar to those of the 6-inch to 12-inch gas transmission pipelines.

4.8.2 Surface Equipment

Some types of pipeline equipment (such as pig launchers and receivers) are always located aboveground. In some instances, other types of pipeline equipment might also be located aboveground (e.g., block valves and blowdown valves). Failure rates for such equipment have been reported by Canada's Energy Resources Conservation Board [ERCB, 1990]. The reported rate for full-bore ruptures is 8.12 x 10^{-5} failures/equipment piece/year; and the reported rate for "leaks" is 2.95 x 10^{-4} failures/equipment piece/year.

Based on these data, the failure rates for surface equipment are expected to be as follows.

Hole size	<1/4 inch	1/4 to 1 inch	1 inch to full rupture
Expected failure rate	1.65 x 10^{-4}/piece/year	1.30 x 10^{-4}/piece/year	8.12 x 10^{-5}/piece/year

4.9 Common Cause Failures

Components that are exposed to a common working environment may be susceptible to common cause failures if they contain a common design error (e.g., wrong materials of construction specified) or a common manufacturing defect (e.g., improper welding technique). Thus, within a particular unit or facility, the failure rates of components such as pipes, valves, pump seals, gaskets, etc., may be higher than the rates obtained from typical failure rate data bases, if the components are susceptible to common cause failures. However, common cause failures seldom exert a large influence on the actual failure rate of a specific type or class of component. Design reviews, quality control and quality assurance programs, process hazards analyses, accident investigations, etc., will generally reveal the sources of common cause failures either before such failures occur, or after only one or two such failures have occurred. The susceptible components are then respecified, repaired, or replaced, as required.

Failures of sensing and control devices seldom lead directly to an accident. In most cases, the failure of such a device would lead to an accident only if other events occur simultaneously or sequentially. The contribution of such failures to the frequency of specific accidents can sometimes be estimated by techniques such as fault tree analysis. The presence of common cause failures in a fault tree will increase the complexity of the analysis.

In the analysis that is the subject of this report, each accident of interest involves the failure of a physical component of a process system. Available data bases for component failures include failures that occurred as the result of common causes. Hence, the expected frequencies of occurrence of the accidents of interest can be based directly on component failure rates obtained from historical data bases, and there is no need to resort to fault tree analysis or to adjust the estimated failure rates to account for common cause failures.

4.10 Human Error

The probability of occurrence of any specific accident can be influenced by human error. However, in most situations, it is not possible to quantify this influence. Fortunately, it is seldom necessary to attempt such quantification.

There are two general forms in which human error can contribute to the failure of a component or system of components. The first form, which is implicit in nature, includes poor component design, improper specification of components, flawed manufacturing, improper selection of materials of construction, and similar situations that result in the installation and use of defective components or the improper use of non-defective components. The second form, which is explicit in nature, includes improper operation and improper maintenance.

Most of the available equipment failure rate data bases do not categorize the causes of the failures. Whether the rupture of a pipe is due to excessive corrosion, poor design, improper welding procedure, or some other cause, the rupture is simply added to the data base as one "pipe failure." Thus, since implicit human errors manifest themselves in the form of component failures, they are already included in the failure rate data bases for component failures.

Many types of explicit human errors also manifest themselves in the form of component failures. Therefore, like implicit human errors, component failures caused by explicit human errors are already included in the failure rate data bases for component failures. For example, if a pump seal is improperly installed (improper maintenance) and it begins to leak after several hours of operation, it would simply be recorded in a failure rate data base as one "pump seal failure." Similarly, if an operator responds improperly (improper operation) to a high pressure alarm and the pressure continues to increase, ultimately resulting in the rupture of a pipe, the event is recorded in a failure rate data base as a "pipe rupture."

Except in rare cases, there is little reason to believe that equipment failures due to implicit or explicit human errors will occur more often or less often in a specific facility than in the facilities that contributed failure rate data to the data bases. Therefore, component failure rates obtained from historical data bases can nearly always be used without being modified to account for human error.

Accidents that are the result of explicit human errors, but do not involve failures of components, are not included in typical failure rate data bases. Examples of such accidents include overfilling a tank (resulting in a liquid spill), opening a flanged connection on a piping system that has not been properly drained and purged (resulting in a leak of gas or liquid), opening a water-draw-off valve on an LPG tank and then walking away (resulting in a release of LPG), etc.

The contribution of explicit human error to the frequency of accidents that do not involve the failure of components can sometimes be estimated by techniques such as fault tree analysis or event tree analysis. These techniques are used to illustrate how the occurrence of an accident is the result of a chain of events or the simultaneous occurrence of several events. These events can be component failures or human failures. Using these techniques, the probability of occurrence of the accident can be quantified IF the probability of occurrence of EVERY event that contributes to the accident can be quantified. In many cases, there is insufficient historical data for some of the events. (This is particularly true for human error events.) Thus, assumed values must often be used. This inevitably leads to questions regarding the accuracy or applicability of the estimated probability of occurrence of the accident.

In the analysis that is the subject of this report, the accidents of interest all involve the failure of a physical component of a process system. Thus, frequencies of occurrence of these accidents (which are based on component failure rates obtained from historical data bases) need not be increased or decreased to account for human error.

4.11 Hazardous Events Following Gas Releases

A release of hazardous gas to the atmosphere may create one or more hazardous conditions, depending on events that occur subsequent to the release. For a gas that is flammable and toxic/asphyxiant, the possibilities are:

(a) No ignition. If a flammable/toxic/asphyxiant vapor cloud forms but never ignites, the only hazard is due to the toxic or asphyxiant characteristics of the cloud.

(b) Immediate ignition. If ignition occurs nearly simultaneously with the beginning of the release, the hazard may be heat radiation from a torch fire.

(c) Delayed ignition. If there is a time delay between the start of the release and ignition of the release, a flammable/toxic vapor cloud will form. Before ignition, the cloud may present a toxic hazard. After ignition, there will be a vapor cloud fire (flash fire) and possibly a vapor cloud explosion, possibly followed by a torch fire.

Each of these three possibilities has some probability of occurring, once a release has occurred. The sum of these three probabilities must equal one. The ignition/explosion probabilities employed in this study are taken from an Institution of Chemical Engineers report [IChemE, 1990]. Estimated values are a function of the “size” of the release.

Consequences of the hazardous events that may occur subsequent to a release of hazardous fluid are also proportional to the “size” of the release. Therefore, when calculating the accident probability, it is necessary to estimate the distribution of releases of various sizes. This is typically done by applying a hole size distribution, such as the one presented in Section 4.4 for pressure vessels.

The estimates used for hole size and ignition probability are best illustrated by event trees, with a release of gas as the initial event. One event tree prepared for this study is presented in Figure 4-1. The event tree describes the risk associated with a release of gas from a welded metal pipe that has a nominal diameter of 30 inches.

Moving from left to right, the tree first branches into three hole sizes, each being defined by the diameter of the hole through which the gas is being released. Each of these three branches divides into three branches based on ignition timing and probability. At the far right of the event tree are the nine “outcomes” that have some probability of occurring if the initiating release occurs. The estimated annual probability of occurrence of each possible outcome, per meter of pipe, is also listed on the event tree.

In general, small releases are the most likely to occur, the least likely to be ignited (small probability of reaching an ignition source), and least likely to result in vapor cloud explosions (insufficient mass of gas in the flammable gas cloud). The largest releases are the least likely to occur, the most likely to be ignited (highest probability of reaching an ignition source), the most likely to be ignited immediately (the force needed to cause a large release may also be capable of igniting the release), and the most likely to result in a vapor cloud explosion.

Since the ignition and explosion probabilities in the event tree are not derived from a historical data base, it could be argued that these probabilities should be increased or decreased. However, even large changes (50%) in the individual probabilities will not make a significant change in the overall analysis. This is due to several factors. First, if the frequency of one event is increased, the frequency of some other event must be lowered. Thus, depending on the magnitude of the potential hazard zones, the overall risk may increase or decrease due to changes in the event frequencies.

As illustrated by the event tree in Figure 4-1, there are three possible outcomes (torch fire, flash fire/torch fire/VCE, and toxic/asphyxiant cloud) for each of the three release sizes (rupture, puncture, and leak). To arrive at the annual probability of a specific outcome, the overall failure rate is modified by the probability at each applicable branching of the event tree. The annual probabilities per meter of pipe for the specific outcomes are presented on the far right of the event tree.

From a review of Figure 4-1, it is found that the most likely outcome following a release from the syngas line leaving the low temperature gas cooling unit is a leak that does not ignite and results in a small gas cloud containing carbon dioxide. This release is defined to have an annual probability of 7.31×10^{-8} per meter of pipe (about once every 13,700,000 years). A review of the event tree also defines a leak from the syngas line which ultimately leads to a vapor cloud explosion to be the most unlikely outcome. This outcome has an annual probability of 7.38×10^{-11} per meter of pipe (about once every 13,500,000,000 years). It should be kept in mind that a specific outcome probability does not account for the wind speed, direction, or stability. These weather factors are accounted for in the risk mapping phase of the analysis described in Section 5.

Similar event trees were constructed for releases of hazardous fluids from a range of pipe sizes throughout the TCEP process units and pipelines. The outcome probabilities from the event trees are combined with consequence outcomes in the risk mapping analysis described in Section 5.

Initiating Event	Hole Size and Probability	Ignition Type	Probability	Conditional Probability	Outcome	Annual Probability Per Meter of Pipe
Release of Syngas from 30-inch [762 mm] process piping 1.476E-07 failures/m/yr	Rupture 0.056	Immediate	0.270	0.0150	Torch Fire	2.21E-09
		Delayed	0.030	0.0017	Flash Fire/Torch Fire Vapor Cloud Explosion	2.46E-10
		None	0.700	0.0389	Toxic/Asphyxiant Cloud	5.74E-09
	Puncture 0.444	Immediate	0.033	0.0149	Torch Fire	2.20E-09
		Delayed	0.004	0.0017	Flash Fire/Torch Fire Vapor Cloud Explosion	2.44E-10
		None	0.963	0.4279	Toxic/Asphyxiant Cloud	6.32E-08
	Leak 0.500	Immediate	0.009	0.0045	Torch Fire	6.64E-10
		Delayed	0.001	0.0005	Flash Fire/Torch Fire Vapor Cloud Explosion	7.38E-11
		None	0.990	0.4950	Toxic/Asphyxiant Cloud	7.31E-08

Figure 4-1
Event Tree for a Flammable/Toxic Release from 30-Inch Syngas Line

SECTION 5
RISK ANALYSIS METHODOLOGY

The TCEP process units and associated pipelines pose no health hazards to the public as long as the equipment does not release flammable, toxic, or asphyxiant fluids into the environment. In the event of an accident that results in a release of hazardous material, persons near the release point may be at risk due to the properties of the vapor cloud created by the release. The objective of a quantitative risk analysis (QRA) is to calculate the level of risk to people. Once the risk level is calculated, it can be evaluated against applicable risk criteria.

The risk posed by hazardous materials is expressed as a product of the probability of occurrence of a hazardous event and the consequences of that event. Therefore, in order to quantify the risk associated with hazardous fluids, it is necessary to quantify the probabilities of accidents that would release fluids into the environment, and the consequences of such releases. The probability of each outcomes and its potential consequences must then be combined using a consistent, accepted methodology that accounts for the influence of weather conditions and other pertinent factors.

The risk quantification methodology developed by Quest has been successfully employed in QRA studies that have undergone regulatory review in several countries worldwide. The following is a brief description of the steps involved in quantifying the risk imposed by a facility handling hazardous materials.

5.1 <u>Risk Quantification</u>

Conceptually, performing a risk analysis is straightforward. For releases of flammable, toxic, and/or asphyxiant fluids, the analysis can be divided into the following steps.

Step 1. Within each "area" of the facility being considered in the study, determine the potential credible events that would create a flammable, toxic, or asphyxiant gas cloud, vapor cloud explosion, torch fire, pool fire, or BLEVE. Potential release sources are determined from a combination of historical accident data, site-specific information, and engineering analyses by process safety engineers. Some of the factors that contribute to the selection of each unique event are:

a. Fluid composition, temperature, and pressure
b. Fluid inventory in the process
c. Hole size
d. Release orientation
e. Release location
f. Process controls and emergency shutdown systems

Step 2. Determine the frequency of occurrence of each of these events. The frequency of occurrence is a summation of the failure frequencies of all components of the process where a release of hazardous fluid would result in a similar hazard. Individual failure frequencies are based on historical experience, failure rate data for similar equipment, and engineering judgment.

Step 3. Use the following equation to convert the frequency of occurrence of each event to an annual probability of occurrence.

$$p = 1 - e^{(-\lambda t)}$$

where: p = annual probability of occurrence (dimensionless)
λ = annual failure frequency (failures per year)
t = time period (one year)

Step 4. Calculate the size of each potentially fatal hazard zone created by each of the releases identified in Step 1.

i. The hazards of interest are:

a. Thermal radiation from flash fires, torch fires, pool fires, and BLEVE fireballs,
b. Overpressure from vapor cloud explosions, and
c. Toxic and asphyxiant vapor clouds.

ii. The size of each hazard zone is a function of one or more of the following factors.

a. Orientation of the release (e.g., vertical or horizontal)
b. Wind speed
c. Atmospheric stability
d. Local terrain (including diking and drainage)
e. Composition, pressure, and temperature of fluid being released
f. Hole size
g. Vessel inventories
h. Diameter of the liquid pool
i. Presence of regions of confinement or congestion

Step 5. Determine the risk in the vicinity of the hazardous materials facilities.

i. The potential exposure of an individual to a specific hazard zone depends on the following factors.

a. Size (area) of the hazard zone.
b. Location of the individual, relative to the release location.
c. Wind direction.

ii. Determine the exposure of an individual to each potential hazard zone.

a. Perform toxic vapor cloud, asphyxiant vapor cloud, flash fire, and vapor cloud explosion hazard zone calculations for all hole sizes, wind directions, wind speeds, atmospheric stabilities, and release orientations.
b. Perform torch fire and pool fire hazard zone calculations for all hole sizes, release orientations, wind speeds, and wind directions. (Fire radiation hazard zones are not dependent on atmospheric stability.)
c. Perform BLEVE hazard zone calculations

iii. Modify each annual probability of occurrence to develop the annual probability for each unique event outcome using event trees. The annual probability, P(acc), as identified in Step 3, is modified by conditional probabilities, such as ignition or non-ignition, and probabilities of specific weather conditions. These probabilities are divided into the following groups.

a. P(wd,ws,stab) = probability that the wind blows from a specified direction (wd), with a certain wind speed (ws), and a given atmospheric stability class, A through F (stab). Meteorological data are generally divided into sixteen wind directions, six wind speed classes, and six Pasquill-Gifford atmospheric stability categories. Although all 576 combinations of these conditions do not exist, a significant number will exist for each meteorological data set. Figure 1 represents a typical wind speed versus stability distribution.
b. P(ii) = probability of immediate ignition (i.e., probability that ignition occurs nearly simultaneously with the release).
c. P(di) = probability of delayed ignition (i.e., probability that ignition occurs after a vapor cloud has formed).
d. P(orientation) = probability that hazardous fluid is released into the atmosphere in a particular orientation.

iv. Sum the potential exposures from each of the hazards for all releases identified in Step 1. This summation involves applying the annual probability of occurrence of each potential hazard zone to the areas covered by that zone. For example, the annual probability of a unique flash fire outcome (delayed ignition of a flammable vapor cloud following release from a process system) is P(acc) • P(orientation) • P(ws,wd,stab) • P(di).

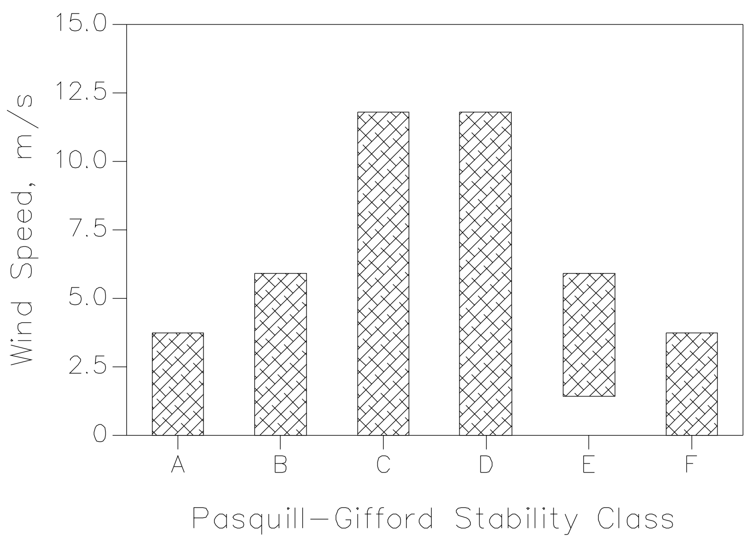

Figure 5-1
Representative Range of Wind Speed/Atmospheric Stability Categories

5.2 Assumptions Employed in Risk Quantification

In this preliminary analysis, several assumptions were necessary to complete the overall project design and to reduce the computation requirements of the study. In each case, the simplifying assumption led to an overprediction of the potential risk to people outside the facility. These assumptions include:

(1) **Process unit data**. Several of the process units to be employed in TCEP are not in the final design stage. The primary piping inputs and outputs with their associated mass balances were available for this work. Quest experience with project of similar function and capacity allowed us to develop equipment estimates for these preliminary design units. In all cases, the equipment "counts" were overestimated to provide a conservative result.

(2) **Consequence modeling.** Similar to the equipment count estimates above, the process variables (mass flow, pressure, temperature, inventory, etc.) were not available for all units. In those cases where process data was not available, the consequences associated with the incoming and outgoing process streams were used to develop the consequence results for the unit. This assumption provides a conservative risk result since the piping transferring the materials from one unit to another contain the largest inventories of flammable, toxic, and asphyxiant materials.

(3) **Ammonia storage.** The preliminary design did not include any anhydrous ammonia storage. It is unlikely that TCEP will operate without some amount of intermediate ammonia storage. As the decision to employ refrigerated and/or pressurized storage has not been made, Quest assumed one refrigerated and one pressurized (bullet) anhydrous ammonia storage vessel would be located on site. This assumption should overpredict the overall risk results since no project-specific safety systems were assumed to be in place. If one or both of the ammonia storage vessels are removed from the product or the standard safety systems are put in place, the predicted risk level will be lower than those presented.

(4) **Local terrain**. Although the terrain outside the facility or along the pipeline route is generally uniform, obstructions to vapor travel within the area are potentially significant. In this analysis, no additional dilution due to obstructions being in the travel path of the vapor cloud was taken into account. This assumption is applicable to all releases studied and results in an overprediction of the size of the potential hazard zones.

(5) **Meteorologic data**. The weather conditions (wind speed, atmospheric stability, and atmospheric temperature) existing at the time of a release all influence the dispersion of the released fluid. In this analysis, average weather conditions were assumed for all releases.

The result of the analysis is a prediction of the risk posed by the facility. Risk may be expressed in several forms (e.g., risk contours, average individual risk, societal risk, etc.). For this analysis, the focus was on the prediction of risk contours.

SECTION 6
RISK ANALYSIS RESULTS AND CONCLUSIONS

This section presents a summary of the results of the preliminary risk analysis. These results are based on the consequence analysis presented in Section 3, the accident frequency analysis presented in Section 4, and the risk analysis methodology presented in Section 5. The analysis results are presented primarily in the form of risk contours for the facility and risk transects for the carbon dioxide and natural gas pipelines

6.1 Summary of Maximum Toxic Impact Zones

Differences in the toxic impact zones generated by potential releases from the various sections of the facility are due primarily to differences in the composition of the toxic fluid, operating pressure, process flow rates, and available inventory. In this study, the emphasis is on calculating the potential lethal exposure of the public to concentrations of H_2S, NH_3, H_2SO_4, HCN, HCl, SO_2, and COS as well as fatal exposure to common asphyxiants such as CO_2 and N_2. For this reason, the toxic and asphyxiant dispersion calculations were performed using probit relationships that account for time-varying effects. The 1% fatality probit level was used to define the maximum extent that a hazard may extend and cause a fatality (1% of the exposed population at the extent of the hazard). The 50% probit level was used to define a zone within which 50% of the exposed members of the public were assumed to be fatalities. The extent of the 99% probit hazard level defined a zone within which all of the exposed members of the public were assumed to be fatalities due to the release of fluid containing a toxic component or a significant asphyxiant concentration.

Table 6-1 presents a list of the ten accidental releases that generate the largest flammable, toxic, or asphyxiant impacts. The maximum predicted distances to the mortality probit levels are listed for each release.

6.2 Measures of Risk Posed by TCEP Process Units, Ammonia Storage Tanks and Pipelines

Several different methods can be used to evaluate the risk of the TCEP and pipeline system. Professionals in risk analysis recognize there is no single measure of risk that completely describes the risk a project poses to the public. Regulatory agencies have used methods such as hazard footprints, risk contours, *f/N* curves, and risk matrices to evaluate the risk posed by a project. This section of the report describes the risk measurement techniques that were applied to TCEP and evaluates the risk posed by the full system.

6.2.1 Hazard Footprints and Vulnerability Zones for TCEP Process Units

Generating hazard footprints and vulnerability zones for all potential accidents within the TCEP does not represent a true measure of the risk posed by the facility. A hazard footprint generally defines the maximum possible zone or area that could be affected by one or more accidents. The size of the maximum footprint will often be much larger than the hazard footprint associated with any other accident. The total area encompassed by rotating the footprint around the point of release will not accurately represent the potential hazard zone since the whole area within the circle cannot be affected by a single accident. These circles are often referred to as “vulnerability zones.” An example is provided in Figure 6-1. Figure 6-1 is the cloud map for the largest toxic vapor cloud which can be produced by a rupture of the 3-inch ammonia line leaving ammonia synthesis unit and going to storage. The maximum distance achieved by the cloud is 190 m (see Table 3-18). The 1% mortality toxic hazard vulnerability zone for this accident is represented by the circle drawn on Figure 6-1.

Table 6-1
Ten Largest Hazard Distances for Releases from TCEP Units and Pipelines

Release from [Largest Hazard]	Hole Size (Effective Diameter)	Weather (Wind Speed (m/s)/ Stability)	Distance [m] from Release Point to Fatality Level		
			1%	50%	99%
Pressurized ammonia storage [Toxic]	6"	1.03/F	1415	972	750
Pressurized ammonia storage [Toxic]	6"	4.63/D	1174	845	622
Pressurized ammonia storage [Toxic]	1"	1.03/F	498	419	294
Pressurized ammonia storage [Toxic]	1"	4.63/D	435	310	215
Ammonia to urea synthesis [Toxic]	1"	1.03/F	401	324	253
Ammonia to urea synthesis [Toxic]	1"	4.63/D	329	233	166
Ammonia to urea synthesis [Toxic]	6"	1.03/F	324	252	195
Ammonia product [Toxic]	1"	1.03/F	266	192	138
Ammonia to urea synthesis [Toxic]	6"	4.63/D	258	194	145
Ammonia product [Toxic]	1"	4.63/D	203	131	82

It is important to note that the cloud map in Figure 6-1 has a specific frequency associated with it. The size of the toxic ammonia cloud outlined in Figure 6-1 depicts the maximum possible area that the cloud might cover IF there is a full rupture, AND the wind speed is low, AND a stable atmospheric environment exists, AND the wind is blowing from the northeast. Thus, for the hazardous ammonia cloud to reach its maximum possible size, many different factors must be present during the course of the accident. For the cloud drawn (i.e., a cloud evolving from the rupture of the 3-inch ammonia line leaving the ammonia synthesis unit, with wind out of the northeast at 1 m/s, and Pasquill F (stable) atmospheric conditions), the annual probability of occurrence is $2.73 \times (10)^{-9}$/year (approximately one chance in 366,300,000 per year that the cloud will form as shown).

When the hazard vulnerability zone (the circle) on Figures 6-1 is presented, there is no associated probability since the cloud cannot cover the entire area at one time. Thus, circular vulnerability zones are not a meaningful measure of risk. The circular vulnerability zone simply provides information about which areas could potentially be exposed, but provides no information about the likelihood of exposure.

6.2.2 TCEP Pipeline Hazard Footprints and Vulnerability Zones

A hazard footprint does not represent a true measure of the risk posed by a pipeline. The hazard footprint produced following a pipeline release will often be much larger than all but one single potential

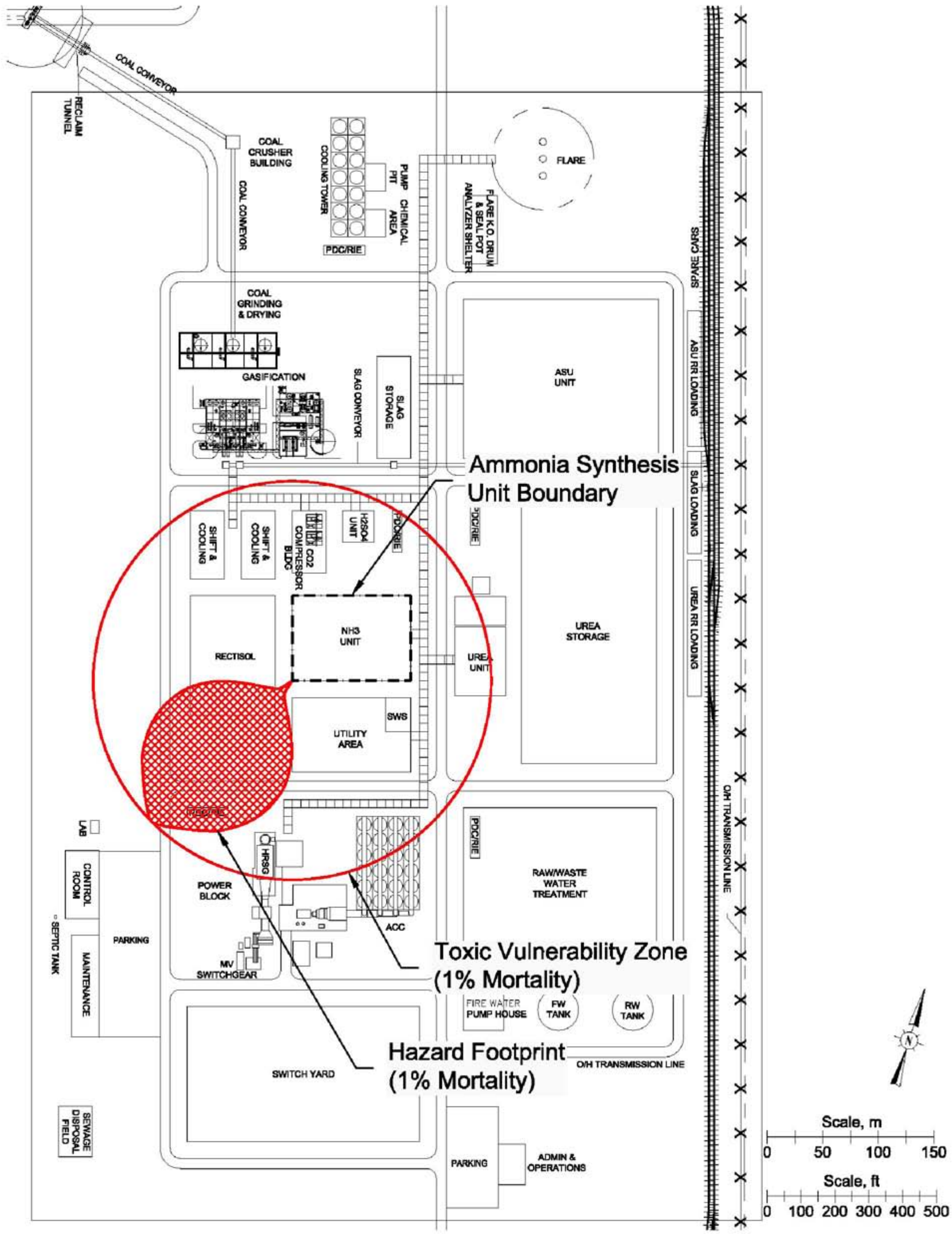

Figure 6-1
Hazard Footprint and Vulnerability Zone
Rupture of 3-inch Line Leaving the Ammonia Synthesis Unit

accident. This is the case for all of outgoing CO_2 and incoming natural gas pipeline sections. For each pipeline section, a unique accident will generate the largest potentially fatal hazard zone along that pipeline route. For example, along the CO_2 export pipeline, a full rupture of the line will create an asphyxiant impact (defined by the 1% fatality CO_2 probit) up to 81 meters away from the pipeline. No other potential accident will generate a hazard farther away than 81 meters from the pipeline.

A similar analysis was made for the incoming natural gas pipeline. The largest fatal hazard posed by the natural gas pipeline is a torch fire following a rupture. A full rupture of the line and subsequent ignition will create a radiant impact (defined by the 1% fatality incident radiation probit) up to 17 meters away from the pipeline.

Generating a continuous hazard footprint for the CO_2 pipeline simply requires drawing a line parallel to the pipeline at a distance of 81 meters. An example of this type of hazard footprint, or more appropriately for a pipeline, a hazard corridor, is shown in Figure 6-2. It is important to note that the size of the hazard corridor is defined by the single worst possible accident.

A second precaution is necessary when reviewing hazard footprints. As stated above, the size of a potential impact resulting from an accidental release is generally much smaller than the defined maximum footprint. This is particularly true for pipeline hazard corridors. As seen in Figure 6-1, the area of the largest toxic impact zone defined by the 1% fatality CO_2 probit is much smaller than the area contained within the hazard corridor along the route. The asphyxiant impact zone outlined in Figure 6-1 (shown as the cross-hatched area) depicts the maximum possible area the toxic cloud might cover in the event of a full rupture, AND the wind blowing perpendicular to the pipeline, AND the wind speed is low, AND the atmosphere is calm. Thus, for the asphyxiant impact zone to reach its maximum possible size, many different factors must be present during the course of the accident.

For these reasons, hazard footprints and corridors are not meaningful measures of the risk posed by a pipeline. A hazard footprint simply provides information about which area could potentially be exposed, but provides no information about the chances of exposure. Nevertheless, the maximum distances that define the hazard corridors for the carbon dioxide and natural gas pipelines are presented in Table 6-2.

6.2.3 Risk Contours

6.2.3.1 Terminology and Numerical Values for Representing Risk Levels

Once each release event has been fully assessed (annual probability of occurrence and consequences of that occurrence) the results can be presented in a concise manner. There are several methods available to present the risk associated with the potential release of flammable, toxic, and asphyxiant fluids from the TCEP configuration. Most methods define the level of exposure of the surrounding population in terms of annual probability of exposure (e.g., fatality) on an individual or societal basis.

In this study, the emphasis is on calculating the potential exposure of the public to lethal hazards posed by flammable, toxic, and asphyxiant materials. For this reason, flammable, toxic, and asphyxiant dispersion calculations as well as radiant and explosion calculations were performed for a wide range of releases representing a full range of mortality levels (1%, 50%, 99%). The result of the analysis is then a prediction of the maximum extent and frequency at which the public may be exposed to a lethal flammable, toxic, or asphyxiant hazard due to an accidental release from one of the TCEP units or pipelines.

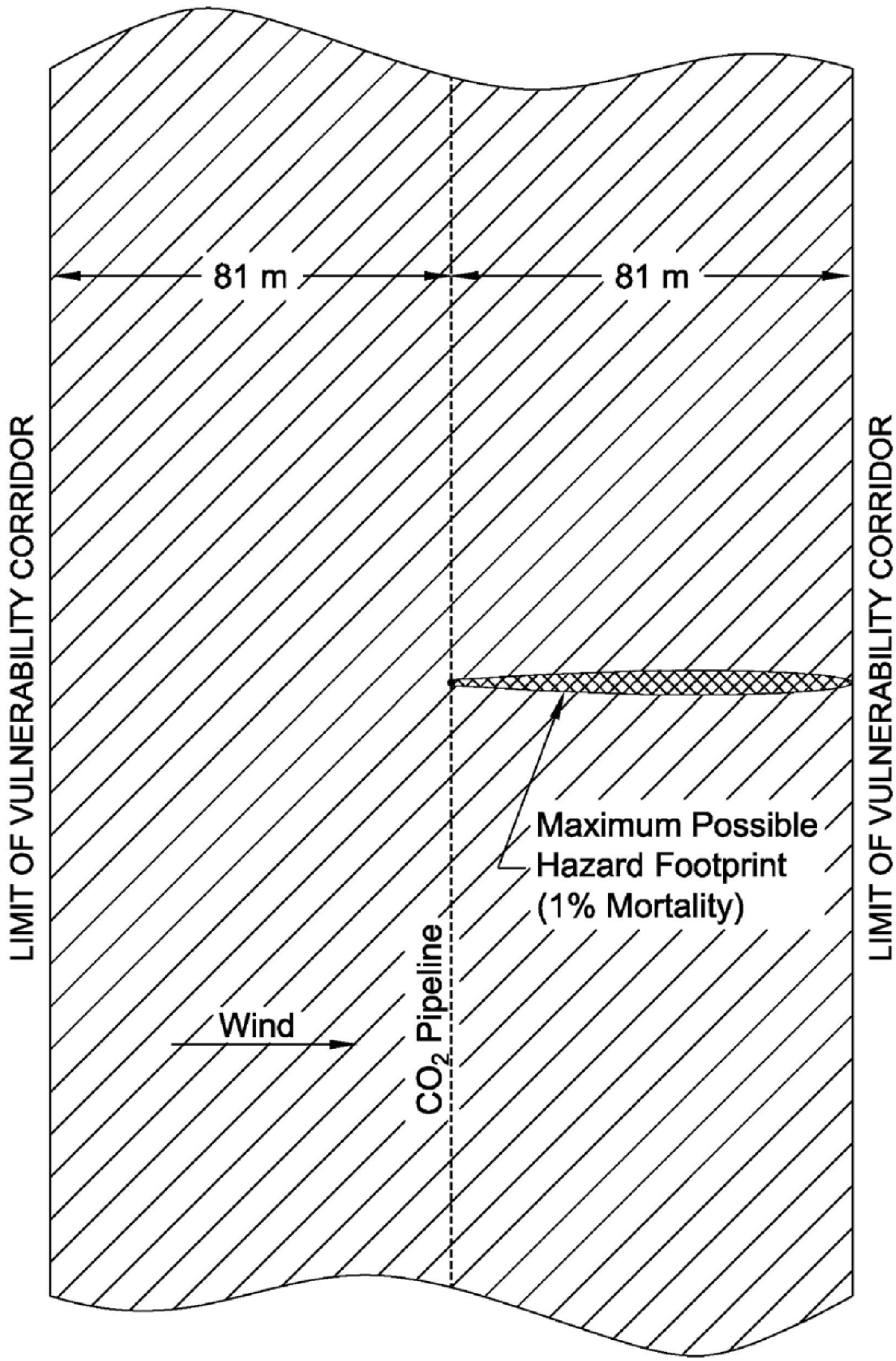

Figure 6-2
Hazard Footprint and Vulnerability Corridor
Rupture of 10-inch Carbon Dioxide Export Pipeline

Table 6-2
Maximum Hazard Footprint Distances

Equipment	Maximum Distance [m] Defining Hazard Corridor
Inlet Natural Gas Pipeline (torch fire)	17
Export CO_2 Pipeline (asphyxiant)	81

The risk an individual is potentially exposed to by events that originate in TCEP or the associated pipelines can be represented by a numerical measure. This numerical measure represents the chance, or probability, that an individual will be exposed to a fatal hazard during a year-long period. For example, a value of 1.0×10^{-6} (or 10^{-6} in shorthand notation) represents one chance in 1,000,000 (one million) per year of being fatally affected by a release originating in the TCEP facility or associated pipelines. If this risk level is predicted to occur at a particular location, it represents the annual chance of fatality at that location due to any of the potential releases from the TCEP equipment.

Risk contours present levels of risk based on annual exposure. For any risk level identified at a specific location, that level of risk is contingent upon one's presence 24 hours a day, 365 days per year. For this reason, risk contours do not describe the risk to populations that are inherently mobile, such as traffic on roadways or employees within a facility. Table 6-3 lists the numerical value, the short-hand representation of that value as it is used in this report, and the value expressed in terms of chances per year.

Table 6-3
Risk Level Terminology and Numerical Values

Numerical Value	Shorthand Notation	Chance per Year of Fatality
1.0×10^{-4}	10^{-4}	One chance in 10,000 of being killed per year
1.0×10^{-5}	10^{-5}	One chance in 100,000 of being killed per year
1.0×10^{-6}	10^{-6}	One chance in 1,000,000 of being killed per year
1.0×10^{-7}	10^{-7}	One chance in 10,000,000 of being killed per year
1.0×10^{-8}	10^{-8}	One chance in 100,000,000 of being killed per year

6.2.3.2 Risk Contours for TCEP and Associated Pipelines

The risk associated with potential flammable, toxic, and asphyxiant fluid releases from the TCEP process units can be thought of as the probability that an individual would be exposed to defined levels of toxic, asphyxiant, radiant, or overpressure hazards at a particular location. This risk is determined by summing the risk of all potential releases, outcomes, and atmospheric combinations. The results of the risk analysis calculations, which were described in Section 5, are best presented graphically.

Combining the potential flammable, toxic, and asphyxiant hazard zones from releases evolving from the proposed process units with the annual probabilities of occurrence and local weather data results in the risk contour plot presented in Figure 6-3. The contour lines on Figure 6-3 represent levels of risk of exposure to a lethal dose of a toxic material or exposure to a lethal asphyxiant level or exposure to a lethal radiant or overpressure exposure for all the potential releases evaluated. This figure is interpreted as follows. If an individual were located on the contour line labeled 10^{-6}, that individual has an annual probability of 1.0 x 10^{-6} (one chance in one million per year) of being exposed to a fatal impact as a result of any flammable, toxic, or asphyxiant fluid release occurring within the TCEP or the entering natural gas pipeline or the CO_2 export pipeline.

Risk contour plots contain the magnitudes of possible accidents and the annual probabilities of occurrence of these accidents. The risk contours contain the hazard maps defined in the consequence portion of the analysis and match them with the probability that conditions exist which would allow the hazard zone to be created. In this manner, the maximum hazard distances which define the hazards described earlier are matched with the probability that the release occurs; the gas cloud does or does not ignite immediately upon release; the winds are low, moderate, or high; the air is calm or unstable; and the wind is blowing in a particular direction, etc.

The risk contour technique also considers potential releases that have little or no impact on the public. An example would be a small corrosion leak on the natural gas line, resulting in a release of flammable gas into the atmosphere on a day when the wind is blowing at 11 m/s under neutral (Pasquill D) atmospheric stability conditions. Clearly, such a release poses little risk to the public.

Note that the low (1.0 x 10^{-7} and 1.0 x 10^{-8}) individual risk contours extend outside the TCEP project property line to the east. These low probability risk contours are composed entirely of the large hazards (rupture events) that have low probabilities of occurrence.

6.2.3.3 Results for the Natural Gas and Carbon Dioxide Pipelines

The risk contours presented in Figure 6-3 show the risk contributions from the TCEP itself, and from the incoming and departing pipelines. Although this provides an overall picture of the risk, it is not helpful in determining the risk associated with either one of the pipelines. Another method of presenting the risk posed by a pipeline is the risk transect. A risk transect plots the annual risk of fatality due to a release from the pipeline against the perpendicular distance from the pipeline. This method of risk presentation provides a simple method of risk comparison for multiple pipelines.

Figure 6-4 presents the calculated risk transects for the incoming 4-inch natural gas and 10-inch export carbon dioxide pipelines associated with the TCEP. Figure 6-4 clearly demonstrates how rapidly the risk associated with the pipelines decays as the distance from the pipeline increases.

6.3 Risk Acceptability Criteria

There have been a few attempts to define acceptability criteria for public risk. In general, the risk criteria have been developed to help regulatory agencies define where permanent housing should be developed near industrial areas. Several recognized international standards are described below.

Western Australia

The Environmental Protection Agency of Western Australia uses the following definitions of acceptable and unacceptable risk limits for new industrial installations.

- Risk levels lower than 1.0 x 10^{-6} per year are defined as acceptable.
- Risk levels greater than 1.0 x 10^{-5} per year are defined as unacceptable.

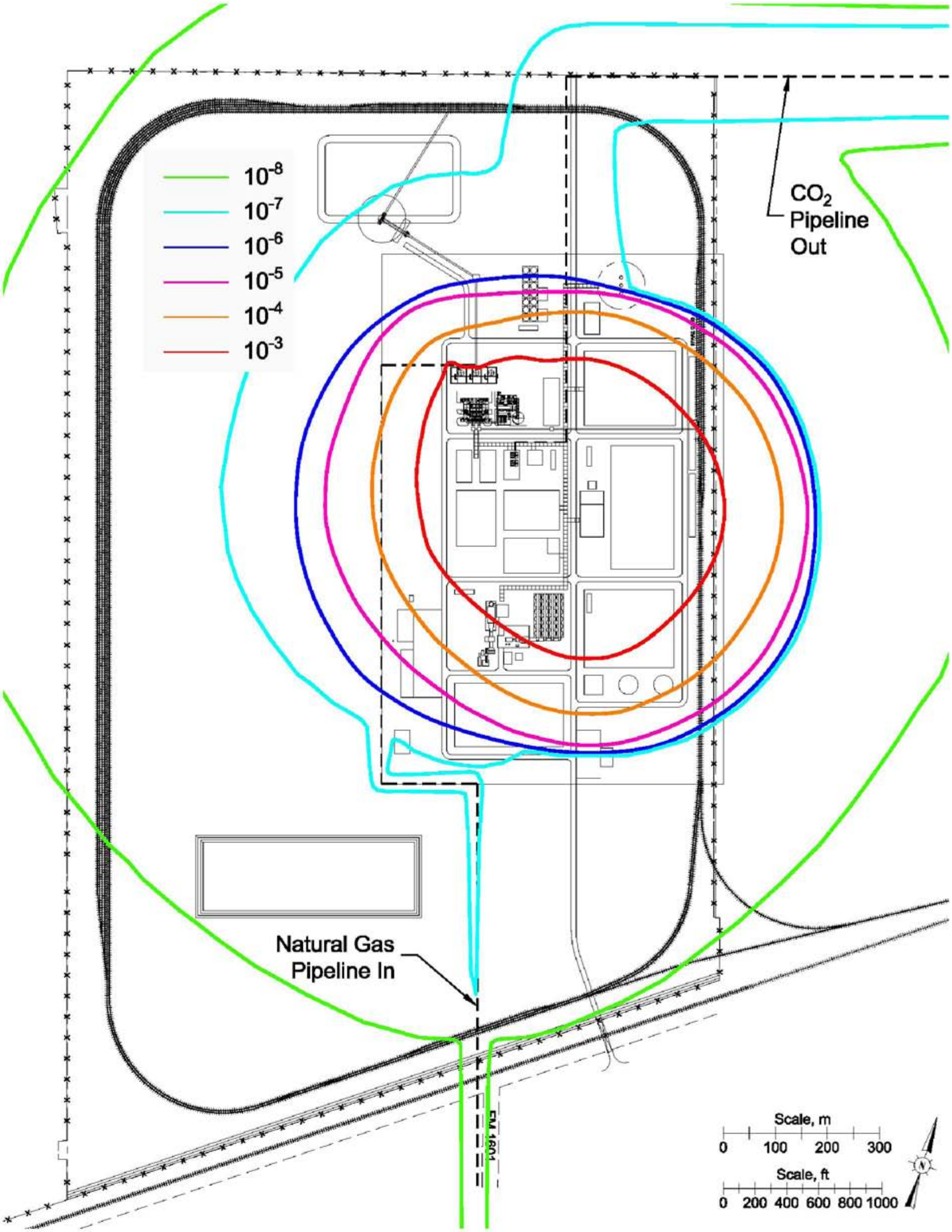

Figure 6-3
Risk Contours for the Proposed TCEP

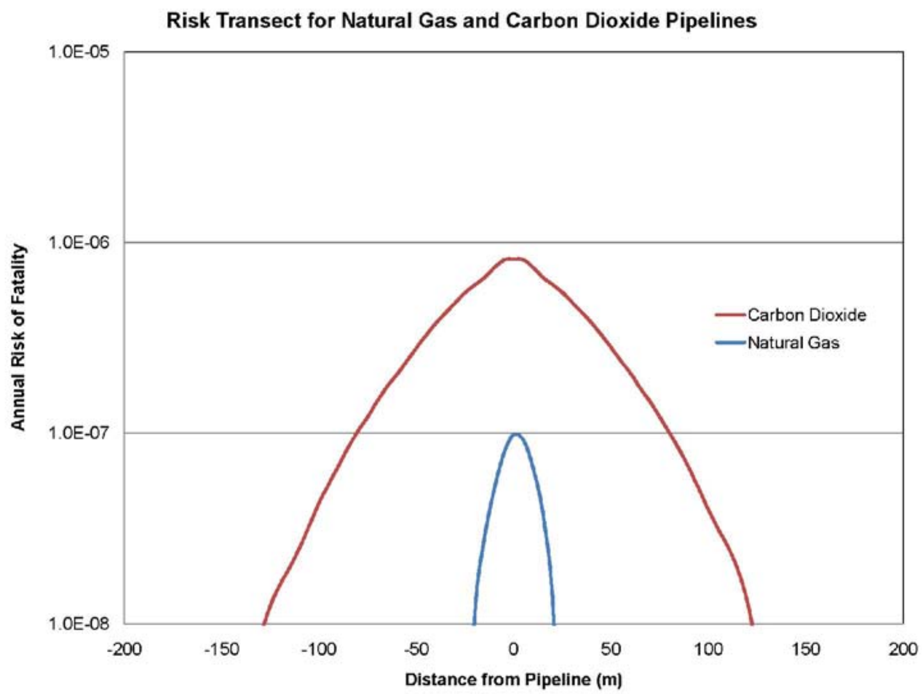

Figure 6-4
Pipeline Risk Transects for the Incoming Natural Gas and Export Carbon Dioxide Pipelines

The use of a "band" between the two limits suggests there is some uncertainty in the calculation of absolute risk. This band (between 1.0 x 10^{-5} and 1.0 x 10^{-6}) allows for some judgment in what is acceptable or unacceptable.

New South Wales Department of Urban Affairs and Planning

The New South Wales Department of Urban Affairs and Planning uses the following definitions of acceptable and unacceptable risk limits for new industrial installations located near residential developments.

- Risk levels lower than 1.0 x 10^{-6} per year are defined as acceptable for residential areas.
- Risk levels greater than 1.0 x 10^{-6} per year are defined as unacceptable.

Hong Kong

Risk guidelines have been developed by the government of Hong Kong for potentially hazardous installations. The guidelines are to be applied to new facilities and the expansion of existing facilities. The purpose of the guidelines was to limit the expansion of housing developments near potentially hazardous installations.

In general, development of new housing near an existing facility, or expansion of a facility near existing housing, would be restricted if the risk of fatality contour of 1.0 x 10^{-5} per year encroaches onto the housing development. Thus, the Hong Kong criteria can be defined as:

- Risk levels lower than 1.0×10^{-5} per year are defined as acceptable.
- Risk levels greater than 1.0×10^{-5} per year are defined as unacceptable.

United Kingdom

The Health and Safety Executive (HSE) is the regulatory authority for hazard identification and risk assessment studies in the United Kingdom. In 1989, the HSE published a document entitled *Risk Criteria for Land Use Planning in the Vicinity of Major Industrial Hazards*. The risk criteria proposed by the HSE are:

- Risk levels lower than 1.0×10^{-6} per year are defined as acceptable.
- Risk levels greater than 1.0×10^{-5} per year are unacceptable for small developments.
- Risk levels greater than 1.0×10^{-6} per year are unacceptable for large developments.

The HSE has also published a document that discusses their process for risk-based decision making. In *Reducing Risks, Protecting People* (2001), the HSE presents another set of risk tolerability limits that are intended as guidelines to be applied with common sense, not with regulatory rigidity.

- Risk levels lower than 1.0×10^{-6} per year for any population group are defined as acceptable.
- For members of the public, risk levels greater than 1.0×10^{-4} per year are unacceptable.
- Risk levels between 1.0×10^{-4} and 1.0×10^{-6} for the public are considered tolerable if the risk is "in the wider interest of society" and the risk is demonstrated to be as low as reasonably practicable (ALARP).

Netherlands

The Dutch Ministry for Housing, Spatial Planning, and the Environment passed a decree in 2004 that defines the acceptable risk levels associated with industrial activities. For facility siting, the regulatory requirements are:

- Risk levels lower than 1.0×10^{-6} per year are defined acceptable for new facilities.
- Risk levels greater than 1.0×10^{-6} per year are unacceptable for new facilities.

Figure 6-5 presents a summary of the risk acceptability criteria.

6.4 Conservatism Built Into the Risk Analysis Study

As with any consequence or risk analysis study, assumptions and engineering approximations are made in order to calculate the risk associated with the project components. In general, assumptions are made that tend to overpredict the risk due to releases from the project components. Thus, Quest believes that the predictions of risk presented in this report are conservative – in other words, they show the risk to be higher than it really may be.

A few of the conservative assumptions (that lead to risk overprediction) are listed below. The contributions of these factors cannot be explicitly quantified. They are presented here to provide qualitative reasons why the actual risk would be expected to be lower than predicted.

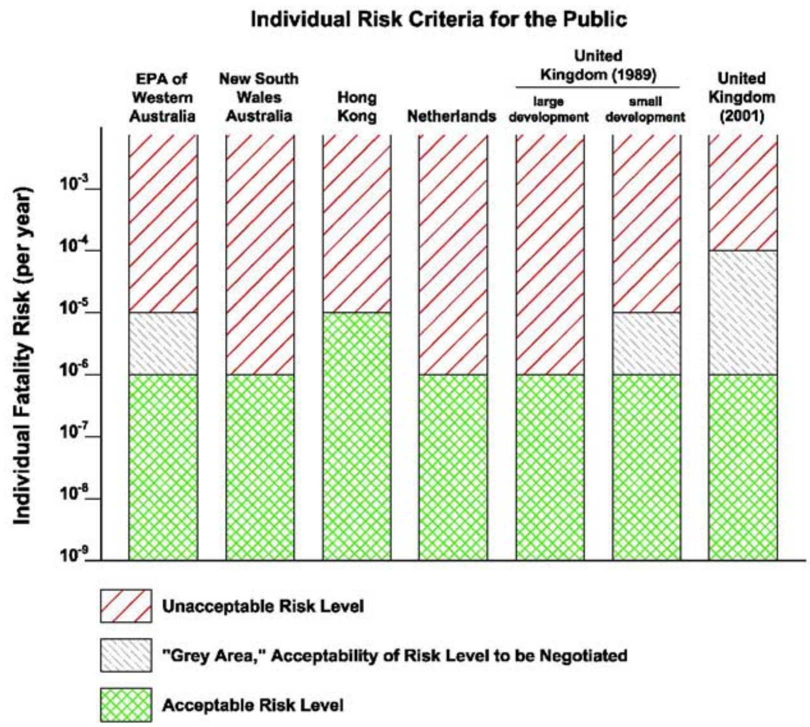

Figure 6-5
International Risk Acceptability Standards

- The risk calculations assume that people are present 24 hours a day, 365 days a year, at locations surrounding the TCEP. The population data available show that there are no permanent public buildings (houses, schools, etc.) within 1.0 kilometer of the facility. Thus, the risk to any member of the public is extremely small since there are no members of the public continuously present near the facility.

- Most releases were assumed to be oriented such that they are pointing horizontally in the direction the wind is blowing. This orientation allows the released material to travel the maximum distance before diluting below the lower flammable limit or below the toxic or asphyxiant concentration endpoint. Any other release direction (upwind, crosswind, etc.) would result in smaller impact zones. The net effect is an overprediction of risk.

- If a release did not ignite immediately upon release, it was assumed to grow (travel) to its full extent (maximum downwind distance) before igniting. This overestimates the risk by not allowing for intermediate ignition and subsequently smaller hazard zones.

- For persons exposed to fire radiation from a pool fire or torch fire, it was assumed that the duration of exposure was equal to thirty (30) seconds. This means that no protective or evasive action is taken by that individual for a full thirty seconds. If an individual moves away from the fire or finds shelter behind a solid object, their exposure to radiant energy will be reduced. Thus, the assumption of a 30-second exposure results in an overprediction of risk.

- Due to the preliminary nature of the QRA, many of the final design parameters for the individual process units are not finalized. The major inventories, and often the highest concentrations of flammable, toxic, and asphyxiant fluids are located in the transfer piping between the major process units. As part of this analysis, the annual probabilities of release were developed from generic data for the proposed units. The consequences of the releases were equated to those of the incoming and outgoing process flow lines. This approach serves to overpredict the risk associated with the process unit releases by forcing the use of the larger impact zones associated with the large inventory release cases. The net result is to overpredict the consequences associated with each proposed unit, thereby overpredicting the risk.

6.5 Study Conclusions

The overall objective of this study was to quantitatively determine the level of risk posed to the public by potential flammable, toxic, and asphyxiant releases originating within the proposed TCEP and associated pipelines, as expressed by risk contours.

The study consisted of three primary tasks.

Task 1. Select potential events that could lead to releases of flammable, toxic, and asphyxiant fluids at rates sufficient to create toxic or asphyxiant vapor clouds, flash fires, torch fires, pool fires, and vapor cloud explosions. This task was described in Sections 2 and 3.

Task 2. Determine the annual probability of occurrence of each event defined in Task 1. This task was presented in Section 4.

Task 3. Perform a consequence analysis for each event defined in Task 1 to determine how far the toxic and asphyxiant vapor clouds could travel to lethal concentrations and the extent of all flammable hazards to lethal levels with the available mitigation systems in place. This task was presented in Section 3. Combine the consequence modeling results with the annual probabilities from Task 2 to calculate the risk to the public from the proposed TCEP and associated pipelines. This task was described in Section 5 and the results presented earlier in Section 6.

In summary, the preliminary quantitative risk analysis of the proposed TCEP and associated pipelines near Penwell, Texas, resulted in four primary findings:

1. The risk levels posed by potential releases of flammable, toxic, and asphyxiant fluids from the proposed TCEP and associated pipelines would be considered acceptable by several international standards. This is demonstrated in Table 6-4.

2. The closest residence in Penwell is located over 1,000 m to the south of the proposed TCEP site. The residents in Penwell are not exposed to any risk levels greater than 1×10^{-8} from the TCEP. The TCEP risk contours are presented in Figure 6-6 on an aerial photograph of the site and surrounding area. The location of the TCEP, relative to the Penwell would be acceptable by all international standards.

3. The high consequence/low probability accidental releases associated with the ammonia storage operations drive the outer (1.0×10^{-7} and 1.0×10^{-8}) risk contours. At the time of this analysis, the anhydrous ammonia storage options and designs were not completed. Quest assumptions involving the inventory and location options that may be employed were purposely conservative. The actual risk associated with the ammonia storage options will most certainly be lower when the design is finalized. When the actual design is incorporated into the analysis, the $1.0 \times (10)^{-7}$ and $1.0 \times 10)^{-8}$ risk contours should contract back toward the TCEP.

4. The risks associated with the natural gas and carbon dioxide pipeline operations are low, below 1.0×10^{-6} in the immediate vicinity of the pipeline. This is not an unexpected result as pipeline operations for both natural gas and carbon dioxide are well understood and there is significant historical data to support this finding.

This preliminary quantitative risk analysis found the hazards and risks associated with the proposed TCEP and associated pipelines to be similar to those of other process plant operations worldwide that handle low concentrations of toxic materials in gas streams. The risks posed by flammable fluids are small due to the majority of the flammable fluids being processed in the gaseous phase. The location of the TCEP results in public risk levels that are clearly acceptable by published international standards.

Table 6-4
Risk Evaluation Criteria

Reference Authority	Location of Public	Criteria Evaluation		
		Acceptable	Requires Examination	Unacceptable
EPA of Western Australia	Public outside the TCEP property line. The $1 \times (10)^{-6}$ contour extends 200 m past the east TCEP property boundary but there are no public residences in that area)	✓		
New South Wales Department of Urban Affairs and Planning	Public outside the TCEP property line. The $1 \times (10)^{-6}$ contour extends 200 m past the east TCEP property boundary but there are no public residences in that area)	✓		
Hong Kong	Public outside the TCEP property line. The $1 \times (10)^{-6}$ contour extends 200 m past the east TCEP property boundary but there are no public residences in that area)	✓		
United Kingdom	Public outside the TCEP property line. The $1 \times (10)^{-6}$ contour extends 200 m past the east TCEP property boundary but there are no public residences in that area)	✓		
Netherlands	Public outside the TCEP property line. The $1 \times (10)^{-6}$ contour extends 200 m past the east TCEP property boundary but there are no public residences in that area)	✓		

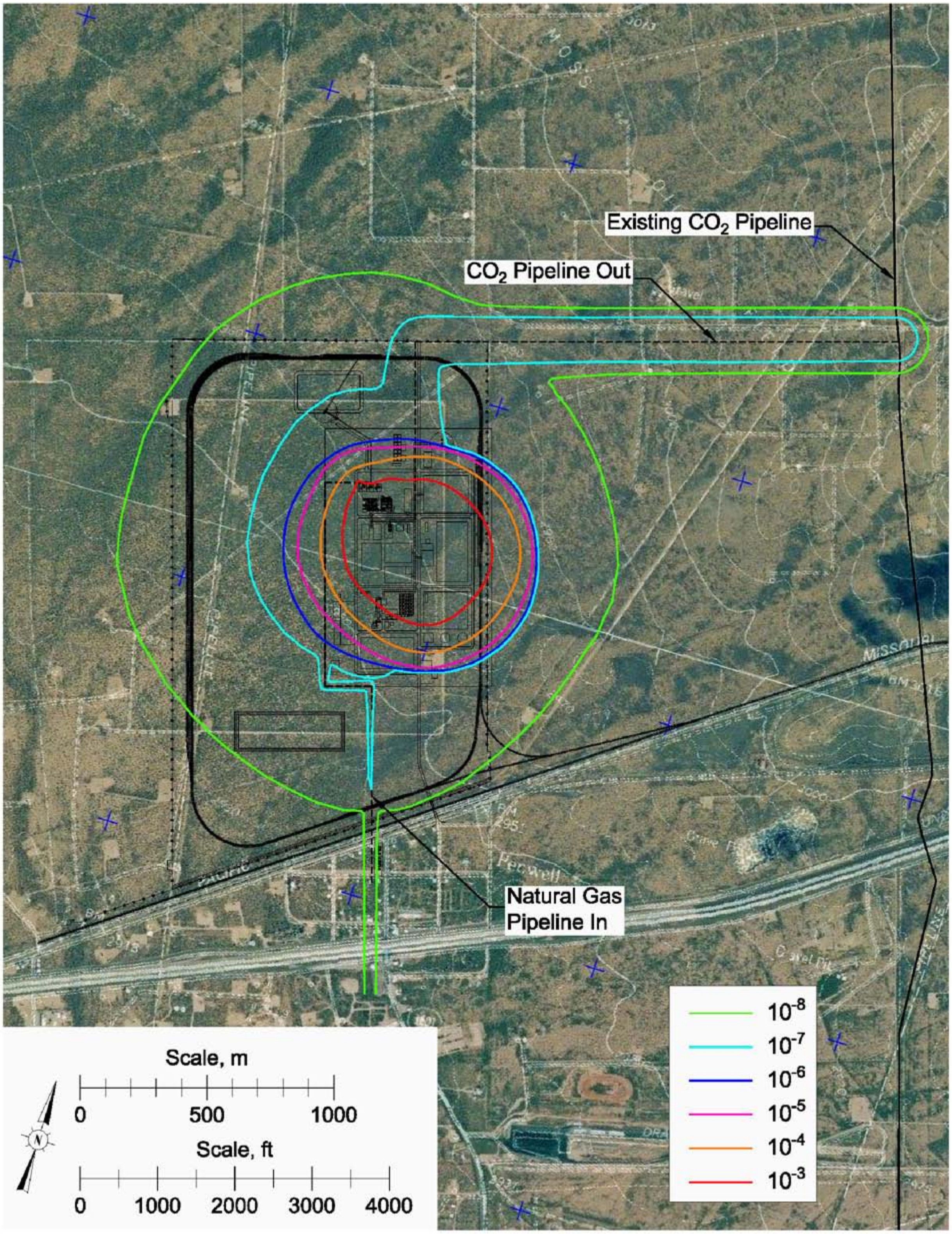

Figure 6-6
Risk Contours for the TCEP Facility

SECTION 7
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APPENDIX A
CANARY by QUEST® MODEL DESCRIPTIONS

The following model descriptions are taken from the CANARY by Quest User Manual.

Engineering Properties

Purpose

The purpose of this model is to provide an accurate means of computing physical and thermodynamic properties of a wide range of chemical mixtures and pure components using a minimum of initial information.

Required Data

(a) Fluid composition
(b) Temperature and pressure of the fluid prior to release

Methodology

Basic thermodynamic properties are computed using the Peng-Robinson equation of state [Peng and Robinson, 1976]. The necessary physical and thermodynamic properties are calculated in the following manner.

Step 1: The temperature and pressure of the fluid at storage conditions and the identity and mole fraction of each component of the fluid are obtained. Mixture parameters are determined using data from the extensive properties data base within CANARY.

Step 2: Each calculation begins with the computation of the vapor and liquid fluid composition. For cases where the temperature and pressure result in only one phase being present, the vapor or liquid composition will be the same as the initial feed composition. The composition calculation is an iterative procedure using a modification of the techniques described by Starling [1973].

Step 3: Once the vapor and liquid compositions are known, the vapor and liquid densities, enthalpies, entropies, and heat capacities can be computed directly. Other physical properties (viscosity, thermal conductivity, surface tension, etc.) are computed using correlations developed in Reid, Prausnitz, and Poling [1987].

Step 4: A matrix of properties is computed over a range of temperatures and pressures. Physical and thermodynamics properties required by other models within CANARY are then interpolated from this table.

Basic Thermodynamic Equations

$$Z^3 - (1 - B) \cdot Z^2 + \left(A - 3 \cdot B^2 - 2 \cdot B\right) \cdot Z - \left(A \cdot B - B^2 - B^3\right) = 0 \qquad (1)$$

where: Z = fluid compressibility factor, $\frac{P \cdot V}{R \cdot T}$, dimensionless

P = system pressure, kPa

V = fluid specific volume, m^3/kmol

R = gas constant, 8.314 $m^3 \cdot kPa/(kmol \cdot K)$
T = absolute temperature, K
$A = \dfrac{a \cdot P}{R^2 \cdot T^2}$

$a = 0.45724 \cdot \dfrac{R^2 \cdot T^2}{P_c} \cdot \alpha$

$\alpha = \left[1 + m \cdot \left(1 - T_r^{0.5}\right)^2\right]$

$m = 0.37464 + 1.54226 \cdot \omega - 0.26992 \cdot \omega^2$

ω = acentric factor

$T_r = \dfrac{T}{T_c}$

T_c = pseudo-critical temperature, K

P_c = pseudo-critical pressure, kPa

$B = \dfrac{b \cdot P}{R \cdot T}$

$b = 0.0778 \cdot R \cdot \dfrac{T_c}{P_c}$

$$H = H^o + \frac{P}{\rho} - R \cdot T + \int_0^{\rho} \left[P - T \cdot \left(\frac{\partial P}{\partial T}\right)_{\rho} \right] \cdot \left(\frac{d\rho}{\rho^2}\right) \tag{2}$$

where: H = enthalpy of fluid at system conditions, kJ/kg
H^o = enthalpy of ideal gas at system temperature, kJ/kg

$$S = S^o - R \cdot \ln\left(\rho \cdot R \cdot T\right) + \int_0^{\rho} \left[\rho \cdot R - \left(\frac{\partial P}{\partial T}\right)_{\rho} \right] \cdot \left(\frac{d\rho}{\rho^2}\right) \tag{3}$$

where: S = entropy of fluid at system conditions, $kJ/(kg \cdot K)$
S^o = entropy of ideal gas at system temperature, $kJ/(kg \cdot K)$

$$R \cdot T \cdot \ln\left(\frac{f_i}{f_i^o}\right) = \left[\left(H_i - H_i^o\right) - T \cdot \left(S_i - S_i^o\right)\right] \tag{4}$$

where: f_i = fugacity of component i, kPa
f_i^o = standard state reference fugacity, kPa

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Pool Fire Radiation Model

Purpose

The purpose of this model is to predict the impact of fire radiation emitted by flames that are fueled by vapors emanating from liquid pools. Specifically, the model predicts the maximum radiant heat flux incident upon a target as a function of distance between the target and the flame.

Required Data

(a) Composition of the liquid in the pool
(b) Temperature of the liquid in the pool
(c) Wind speed
(d) Air temperature
(e) Relative humidity
(f) Elevation of the target (relative to grade)
(g) Elevation of the pool (relative to grade)
(h) Dimensions of the free surface of the pool
(i) Orientation of the pool (relative to the wind direction)
(j) Spill surface (land or water)

Methodology

Step 1: The geometric shape of the flame is defined. The flame column above a circular pool, square pool, or rectangular pool is modeled as an elliptical cylinder.

Step 2: The dimensions of the flame column are determined. The dimensions of the base of the flame are defined by the pool dimensions. An empirical correlation developed by Thomas [1965] is used to calculate the length (height) of the flame.

$$L = 42 \cdot D_h \cdot \left(\frac{\dot{m}}{\rho_a \cdot \left(g \cdot D_h \right)^{0.5}} \right)^{0.61}$$

where: L = length (height) of the flame, m
D_h = hydraulic diameter of the liquid pool, m
$\dot{m}$ = mass burning flux, kg/(m$^2 \cdot$ s)
ρ_a = density of air, kg/m^3
g = gravitational acceleration, 9.8 m/s^2

Notes: Mass burning fluxes used in the Thomas equation are the steady-state rates for pools on land (soil, concrete, etc.) or water, whichever is specified by the user.

For pool fires with hydraulic diameters greater than 100 m, the flame length, L, is set equal to the length calculated for $D_h = 100$ m.

Step 3: The angle (Φ) to which the flame is bent from vertical by the wind is calculated using an empirical correlation developed by Welker and Sliepcevich [1970].

$$\frac{\tan(\Phi)}{\cos(\Phi)} = 3.2 \cdot \left(\frac{D_h \cdot u \cdot \rho_a}{\mu_a}\right)^{0.07} \cdot \left(\frac{u^2}{g \cdot D_h}\right)^{0.7} \cdot \left(\frac{\rho_v}{\rho_a}\right)^{-0.6}$$

where: Φ = angle the flame tilts from vertical, degrees
u = wind speed, m/s
μ_a = viscosity of air, kg/(m · s)
ρ_v = density of fuel vapor, kg/m^3

Step 4: The increase in the downwind dimension of the base of the flame (flame drag) is calculated using a generalized form of the empirical correlation Moorhouse [1982] developed for large circular pool fires.

$$D_w = 1.5 \cdot D_x \cdot \left(\frac{u^2}{g \cdot D_x}\right)^{0.069}$$

where: D_w = downwind dimension of base of tilted flame, m
D_x = downwind dimension of the pool, m

Step 5: The flame is divided into two zones: a clear zone in which the flame is not obscured by smoke; and a smoky zone in which a fraction of the flame surface is obscured by smoke. The length of the clear zone is calculated by the following equation, which is based on an empirical correlation developed by Pritchard and Binding [1992].

$$L_c = 55.05 \cdot D_h^{-0.6} \cdot \left(\frac{\dot{m}}{\rho_a}\right)^{1.13} \cdot (u+1)^{0.179} \cdot \left(\frac{C}{H}\right)^{-2.49}$$

where: L_c = length of the clear zone, m
$\frac{C}{H}$ = carbon/hydrogen ratio of fuel, dimensionless

Step 6: The surface flux of the clear zone is calculated using the following equation.

$$q_{cz} = q_{sm} \cdot \left(1 - e^{-b \cdot D_h}\right)$$

where: q_{cz} = surface flux of the clear zone, kW/m^2
q_{sm} = maximum surface flux, kW/m^2
b = extinction coefficient, m^{-1}

Average surface flux of the smoky zone, q_{sz}, is then calculated, based on the following assumptions.

- The smoky zone consists of clean-burning areas and areas in which the flame is obscured by smoke.
- Within the smoky zone, the fraction of the flame surface that is obscured by smoke is a function of the fuel properties and pool diameter.
- Smoky areas within the smoky zone have a surface flux of 20 kW/m^2 [Hagglund and Persson,1976].
- Clean-burning areas of the smoky zone have the same surface flux as the clean-burning zone.
- The average surface flux of the smoky zone is the area-weighted average of the surface fluxes for the smoky areas and the clean-burning areas within the smoky zone.

(This two-zone concept is based on the Health and Safety Executive POOLFIRE6 model, as described by Rew and Hulbert [1996].)

Step 7: The surface of the flame is divided into numerous differential areas. The following equation is then used to calculate the view factor from a differential target, at a specific location outside the flame, to each differential area on the surface of the flame.

$$F_{dA_t \to dA_f} = \frac{\cos(\beta_t) \cdot \cos(\beta_f)}{\pi \cdot r^2} \cdot dA_f \qquad \text{for } [\beta_t] \text{ and } [\beta_f] < 90°$$

where:

$F_{dA_t \to dA_f}$ = view factor from a differential area on the target to a differential area on the surface of the flame, dimensionless
dA_f = differential area on the flame surface, m^2
dA_t = differential area on the target surface, m^2
r = distance between differential areas dA_t and dA_f, m
β_t = angle between normal to dA_t and the line from dA_t to dA_f, degrees
β_f = angle between normal to dA_f, and the line from dA_t to dA_f, degrees

Step 8: The radiant heat flux incident upon the target is computed by multiplying the view factor for each differential area on the flame by the appropriate surface flux $(q_{cz}$ or $q_{sz})$ and by the appropriate atmospheric transmittance, then summing these values over the surface of the flame.

$$q_{ai} = \sum_{A_f} q_{sf} \cdot F_{dA_t \to dA_f} \cdot \tau$$

where:

q_{ai} = attenuated radiant heat flux incident upon the target due to radiant heat emitted by the flame, kW/m^2
A_f =area of the surface of the flame
q_{sf} = radiant heat flux emitted by the surface of the flame, kW/m^2 (q_{sf} equals either q_{cz} or q_{sz}, as appropriate)
τ =atmospheric transmittance, dimensionless

Atmospheric transmittance, τ, is a function of absolute humidity and r, the path length between differential areas on the flame and target [Wayne, 1991].

Step 9: Steps 7 and 8 are repeated for numerous target locations.

Validation

Several of the equations used in the Pool Fire Radiation Model are empirical relationships based on data from medium- to large-scale experiments, which ensures reasonably good agreement between model predictions and experimental data for variables such as flame length and tilt angle. Comparisons of experimental data and model predictions for incident heat flux at specific locations are more meaningful and of greater interest. Unfortunately, few reports on medium- or large-scale experiments contain the level of detail required to make such comparisons.

One source of detailed test data is a report by Welker and Cavin [1982]. It contains data from sixty-one pool fire tests involving commercial propane. Variables that were examined during these tests include pool size (2.7 to 152 m^2) and wind speed. Figure B-1 compares the predicted values of incident heat flux with experimental data from the sixty-one pool fire tests.

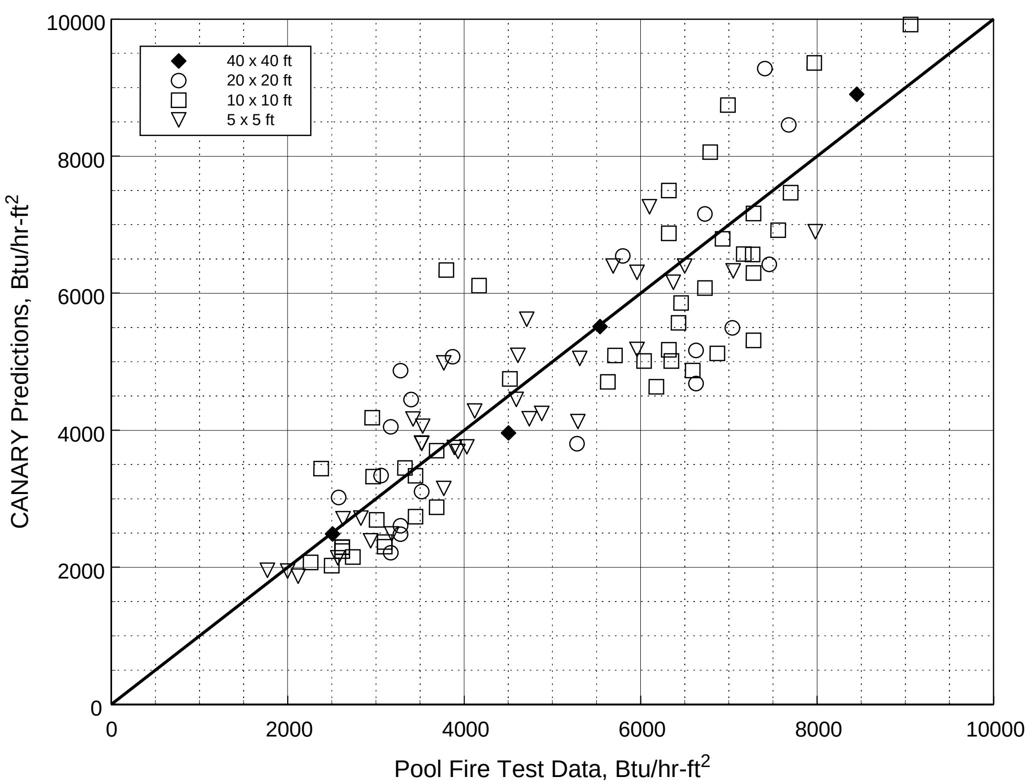

Figure B-1

In another series of tests, fire radiation measurements were taken for large liquefied natural gas (LNG) pool fires. The Montoir tests are the largest tests of LNG fires, involving pools up to 35 meters in diameter [Nédelka, Moorhouse, and Tucker, 1989]. Figure B-2 compares the radiation isopleths predicted by CANARY with the actual measurements taken in Test 2 of the Montoir series.

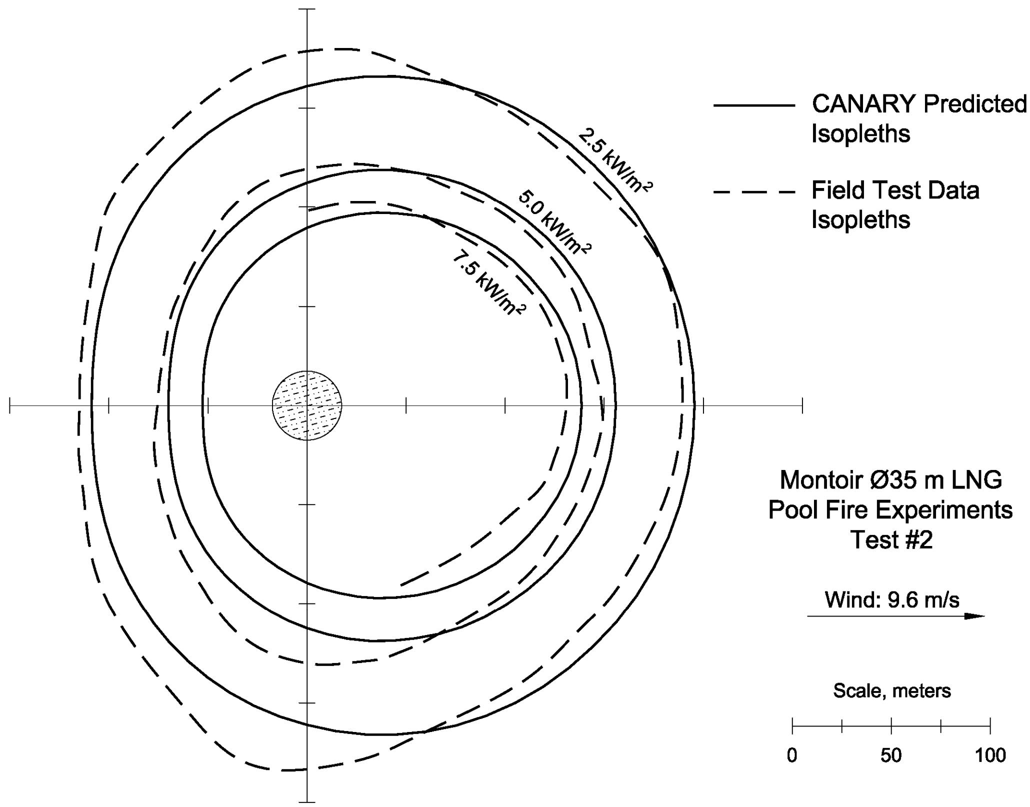

Figure B-2

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Torch Fire and Flare Radiation Model

Purpose

The purpose of this model is to predict the impact of fire radiation emitted by burning jets of vapor. Specifically, the model predicts the maximum radiant heat flux incident upon a target as a function of distance between the target and the point of release.

Required Data

(a) Composition of the released material
(b) Temperature and pressure of the material before release
(c) Mass flow rate of the material being released
(d) Diameter of the exit hole
(e) Wind speed
(f) Air temperature
(g) Relative humidity
(h) Elevation of the target (relative to grade)
(i) Elevation of the point of release (relative to grade)
(j) Angle of the release (relative to horizontal)

Methodology

Step 1: A correlation based on a Momentum Jet Model is used to determine the length of the flame. This correlation accounts for the effects of:

- composition of the released material,
- diameter of the exit hole,
- release rate,
- release velocity, and
- wind speed.

Step 2: To determine the behavior of the flame, the model uses a momentum-based approach that considers increasing plume buoyancy along the flame and the bending force of the wind. The following equations are used to determine the path of the centerline of the flame [Cook, et al., 1987].

$$\Phi_X = (\rho_{ja})^{0.5} \cdot \bar{u} \cdot \sin(\theta) \cdot \cos(\varphi) + (\rho_\infty)^{0.5} \cdot u_\infty \qquad \text{(downwind)}$$

$$\Phi_Y = (\rho_{ja})^{0.5} \cdot \bar{u} \cdot \sin(\theta) \cdot \sin(\varphi) \qquad \text{(crosswind)}$$

$$\Phi_Z = (\rho_{ja})^{0.5} \cdot \bar{u} \cdot \cos(\theta) + (\rho_\infty)^{0.5} \cdot u_b \cdot \frac{(i+1)}{n} \qquad \text{(vertical)}$$

where: Φ_{XYZ} = momentum flux in X, Y, Z direction
ρ_{ja} = density of the jet fluid at ambient conditions, kg/m^3

$\bar{u}$ = average axial velocity of the flame, m/s
θ = release angle in X–Z plane (relative to horizontal), degrees
φ = release angle in X–Y plane (relative to downwind), degrees
ρ_∞ = density of air, kg/m^3
u_∞ = wind speed, m/s
ρ_b = density of combustion products, kg/m^3
u_b = buoyancy velocity, m/s
n = number of points taken along the flame length

These correlations were developed to predict the path of a torch flame when released at various orientations. The model currently does not allow a release angle in a crosswind direction; the release angle is confined to the downwind/vertical plane (i.e., φ = 0).

Step 3: The angle of flame tilt is defined as the inclination of a straight line between the point of release and the end point of the flame centerline path (as determined in Step 2).

Step 4: The geometric shape of the flame is defined as a frustum of a cone (as suggested by several flare/fire researchers [e.g., Kalghatgi, 1983, Chamberlain, 1987]), but modified by adding a hemisphere to the large end of the frustum. The small end of the frustum is positioned at the point of release, and the centerline of the frustum is inclined at the angle determined in Step 3.

Step 5: The surface emissive power is determined from the molecular weight and heat of combustion of the burning material, the release rate and velocity, and the surface area of the flame.

Step 6: The surface of the flame is divided into numerous differential areas. The following equation is then used to calculate the view factor from a differential target, at a specific location outside the flame, to each differential area on the surface of the flame.

$$F_{dA_t \to dA_f} = \frac{\cos(\beta_t)\cdot\cos(\beta_f)}{\pi\cdot r^2}\cdot dA_f \qquad \text{for } [\beta_t] \text{ and } [\beta_f] < 90°$$

where: $F_{dA_t \to dA_f}$ = view factor from a differential area on the target to a differential area on the surface of the flame, dimensionless
dA_f = differential area on the flame surface, m^2
dA_t = differential area on the target surface, m^2
r = distance between differential areas dA_t and dA_f, m
β_t = angle between normal to dA_t and the line from dA_t to dA_f, degrees
β_f = angle between normal to dA_f and the line from dA_t to dA_f, degrees

Step 7: The radiant heat flux incident upon the target is computed by multiplying the view factor for each differential area on the flame by the surface missive power and by the appropriate atmospheric transmittance, then summing these values over the surface of the flame.

$$q_{ai} = \sum_{A_f} q_{sf}\cdot F_{dA_t \to dA_f}\cdot\tau$$

where: q_{ai} = attenuated radiant heat flux incident upon the target due to radiant heat emitted by the flame, kW/m^2

A_f = area of the surface of the flame

q_{sf} = radiant heat flux emitted by the surface of the flame, kW/m^2

τ = atmospheric transmittance, dimensionless

Atmospheric transmittance, τ, is a function of absolute humidity and r, the path length between differential areas on the flame and target [Wayne, 1991].

Step 8: Steps 6 and 7 are repeated for numerous target locations.

Validation

Several of the equations used in the Torch Fire and Flare Radiation Model are empirical relationships based on data from medium- to large-scale experiments, which ensures reasonably good agreement between model predictions and experimental data for variables such as flame tilt angle. Comparisons of experimental data and model predictions for incident heat flux at specific locations are more meaningful and of greater interest. Unfortunately, few reports on medium- or large-scale experiments contain the level of detail required to make such comparisons.

One reasonable source of test data is a report by Chamberlain [1987]. It contains data from seven flare tests involving natural gas releases from industrial flares, with several data points being reported for each test. Variables that were examined during these tests include release diameter (0.203 and 1.07 m), release rate and velocity, and wind speed. Figure C-1 compares the predicted values of incident heat flux with experimental data from the seven flare tests.

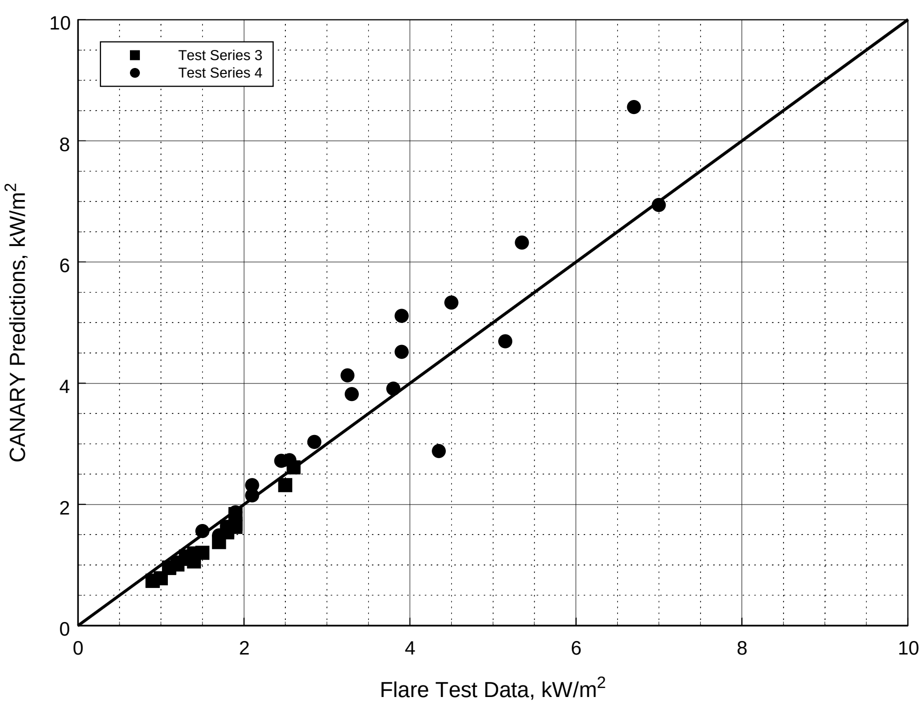

Figure C-1

References

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Fireball Model

Purpose

The purpose of the Fireball Model is to predict the impact of thermal radiation emitted by fireballs that result from catastrophic failures of pressure vessels containing superheated liquids. Specifically, the model predicts the average radiant heat flux incident upon a grade-level target as a function of the horizontal distance between the target and the center of the fireball.

Required Data

(a) Composition of flammable liquid within the pressure vessel
(b) Mass of flammable liquid within the pressure vessel
(c) Pressure within vessel just prior to rupture
(d) Temperature of the liquid within the vessel just prior to rupture
(e) Air temperature
(f) Relative humidity

Methodology

Step 1: Calculate the mass of fuel consumed in the fireball. The mass of fuel in the fireball is equal to the smaller of the mass of fuel in the vessel (as specified by the user), or three times the mass of fuel that flashes to vapor when it is released to the atmosphere [Hasegawa and Sato, 1977].

Step 2: Calculate the maximum diameter of the fireball using the empirical correlation from Roberts [1981/82].

$$D_{max} = 5.8 \cdot M_f^{1/3}$$

where: D_{max} = maximum diameter of the fireball, m
M_f = mass of fuel in the fireball, kg

Step 3: Calculate fireball duration using the following empirical correlation [Martinsen and Marx, 1999].

$$t_d = 0.9 \cdot M_f^{1/4}$$

where: t_d = fireball duration, s
M_f = mass of fuel in the fireball, kg

Step 4: Calculate the size of the fireball and its location, as a function of time. The fireball is assumed to grow at a rate that is proportional to the cube root of time, reaching its maximum diameter, D_{max}, at the time of liftoff, $t_d / 3$. During its growth phase, the fireball remains tangent to grade. After liftoff, it rises at a constant rate [Shield, 1994].

Step 5: Estimate the surface flux of the fireball. The fraction of the total available heat energy that is emitted as radiation is calculated using the equation derived by Roberts [1981/82].

$$f = 0.0296 \cdot P^{0.32}$$

where: f = fraction of available heat energy released as radiation, dimensionless
P = pressure in vessel at time of rupture, kPa

The total amount of energy emitted as radiation is then calculated.

$$E_r = f \cdot M_f \cdot \Delta H_c$$

where: E_r = energy emitted as radiation, kJ
ΔH_c = heat of combustion, kJ/kg

The surface flux is estimated by dividing E_r by the average surface area of the fireball and the fireball duration, but it is not allowed to exceed 400 kW/m^2.

Step 6: Calculate the maximum view factor from a differential target (at specific grade level locations outside the fireball) to the fireball, using the simple equation for a spherical radiator [Howell, 1982].

$$F = \frac{R^2}{H^2}$$

where: F = view factor from differential area to the fireball, dimensionless
R = radius of the fireball, m
H = distance between target and the center of the fireball, m

R and H vary with time due to the growth and rise of the fireball. Therefore, the duration of the fireball is divided into time intervals and a view factor is calculated at the end of each interval.

Step 7: Compute the attenuated radiant heat flux at each target location, at the end of each time interval, by multiplying the appropriate view factor by the surface flux of the fireball and by the appropriate atmospheric transmittance. The transmittance of the atmosphere is a function of the absolute humidity and path length from the fireball to the target [Wayne, 1991]. For each target location, calculate the average attenuated heat flux over the duration of the fireball.

Step 8: Calculate the absorbed energy at each target location. For a given location, the energy absorbed during each time interval is computed by multiplying the length of the interval by the average attenuated radiant heat flux for that interval. The absorbed energies for all time intervals are then summed to determine the radiant energy absorbed over the duration of the fireball.

Step 9: Calculate the integrated dosage at each target location. This is computed in the same manner as absorbed energy is computed in Step 8, except that the average attenuated radiant heat flux for each time interval is taken to the 4/3rds power before it is multiplied by the time interval. This allows the dosage to be used in the probit equation for fatalities from thermal radiation [Eisenberg, Lynch, and Breeding, 1975].

$$Pr = -38.4785 + 2.56 \cdot \ln\left(q^{4/3} \cdot t\right)$$

where: Pr = probit
q = radiant heat flux, W/m^2
t = exposure time, s

Validation

Several of the equations used in the Fireball Model are empirical relationships based on data from small- to medium-scale experiments, which ensures reasonably good agreement between model predictions and experimental data for variables such as maximum fireball diameter. Comparisons of experimental data and model predictions for average incident heat flux, absorbed energy, or dosage are more meaningful and of greater interest. Unfortunately, very few reports on small- or medium-scale fireball experiments contain the level of detail required to make such comparisons, and no such data are available for large-scale experiments.

One of the most complete sources of test data for medium-scale fireball tests is a report by Johnson, Pritchard, and Wickens [1990]. It contains data on five BLEVE tests that involved butane and propane, in quantities up to 2,000 kg. Figure D-1 compares the predicted values of absorbed energy with experimental data from those five BLEVE tests.

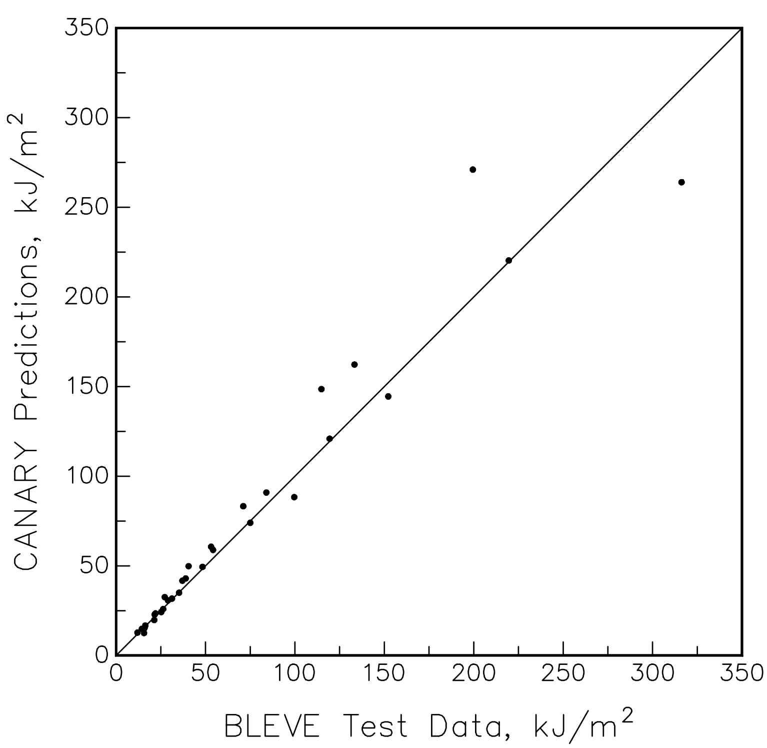

Figure D-1

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Fluid Release Model

Purpose

The purpose of the Fluid Release Model is to predict the rate of mass release from a breach of containment. Specifically, the model predicts the rate of flow and the physical state (liquid, two-phase, or gas) of the release of a fluid stream as it enters the atmosphere from a circular breach in a pipe or vessel wall. The model also computes the amount of vapor and aerosol produced and the rate at which liquid reaches the ground.

Required Data

(a) Composition of the fluid
(b) Temperature and pressure of the fluid just prior to the time of the breach
(c) Normal flow rate of fluid into the vessel or in the pipe
(d) Size of the pipe and/or vessel
(e) Length of pipe
(f) Area of the breach
(g) Angle of release relative to horizontal
(h) Elevation of release point above grade

Methodology

Step 1: Calculation of Initial Flow Conditions

The initial conditions (before the breach occurs) in the piping and/or vessel are determined from the input data, coupled with a calculation to determine the initial pressure profile in the piping. The pressure profile is computed by dividing the pipe into small incremental lengths and computing the flow conditions stepwise from the vessel to the breach point. As the flow conditions are computed, the time required for a sonic wave to traverse each section is also computed. The flow in any length increment can be all vapor, all liquid, or two-phase (this implies that the sonic velocity within each section may vary). As flow conditions are computed in each length increment, checks are made to determine if the fluid velocity has exceeded the sonic velocity or if the pressure in the flow increment has reached atmospheric. If either condition has been reached, an error code is generated and computations are stopped.

Step 2: Initial Unsteady State Flow Calculations

When a breach occurs in a system with piping, a disturbance in flow and pressure propagates from the breach point at the local sonic velocity of the fluid. During the time required for the disturbance to reach the upstream end of the piping, a period of highly unsteady flow occurs. The portion of the piping that has experienced the passage of the pressure disturbance is in accelerated flow, while the portion upstream of the disturbance is in the same flow regime as before the breach occurred.

To compute the flow rate from the breach during the initial unsteady flow period, a small time increment is selected and the distance that the pressure disturbance has moved in that time increment is computed using the sonic velocity profile found in the initial pressure profile calculation. The disturbed length is subdivided into small increments for use in an iterative pressure balance calculation. A pressure balance is achieved when a breach pressure is found that balances the flow from the breach and the flow in the disturbed section of piping. Another time increment is added, and the iterative procedure continues. The unsteady period continues until the pressure disturbance reaches the upstream end of the pipe.

Step 3: Long-Term Unsteady State Flow Calculations

The long-term unsteady state flow calculations are characterized by flow in the piping system that is changing more slowly than during the initial unsteady state calculations. The length of accelerated flow in the piping is constant, set by the user input pipe length. The vessel contents are being depleted, resulting in a potential lowering of pressure in the vessel. As with the other flow calculations, the time is incremented and the vessel conditions are computed. The new vessel conditions serve as input for the pressure drop calculations in the pipe. When a breach pressure is computed that balances the breach flow with the flow in the piping, a solution for that time is achieved. The solution continues until the ending time or other ending conditions are reached.

The frictional losses in the piping system are computed using the equation:

$$h = \left(\frac{4 \cdot f \cdot L \cdot U_{ls}^2}{2 \cdot g_c \cdot D_e}\right) \quad (1)$$

where: h = head (pressure) loss, ft of fluid
f = friction factor
L = length of system, ft
U = average flowing velocity, ft/sec
g_c = gravitational constant, 32.2 $lb_m \cdot ft/(lb_f \cdot sec^2)$
D_e = equivalent diameter of duct, ft

The friction factor is computed using the following equation:

$$\frac{1}{\sqrt{f}} = 1.74 - 2.0 \cdot \log_{10}\left[\frac{2 \cdot \varepsilon}{D_e} + \frac{18.7}{Re \cdot \sqrt{f}}\right] \quad (2)$$

where: ε = pipe roughness, ft
Re = Reynolds number, $D_e \cdot U \cdot \rho / \mu$, dimensionless
ρ = fluid density, lb/ft^3
μ = fluid viscosity, $lb/(ft \cdot sec)$

Equations (1) and (2) are used for liquid, vapor, and two-phase flow regimes. Since the piping is subdivided into small lengths, changes in velocity and physical properties across each segment are assumed to be negligible. At each step in the calculation, a check is made to determine if the fluid velocity has reached or exceeded the computed critical (sonic) velocity for the fluid. If the critical velocity has been exceeded, the velocity is constrained to the critical velocity and the maximum mass flow rate in the piping has been set.

If the fluid in the piping is in two-phase flow, the Lockhart and Martinelli [1949] modification to Equation (1) is used. The Lockhart and Martinelli equation for head loss is shown below:

$$h_{TP} = \Phi^2 \cdot \left(\frac{4 \cdot f \cdot L \cdot U_{ls}^2}{2 \cdot g_c \cdot D_e} \right) \quad (3)$$

where: h_{TP} = head loss for two-phase flow, ft of fluid
Φ = empirical parameter correlating single- and two-phase flow, dimensionless
U_{ls} = superficial liquid velocity (velocity of liquid if liquid filled the pipe), ft/sec

This equation is valid over short distances where the flowing velocity does not change appreciably.

Validation

Validation of fluid flow models is difficult since little data are available for comparison. Fletcher [1983] presented a set of data for flashing CFC-11 flowing through orifices and piping. Figures E-1 through E-4 compare calculations made using the Fluid Release Model with the data presented by Fletcher. Figure E-1 compares fluid fluxes for orifice type releases. These releases had length-to-diameter (L/D) ratios less than 0.88. Figure E-2 compares computed and experimental release fluxes for an L/D ratio of 120 at several levels of storage pressure. Figure E-3 compares similar releases for an L/D of 37.5. Figure E-4 shows predicted and experimental release fluxes at a given pressure for L/D ratios from 1 to 200.

Figures E-5 and E-6 compare computed and experimental gas discharge rates for the complete breach of two pipes. One pipe had an internal diameter of 6.2 inches (0.157 m); the other had a diameter of 12 inches (0.305 m). These pipes were initially pressurized to 1,000 psia with air and then explosively ruptured. The experimental values were reported in a research paper for Alberta Environment, authored by Wilson [1981].

Aerosols and Liquid Droplet Evaporation

Liquids stored at temperatures above their atmospheric pressure boiling point (superheated liquids) will give off vapor when released from storage. If the temperature of storage is sufficiently above the normal boiling point, the energy of the released vapor will break the liquid stream into small droplets. If these droplets are small enough, they will not settle, but remain in the vapor stream as aerosol droplets. The presence of aerosol droplets in the vapor stream changes its apparent density and provides an additional source of vapor. Droplets large enough to fall to the ground will lose mass due to evaporation during their fall.

The prediction of aerosol formation and amount of aerosol formed is based on the theoretical work performed for the Center for Chemical Process Safety (CCPS) by CREARE. CREARE's work has been extended and corrected by Quest. The extension to the model computes the non-aerosol drop evaporation. In Figure E-7, the four experimental data sets available for comparison (chlorine (Cl_2), methylamine (MMA), CFC-11, and cyclohexane) are compared to the values computed by the CANARY Aerosol Model.

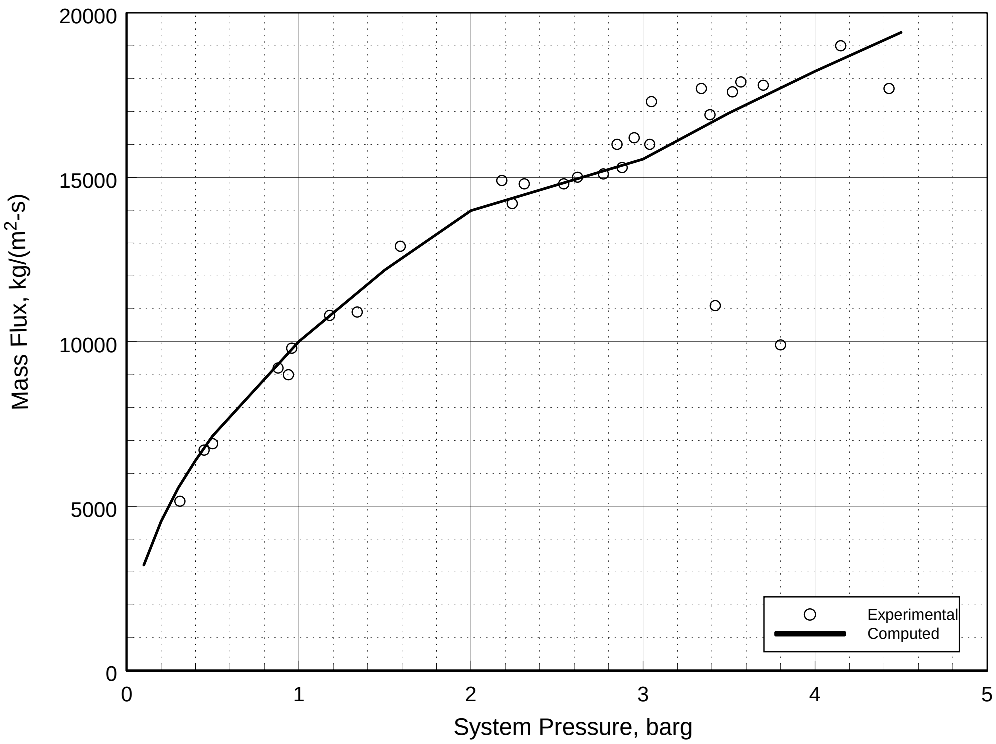

Figure E-1
Comparison of CFC-11 Orifice Releases as a Function of System Pressure

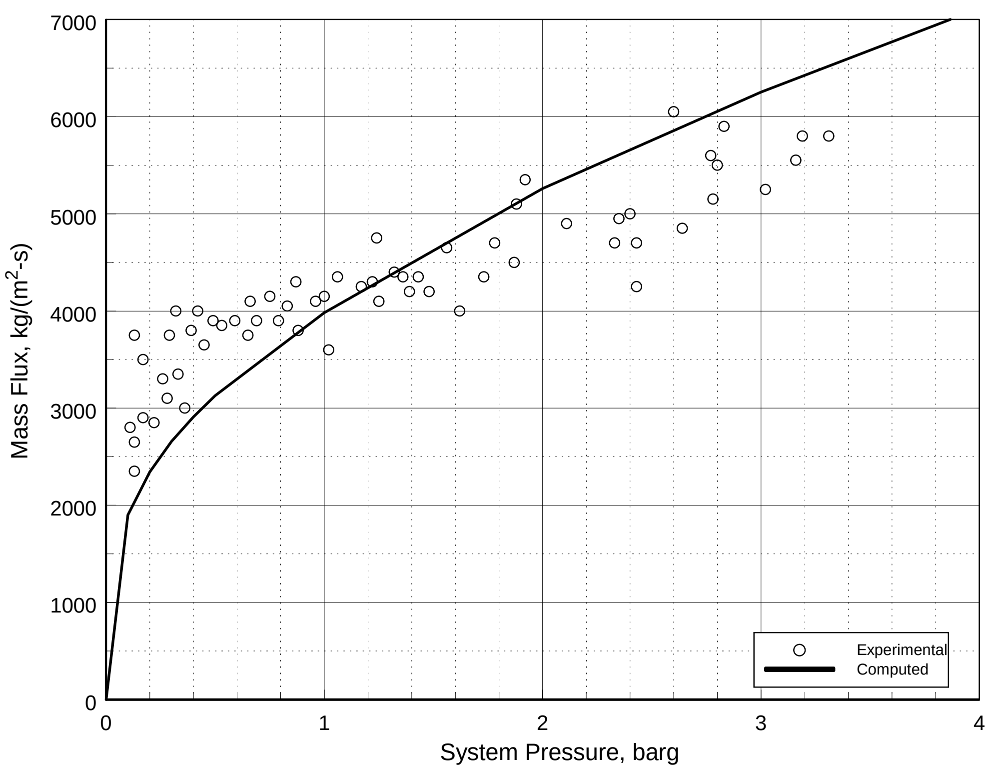

Figure E-2
CFC-11 Release Rate Comparison with L/D of 120

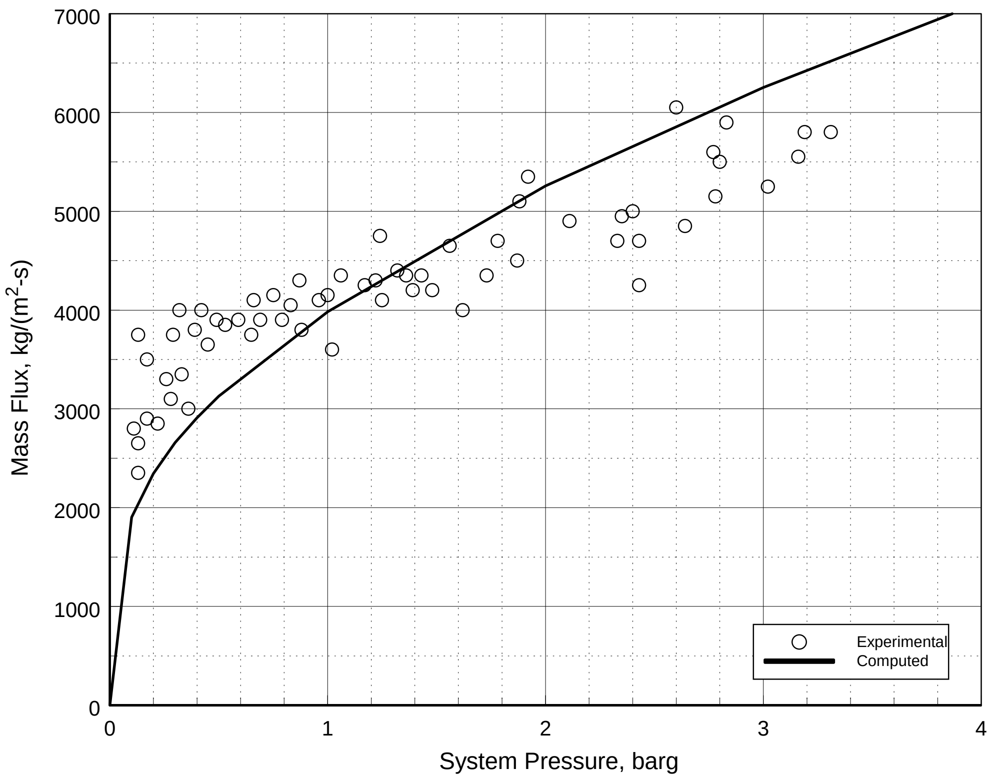

Figure E-3
CFC-11 Release Rate Comparison with L/D of 37.5

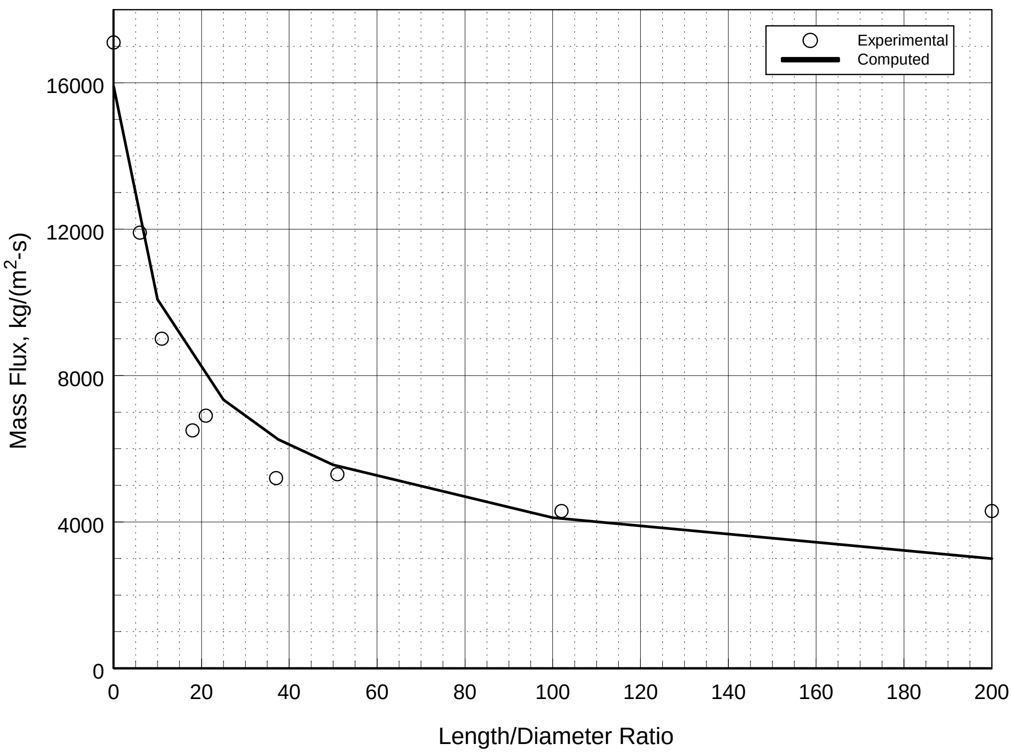

Figure E-4
CFC-11 Release Rate Comparison at Varying L/D Ratios

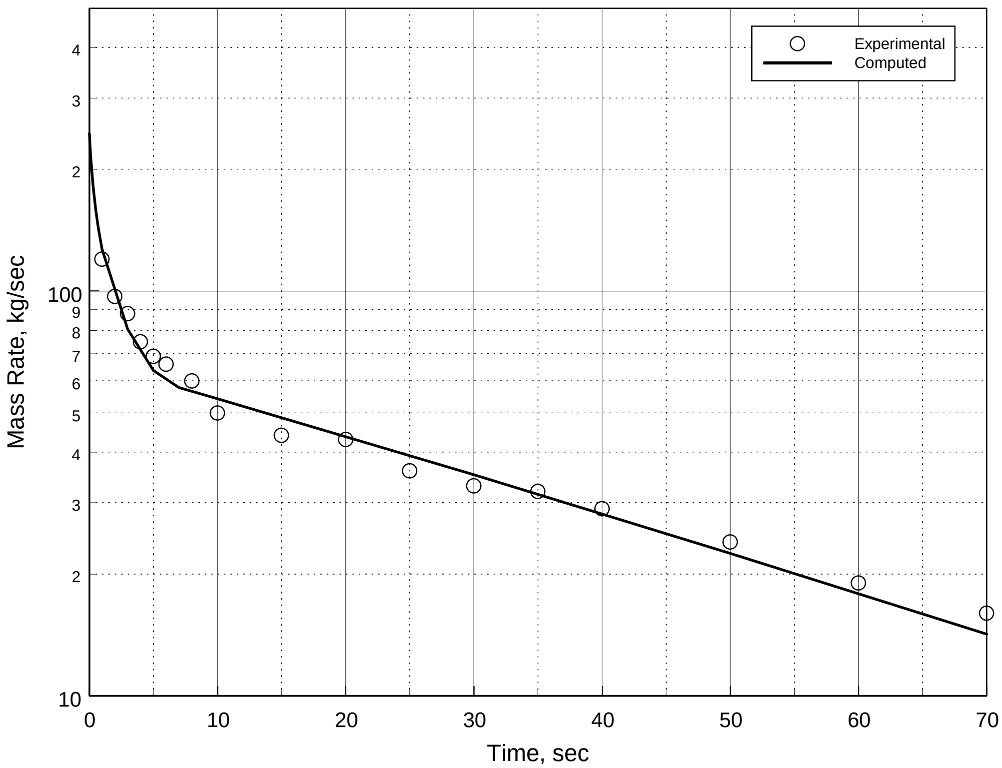

Figure E-5
Air Discharge Rates for 0.157 m Diameter Piping

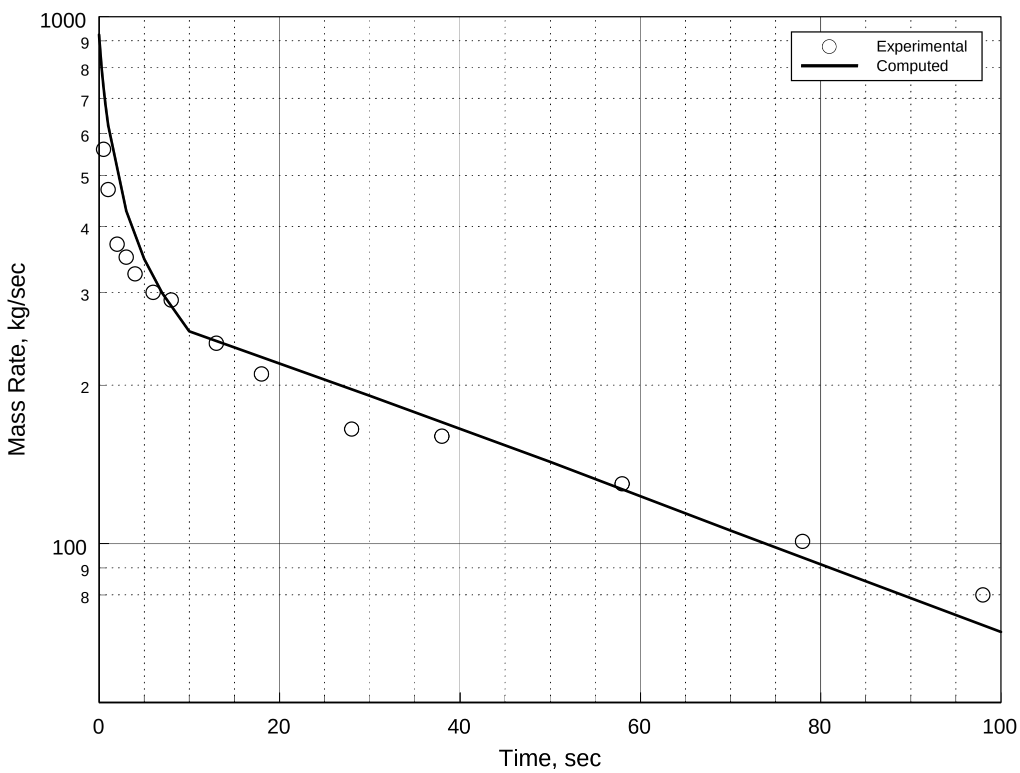

Figure E-6
Air Discharge Rates for 0.305 m Diameter Piping

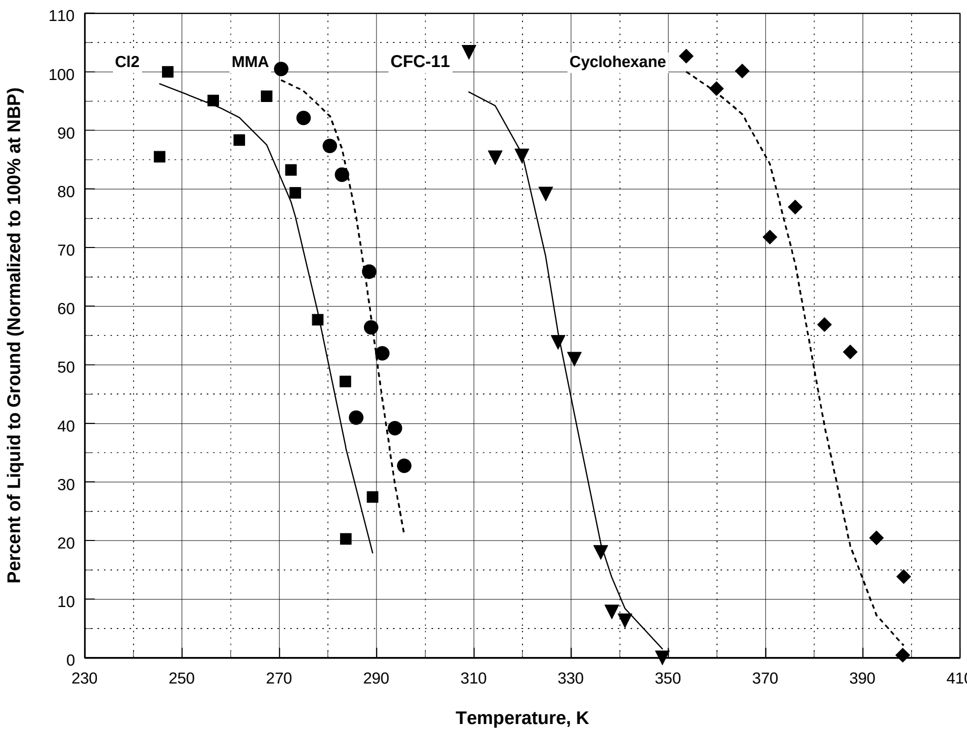

Figure E-7
Aerosol Formation as a Function of Storage Temperature

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Momentum Jet Dispersion Model

Purpose

The purpose of this model is to predict the dispersion of a jet release into ambient air. It is used to predict the downwind travel of a flammable or toxic gas or aerosol momentum jet release.

Required Data

(a) Composition and properties of the released material
(b) Temperature of released material
(c) Release rate of material
(d) Vertical release angle relative to wind direction
(e) Height of release
(f) Release area
(g) Ambient wind speed
(h) Ambient Pasquill-Gifford stability class
(i) Ambient temperature
(j) Relative humidity
(k) Surface roughness scale

Methodology

Step 1: An assumption is made that flow perpendicular to the main flow in the plume is negligible, that the velocity and concentration profiles in the jet are similar at all sections of the jet, that molecular transport in the jet is negligible, and that longitudinal turbulent transport is negligible when compared to longitudinal convective transport. The coordinate system is then defined in s and r, where s is the path length of the plume and r is the radial distance from the plume centerline. The angle between the plume axis and horizontal is referred to as θ. Relationships between the downwind coordinate, x, vertical coordinate, y, and plume axis are given simply by:

$$\frac{dx}{ds} = \cos(\theta) \tag{1}$$

and

$$\frac{dy}{ds} = \sin(\theta) \tag{2}$$

Step 2: Velocity, concentration, and density profiles are assumed to be cylindrically symmetric about the plume axis and are assumed to be Gaussian in shape. The three profiles are taken as:

$$u(s,r,\theta) = U_a \cdot \cos(\theta) + u^*(s) \cdot e^{\frac{-r^2}{b^2(s)}} \tag{3}$$

where: u = plume velocity, m/s

U_a = ambient wind speed, m/s
u^* = plume velocity relative to the wind in the downwind direction at the plume axis, m/s
$b(s)$ = characteristic width of the plume at distance s from the release, m

$$\rho(s, r, \theta) = \rho_a + \rho^*(s) \cdot e^{\frac{-r^2}{\lambda^2 \cdot b^2(s)}} \tag{4}$$

where: ρ = plume density, kg/m^3
ρ_a = density of ambient air, kg/m^3
$\rho^*(s)$ = density difference between plume axis and ambient air, kg/m^3
λ^2 = turbulent Schmidt number, 1.35

$$c(s,r,\theta) = c^*(s) \cdot e^{\frac{-r^2}{\lambda^2 \cdot b^2(s)}} \tag{5}$$

where: c = pollutant concentration in the plume, kg/m^3
$c^*(s)$ = pollutant concentration at plume centerline, kg/m^3

Step 3: The equation for air entrainment into the plume and the conservation equations can then be solved. The equation for air entrainment is:

$$\frac{d}{ds}\left(\int_0^{b\sqrt{2}} \rho \cdot u \cdot 2 \cdot \pi \cdot dr\right) \tag{6}$$
$$= 2 \cdot \pi \cdot b \cdot \rho_a \cdot \left\{\alpha_1 \cdot |u^*(s)| + \alpha_2 \cdot U_a \cdot |\sin(\theta)| \cos(\theta) + \alpha_3 \cdot u'\right\}$$

where: α_1 = entrainment coefficient for a free jet, 0.057
α_2 = entrainment coefficient for a line thermal, 0.5
α_3 = entrainment coefficient due to turbulence, 1.0
u' = turbulent entrainment velocity (root mean square of the wind velocity fluctuation is used for this number), m/s

Step 4: The equations of conservation of mass, momentum, and energy are given as:

$$\frac{d}{ds}\left(\int_0^{b\sqrt{2}} c \cdot u \cdot 2 \cdot \pi \cdot dr\right) = 0 \tag{7}$$

$$\frac{d}{ds}\left(\int_0^{b\sqrt{2}} \left(\rho \cdot u^2 \cdot \cos(\theta) \cdot 2 \cdot \pi \cdot dr\right)\right) \tag{8}$$
$$= 2 \cdot \pi \cdot b \cdot \rho_a \cdot \left\{\alpha_1 \cdot \left|u^*(s)\right| + \alpha_2 \cdot U_a \cdot \left|\sin(\theta)\right| \cdot \cos(\theta) + \alpha_3 \cdot u'\right\}$$
$$+ C_d \cdot \pi \cdot b \cdot \rho_a \cdot U_a^2 \left|\sin(\theta)\right|$$

$$\frac{d}{ds}\left(\int_0^{b\sqrt{2}} \rho \cdot u^2 \cdot \cos(\theta) \cdot 2 \cdot \pi \cdot dr\right) \tag{9}$$
$$= \int_0^{b\sqrt{2}} g \cdot (\rho_a - \rho)\, \pi \cdot r \cdot dr \pm C_d \cdot \pi \cdot b \cdot \rho_a \cdot U_a^2 \cdot \sin(\theta) \cdot \cos(\theta)$$

$$\frac{d}{ds}\left(\int_0^{b\sqrt{2}} \rho \cdot u \left(\frac{1}{\rho} - \frac{1}{\rho_{a0}}\right) \cdot 2 \cdot \pi \cdot r \cdot dr\right) \tag{10}$$
$$= \rho_a \cdot 2 \cdot \pi \cdot b \left(\frac{1}{\rho_a} - \frac{1}{\rho_{a0}}\right) \cdot \left\{\alpha_1 \cdot |u^*(s)| + \alpha_2 \cdot U_a \ \sin(\theta)| \cdot \cos(\theta) + \alpha_3 \cdot \acute{u}\right\}$$

The subscript 0 refers to conditions at the point of release. These equations are integrated along the path of the plume to yield the concentration profiles as a function of elevation and distance downwind of the release.

Step 5: After the steady-state equations are solved, an along-wind dispersion correction is applied to account for short-duration releases. This is accomplished using the method outlined by Palazzi, et al. [1982].

Step 6: If the plume reaches the ground, it is coupled to the Heavy Gas Dispersion Model (described in Section G) and the dispersion calculations continue.

Validation

The Momentum Jet Dispersion Model used in CANARY was validated by comparing results obtained from the model with experimental data from field tests. Data used for this comparison and the conditions used in the model were taken from an American Petroleum Institute (API) study [Hanna, Strimaitis, and Chang, 1991]. For this model, comparisons were made with the Desert Tortoise, Goldfish, and Prairie Grass series of dispersion tests. Results of these comparisons are shown in Figure F-1.

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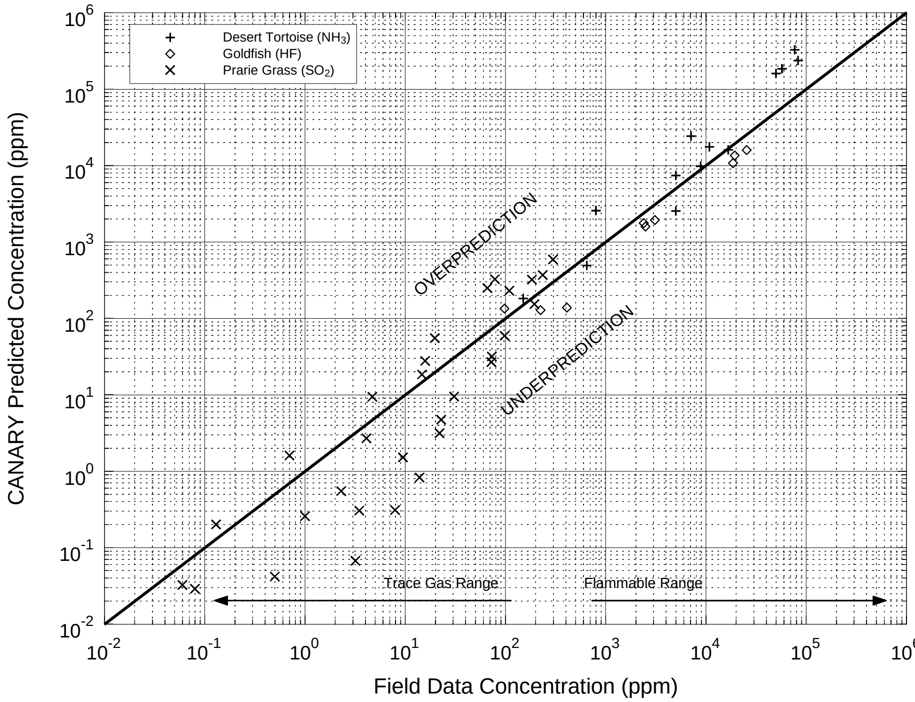

Figure F-1

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Palazzi, E., M. De Faveri, G. Fumarola, and G. Ferraiolo, "Diffusion from a Steady Source of Short Duration." *Atmospheric Environment*, Vol. 16, No. 12, 1982: pp. 2785-2790.

Heavy Gas Dispersion Model

Purpose

The purpose of this model is to predict the dispersion and gravity flow of a heavy gas released into the air from liquid pools or instantaneous gas releases. It is used to predict the downwind travel of a flammable or toxic vapor cloud.

Required Data

(a) Composition and properties of the released material
(b) Temperature of released material
(c) Vapor generation rate
(d) Vapor source area
(e) Vapor source duration
(f) Ambient wind speed
(g) Ambient Pasquill-Gifford atmospheric stability class
(h) Ambient temperature
(i) Relative humidity
(j) Surface roughness scale

Methodology

Step 1: For a steady-state plume, released from a stationary source, the Heavy Gas Dispersion Model solves the following equations:

$$\frac{d}{dx}\left(\rho \cdot U \cdot B \cdot h \cdot m\right) = \rho_s \cdot W_s \cdot B_s \tag{1}$$

$$\frac{d}{dx}\left(\rho \cdot U \cdot B \cdot h\right) = \rho_a \cdot \left(V_e \cdot h + W_e \cdot B\right) + \rho_s \cdot W_s \cdot B_s \tag{2}$$

$$\frac{d}{dx}\left(\rho \cdot U \cdot B \cdot h \cdot C_p \cdot T\right) = \rho_a \cdot \left(V_e \cdot h + W_e \cdot B\right) \cdot C_{pa} \cdot T_a + \rho_s \cdot W_s \cdot B_s \cdot C_{ps} \cdot T_s + f_t \tag{3}$$

$$\frac{d}{dx}\left(\rho \cdot U \cdot B \cdot h \cdot U\right) = -0.5 \cdot \alpha_g \cdot g \cdot \frac{d}{dx}\left[\left(\rho - \rho_a\right) \cdot B \cdot h^2\right] + \rho_a \cdot \left(V_e \cdot h + W_e \cdot B\right) \cdot U_a + f_u \tag{4}$$

$$\frac{d}{dx}\left(\rho \cdot U \cdot B \cdot h \cdot V_g\right) = g \cdot \left(\rho - \rho_a\right) \cdot h^2 + f_{vg} \tag{5}$$

$$U \cdot \frac{dZ_c}{dx} = -V_g \cdot \frac{Z_c}{B} \tag{6}$$

$$U \cdot \frac{dB}{dx} = \frac{\rho_a}{\rho} \cdot V_e + V_g \tag{7}$$

$$\rho \cdot T = \frac{\rho_a \cdot T_a \cdot M_s}{\left[M_s + \left(M_a - M_s \right) \cdot m \right]} \tag{8}$$

where: x = downwind distance, m
ρ = density, kg/m^3
U = velocity in the direction of the wind, m/s
B = cloud width parameter, m
h = cloud height parameter, m
m = mass fraction of source gas
T = temperature, K
C_p = specific heat, J/(kg·K)
f_t = ground heat flux, J/(m·s)
f_u = downwind friction term, kg/s^2
f_v = crosswind friction term, kg/s^2
V_e = horizontal entrainment rate, m/s
V_g = horizontal crosswind gravity flow velocity, m/s
W_e = vertical entrainment rate, m/s
W_s = vertical source gas injection velocity, m/s
M = molecular weight, kg/kmole
s = refers to source properties
a = refers to ambient properties

The first six equations are crosswind-averaged conservation equations. Equation (7) is the width equation, and Equation (8) is the equation of state.

Step 2: All of the gas cloud properties are crosswind averaged. The three-dimensional concentration distribution is calculated from the average mass concentration by assuming the following concentration profile:

$$C(x,y,z) = C(x) \cdot C_1(y) \cdot C_2(z) \tag{9}$$

$$C(x) = \frac{M_a \cdot m(x)}{M_s + \left(M_a - M_s \right) \cdot m(x)} \tag{10}$$

$$C_1(y) = \frac{1}{4 \cdot b} \cdot \left\{ erf\left(\frac{y+b}{2 \cdot \beta} \right) - erf\left(\frac{y-b}{2 \cdot \beta} \right) \right\} \tag{11}$$

$$B^2 = b^2 + 3 \cdot \beta^2 \tag{12}$$

$$C_2(z) = \left(\frac{6}{\pi}\right)^{1/2} \cdot \frac{1}{h} \cdot \exp\left(\frac{-3 \cdot z^2}{2 \cdot h^2}\right) \tag{13}$$

where: $C(x,y,z)$ = concentration in plume at $x, y, z,$ kg/m^3
y = crosswind coordinate, m
z = vertical coordinate, m
b, B, β = half-width parameters, m

Step 3: As there are now two parameters used to define $C_1(y)$, the following equation is needed to calculate b:

$$U \cdot \left(\frac{db}{dx}\right) = V_g \cdot \frac{b}{B} \tag{14}$$

Step 4: The vertical entrainment rate is defined to be:

$$W_e = \frac{\sqrt{3} \cdot a \cdot k \cdot U_* \cdot \delta\left(\frac{h}{H}\right)}{\Phi_h\left(\frac{h}{L}\right)} \tag{15}$$

where: a = constant, 1.5
k = constant, 0.41
U_* = friction velocity, m/s
L = Monin-Obukhov length derived from the atmospheric stability class

Step 5: The profile function δ is used to account for the height of the mixing layer, $H,$ and to restrict the growth of the cloud height to that of the mixing layer. H is a function of stability class and is defined as:

$$\delta\left(\frac{h}{H}\right) = 1 - \frac{h}{H} \tag{16}$$

The Monin-Obukhov function, $\Phi_h,$ is defined by:

$$\Phi_h\left(\frac{h}{L}\right) = \begin{cases} 1 + 5 \cdot \frac{h}{L} & L \geq 0 \text{ (stable)} \\ \left[1 - 16 \cdot \frac{h}{L}\right]^{-1/2} & L < 0 \text{ (unstable)} \end{cases} \tag{17}$$

Step 6: After the steady-state equations are solved, an along-wind dispersion correction is applied to account for short-duration releases. This is accomplished using the method outlined by Palazzi, et al. [1982]

Validation

The Heavy Gas Dispersion Model used in CANARY was validated by comparing results obtained from the model with experimental data from field tests. Data used for this comparison and the conditions used in the model were taken from an American Petroleum Institute (API) study [Hanna, Strimaitis, and Chang, 1991]. For this model, comparisons were made with the Burro, Maplin Sands, and Coyote series of dispersion tests. Results of these comparisons are shown in Figure G-1.

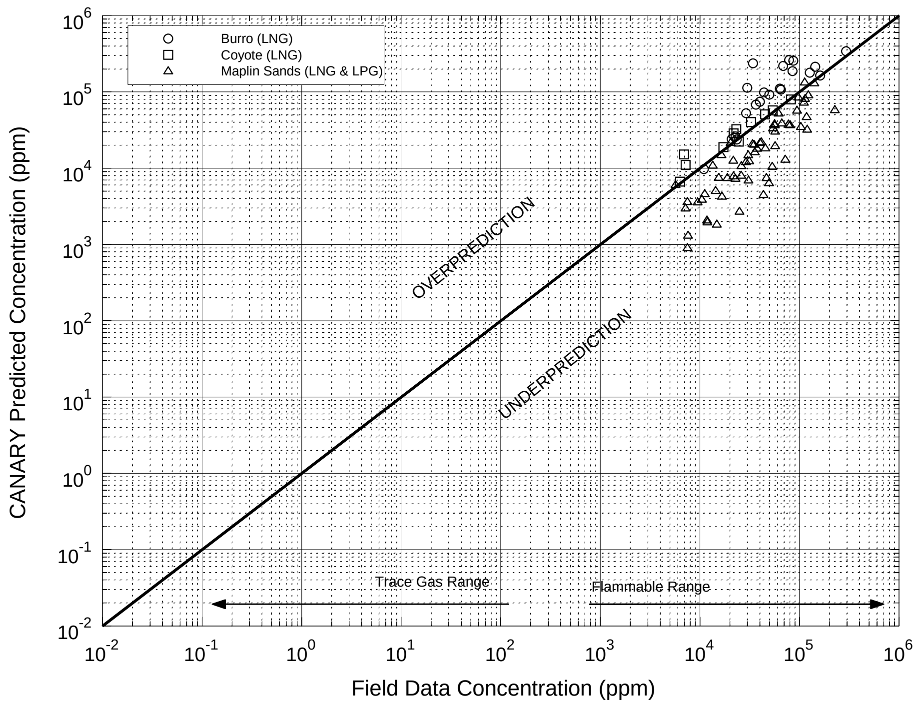

Figure G-1

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Vapor Cloud Explosion Model

Purpose

The purpose of this model is to predict the overpressure field that would be produced by the explosion of a partially confined and/or obstructed fuel-air cloud, based on the Baker-Strehlow-Tang methodology. Specifically, the model predicts the magnitude of the peak side-on overpressure and specific impulse as a function of distance from the source of the explosion.

Required Data

(a) Composition of the fuel (flammable fluid) involved in the explosion
(b) Total mass of fuel in the flammable cloud at the time of ignition or the volume of the partially-confined/obstructed area
(c) Fuel reactivity (high, medium, or low)
(d) Obstacle density (high, medium, or low)
(e) Flame expansion (1-D, 2-D, 2½-D, or 3-D)
(f) Reflection factor

Methodology

Step 1: The combustion energy of the cloud is estimated by multiplying its mass by the heat of combustion. If the volume of the flammable cloud is input, the mass is estimated by assuming that a stoichiometric mixture of gas and air exists within that volume.

Step 2: The combustion energy is multiplied by the reflection factor to account for blast reflection from the ground or surrounding objects.

Step 3: Flame speed is determined from the fuel reactivity, obstacle density, and flame expansion parameters, as presented in Baker, et al. [1994, 1998, 1999, 2005].

Fuel reactivity and obstacle density each have low, medium, and high choices. The flame expansion parameter allows choices of 1-D, 2-D, 2.5-D, and 3-D. The choices for these three parameters create a matrix of 36 possibilities, thus allowing locations that have differing levels of congestion or confinement to produce different overpressures. Each matrix possibility corresponds to a flame speed, and thus a peak (source) overpressure. The meanings of the three parameters and their options are:

Fuel Reactivity (High, Medium, or Low). Some of the fuels considered to have high reactivity are acetylene, ethylene oxide, propylene oxide, and hydrogen. Low reactivity fuels are (pure) methane and carbon monoxide. Most other fuels are medium reactivity. If fuels from different reactivity categories are mixed, the model recommends using the higher category unless the amount of higher reactivity fuel is less than 2% of the mixture.

Obstacle Density (High, Medium, or Low). High obstacle density is encountered when objects in the flame's path are closely spaced. This is defined as multiple layers of obstruction resulting in at least a 40% blockage ratio (i.e., 40% of the area is occupied by obstacles). Low density areas are defined as having a blockage ratio of less than 10%. All other blockage ratios fall into the medium category.

Flame Expansion (1-D, 2-D, 2.5-D, or 3-D). The expansion of the flame front must be characterized with one of these four descriptors. 1-D expansion is likened to an explosion in a pipe or hallway. 2-D expansion can be described as what occurs between flat, parallel surfaces. An unconfined (hemispherical expansion) case is described as 3-D. The additional descriptor of 2.5-D is used for situations that begin as 2-D and quickly transition to 3-D or situations where the confinement is made by either a frangible panel or by a nearly-solid confining plane.

Step 4: Based on the calculated flame speed, appropriate blast curves are selected from the figures in Baker, et al., 1999. For flame speeds not shown on the graph, appropriate curves are prepared by interpolation between existing curves.

Step 5: The Sachs scaled distance, $\bar{R}$, is calculated for several distances using the equation:

$$\bar{R} = \frac{R}{\left(\frac{E}{P_0}\right)^{1/3}}$$

where: R = distance from the center of the explosion

E = total energy calculated in step 2, above

P_0 = atmospheric pressure

Step 6: The peak side-on overpressure and specific impulse at each scaled distance are determined from the blast curves in Baker, et al., 1999.

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