

Quality Assurance for Performance Assessment Modeling

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Motivation for QA in PA

The overarching motivation for Performance Assessment work is defensible decision making, and that requires:

- a defensible basis for modeling,
- transparent and intelligible modeling, and
- effective communication of modeling approaches and results

These are goals shared by the CoP.



Defensibility in Modeling

Defensible decision making needs defensible modeling. This requires:

- an accepted Conceptual Site Model (CSM),
- concepts and parameters that are traceable to their source,
- a transparent analysis of parameters, and
- coherent statistics.

**Without these, it may as well be
Garbage IN ⇨ Garbage OUT.**



Computers are not Magic

“On two occasions I have been asked, “Pray, Mr. Babbage, if you put into the machine wrong figures, will the right answers come out?”

I am not able rightly to apprehend the kind of confusion of ideas that could provoke such a question.”



Charles Babbage
1791 – 1871

Passages from the Life of a Philosopher (1864), Ch. 5
“Difference Engine No. 1”



Model Evaluation

Best Practices:

- Peer Review
- Model Corroboration
- Sensitivity Analysis
- QA Project Planning – data quality assessment



Neptune's GoldSim PA QA

Neptune's Quality Assurance (QA) for GoldSim PA models includes

- development of FEPSs* and CSM,
- stochastic parameter development,
- manual QA checking of all values,
- model building, and
- model testing,
- subject to strict configuration control.

***Features, Events, Processes, and Scenarios.**



FEPSs and CSM

Features, **E**vents, **P**rocesses and **S**cenarios analysis:

- Defining and screening FEPSs assures that the PA and its model are not missing anything.

Development of a **C**onceptual **S**ite **M**odel:

- Defining a CSM helps to vet the model among stakeholders and model developers alike.

These are part of QA.



Parameter QA Process

Neptune's Process:

- *Identify and collect information* about a process or parameter, from literature, site specific studies, etc.
- Perform *manual number-by-number QA check* on that information. This is called a check print.
- Develop *statistically appropriate stochastic input distribution(s)*.
- Perform manual *QA check* on statistical analysis.
- Incorporate synopsis of parameter development into a topical *white paper*.
- Perform manual *QA check* on values in white paper.
- Add values to the model *Parameters Document* or *Workbook*.
- Perform manual *QA check* on Param Doc or Workbook.
- *Transfer values* to the GoldSim PA model.
- Perform Manual *QA check* on model values, and record in the model using GoldSim's native QA note tools.



Check Prints

Neptune's Manual QA *Check Print* Process:

- A calculation sheet, white paper, or other document is prepared by an analyst, with a copy of all cited references. This is printed to hard copy.
- An independent person, not associated with the collection and assembly of information, checks every value in the document against the value(s) in the cited references, and marks each item. For electronic transfers, every 10th value is checked.
- Errors are flagged, and the checker signs and dates the check print document to the analyst.
- Errors are fixed by the analyst, and the document is resubmitted for another check print.
- This iterates until all errors have been resolved.



Distribution Development

Stochastic input distributions must be developed with care.

- Data should not be censored without cause.
- Spatial and temporal aspects must be considered.
- Distributional forms should be based on natural behavior as well as data. A natural uniform or triangular distribution is rare.



Types of Distributions

Several types of stochastic input distributions:

- independent, single value parameter
- tables of related single values
- time series
- functional forms
- environmentally-related values
- values that must sum to unity
- complex interrelated variables
- values with patterns seen collectively
- values with spatiotemporal variability



Model Configuration Control

Neptune's rules for configuration control:

- There is only One True Model File at any given time.
- No two model files ever have the same filename.
- The custodian of the True Model is always known.
- Custodianship is passed explicitly to another.
- Model file naming follows a strict convention.
- Model development may take place in branch copies, but these are never confused with the One True Model.
- Native GoldSim versioning is used.



QA in Model Building

Building a model in GoldSim requires

- appropriate distribution development,
- clarity and transparency in coding,
- clear documentation of model development, and
- enhanced communication of concepts.

- Native GoldSim QA tools are used.



Transparency in Coding

This is opaque code:

```
FUNCTION BESSI(N,X)
  PARAMETER (IACC=40,BIGNO=1.0E10,BIGNI=1.0E-10)
  IF (N.LT.2) PAUSE 'bad argument N in BESSI'
  TOX=2.0/X
  BIP=0.0
  BI=1.0
  BESSI=0.
  M=2*((N+INT(SQRT(FLOAT(IACC*N))))))
  DO 11 J=M,1,-1
    BIM=BIP+FLOAT(J)*TOX*BI
    BIP=BI
    BI=BIM
    IF (ABS(BI).GT.BIGNO) THEN
      BESSI=BESSI*BIGNI
      BI=BI*BIGNI
      BIP=BIP*BIGNI
    ENDIF
    IF (J.EQ.N) BESSI=BIP
11 CONTINUE
  BESSI=BESSI*BESSIO(X)/BI
  RETURN
END
```

```
#include <math.h>
#define ACC 40.0
#define BIGNO 1.0e10
#define BIGNI 1.0e-10
float bessio(n,x)
int n;
float x;
{
  int j;
  float bi,bim,bip,tox,ans;
  float bessio();
  void nrerror();
  if (n < 2) nrerror("Index n less than 2 in BESSI");
  if (x == 0.0)
    return 0.0;
  else {
    tox=2.0/fabs(x);
    bip=ans=0.0;
    bi=1.0;
    for (j=2*(n+(int) sqrt(ACC*n));j>0;j--) {
      bim=bip+j*tox*bi;
      bip=bi;
      bi=bim;
      if (fabs(bi) > BIGNO) {
        ans *= BIGNI;
        bi *= BIGNI;
        bip *= BIGNI;
      }
      if (j == n) ans=bip;
    }
    ans *= bessio(x)/bi;
    return x < 0.0 && n%2 == 1 ? -ans : ans;
  }
}
#undef ACC
#undef BIGNO
#undef BIGNI
```

with apologies to *Numerical Recipes*



Always a Documentation Nut

This is commented code: Remember ASCII art?

```
/* dfWinbox and dfCellSize are defined globally */
double dfX, dfY; /* f.p. index to cell */
double dfDenominator; /* temp variable */
int iX, iY; /* cell index number */
int nxLower, nyLower; /* index to lower bounding cell */
int nxUpper, nyUpper; /* index to upper bounding cell */
POINT ptLower, ptUpper; /* corner points bounding cell */
float fTemp; /* temporary variable */

/* I was forced to add this since for some reason nCols and nRows
 * are not consistently read properly above using PrivateWindowCols
 * and PrivateWindowCols. */
nCols = (int)( ( Xmax( dfWinbox ) - Xmin( dfWinbox ) ) / dfCellSize );
nRows = (int)( ( Ymax( dfWinbox ) - Ymin( dfWinbox ) ) / dfCellSize );

/* Determine which cell contains the point ppt. */
/* First, work with the GRID cells, to subdivide later. */

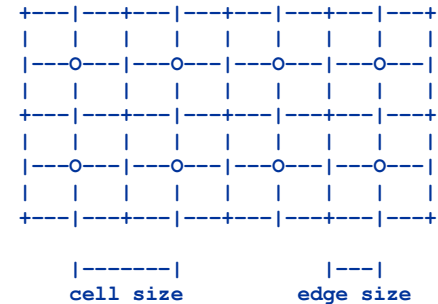
/* Find cell index number of Lower bounding cell. */
dfX = ( ppt->x - Xmin( dfWinbox ) ) / dfCellSize;
iX = (int)dfX; /* truncation to integer */

dfY = ( Ymax( dfWinbox ) - ppt->y ) / dfCellSize;
iY = (int)dfY; /* truncation to integer */

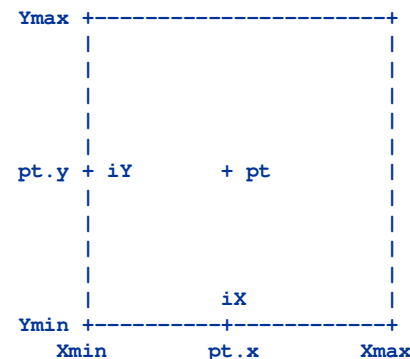
pcell->iX = iX;
pcell->iY = iY;
```

some of my C code from graduate school

```
* So for the purposes of this DarcyTrack function, the elemental
* cell over which calculations are done must be a quarter
* of the original GRID cells, to ensure uniform properties
* over the cell area:
```



```
* Notes on orientation: (This is a square GRID cell)
```



```
pt.x and pt.y are in real
coordinates

Xmin, Xmax, Ymin, Ymax are
in real coordinates,
and are the limits of
the grid, as stored
in the global
variable dfWinbox

iX and iY are cell column
(left to right) and
row (top to bottom)
```



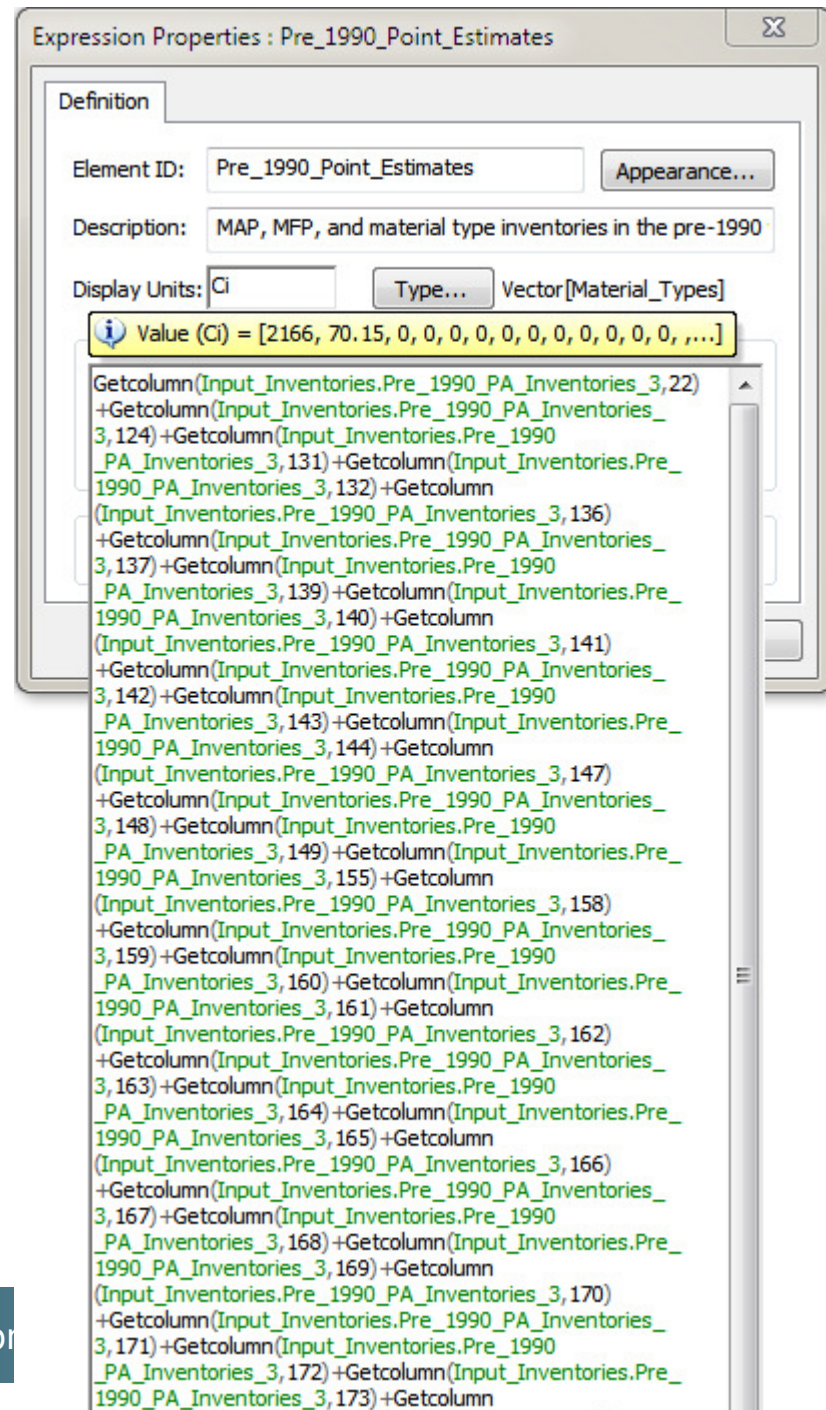
Transparency in GoldSim Coding

This is an example of sloppy GoldSim coding.

Aliases are not used, nor are sensible indices to the cited columns used by `GetColumn()`.

The QA on this would be time-consuming and difficult.

(About 1/2 of this expression is shown here.)



Expression Properties : Pre_1990_Point_Estimates

Definition

Element ID: Pre_1990_Point_Estimates Appearance...

Description: MAP, MFP, and material type inventories in the pre-1990

Display Units: Ci Type... Vector[Material_Types]

Value (Ci) = [2166, 70.15, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, ...]

```
Getcolumn(Input_Inventories.Pre_1990_PA_Inventories_3,22)
+Getcolumn(Input_Inventories.Pre_1990_PA_Inventories_
3,124)+Getcolumn(Input_Inventories.Pre_1990
_PA_Inventories_3,131)+Getcolumn(Input_Inventories.Pre_
1990_PA_Inventories_3,132)+Getcolumn
(Input_Inventories.Pre_1990_PA_Inventories_3,136)
+Getcolumn(Input_Inventories.Pre_1990_PA_Inventories_
3,137)+Getcolumn(Input_Inventories.Pre_1990
_PA_Inventories_3,139)+Getcolumn(Input_Inventories.Pre_
1990_PA_Inventories_3,140)+Getcolumn
(Input_Inventories.Pre_1990_PA_Inventories_3,141)
+Getcolumn(Input_Inventories.Pre_1990_PA_Inventories_
3,142)+Getcolumn(Input_Inventories.Pre_1990
_PA_Inventories_3,143)+Getcolumn(Input_Inventories.Pre_
1990_PA_Inventories_3,144)+Getcolumn
(Input_Inventories.Pre_1990_PA_Inventories_3,147)
+Getcolumn(Input_Inventories.Pre_1990_PA_Inventories_
3,148)+Getcolumn(Input_Inventories.Pre_1990
_PA_Inventories_3,149)+Getcolumn(Input_Inventories.Pre_
1990_PA_Inventories_3,155)+Getcolumn
(Input_Inventories.Pre_1990_PA_Inventories_3,158)
+Getcolumn(Input_Inventories.Pre_1990_PA_Inventories_
3,159)+Getcolumn(Input_Inventories.Pre_1990
_PA_Inventories_3,160)+Getcolumn(Input_Inventories.Pre_
1990_PA_Inventories_3,161)+Getcolumn
(Input_Inventories.Pre_1990_PA_Inventories_3,162)
+Getcolumn(Input_Inventories.Pre_1990_PA_Inventories_
3,163)+Getcolumn(Input_Inventories.Pre_1990
_PA_Inventories_3,164)+Getcolumn(Input_Inventories.Pre_
1990_PA_Inventories_3,165)+Getcolumn
(Input_Inventories.Pre_1990_PA_Inventories_3,166)
+Getcolumn(Input_Inventories.Pre_1990_PA_Inventories_
3,167)+Getcolumn(Input_Inventories.Pre_1990
_PA_Inventories_3,168)+Getcolumn(Input_Inventories.Pre_
1990_PA_Inventories_3,169)+Getcolumn
(Input_Inventories.Pre_1990_PA_Inventories_3,170)
+Getcolumn(Input_Inventories.Pre_1990_PA_Inventories_
3,171)+Getcolumn(Input_Inventories.Pre_1990
_PA_Inventories_3,172)+Getcolumn(Input_Inventories.Pre_
1990_PA_Inventories_3,173)+Getcolumn
```

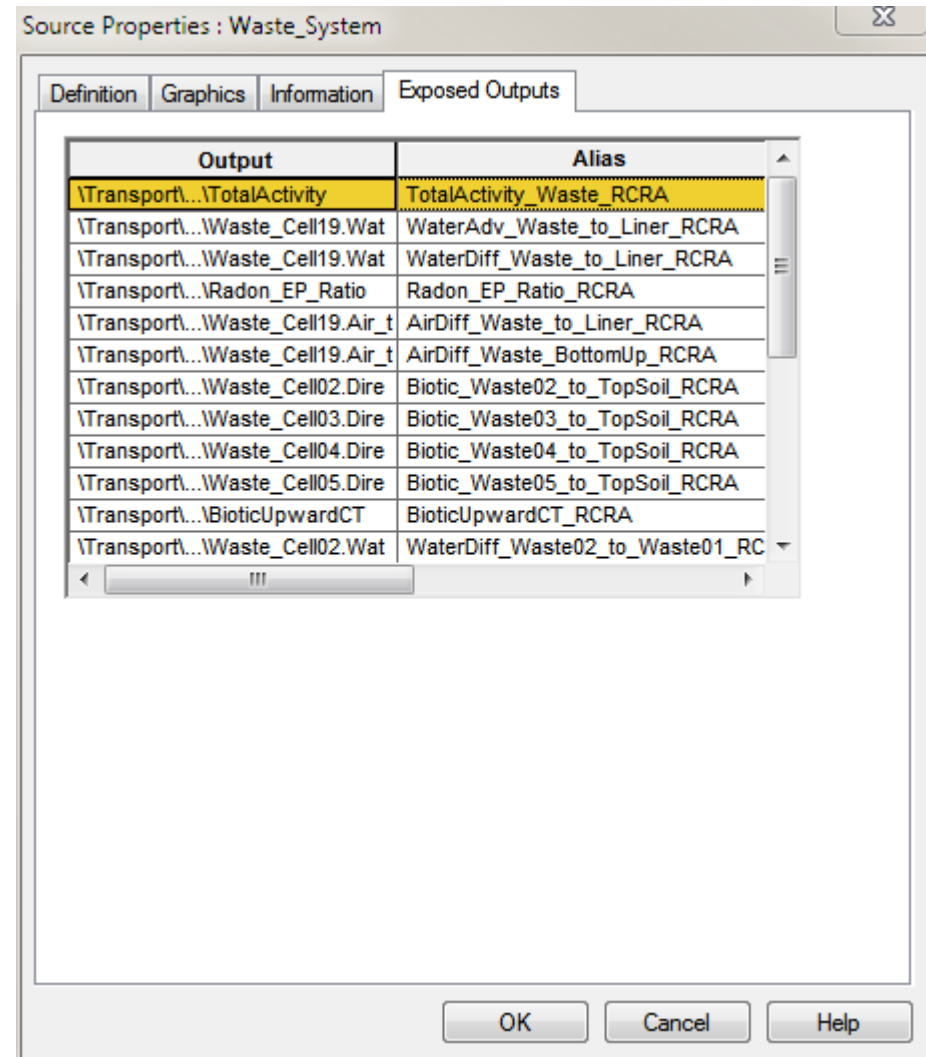


Transparency in GoldSim Coding

Tools at your disposal:

Use *aliases* for exposed outputs from Localized containers.

The aliases should be clear and have unique names.

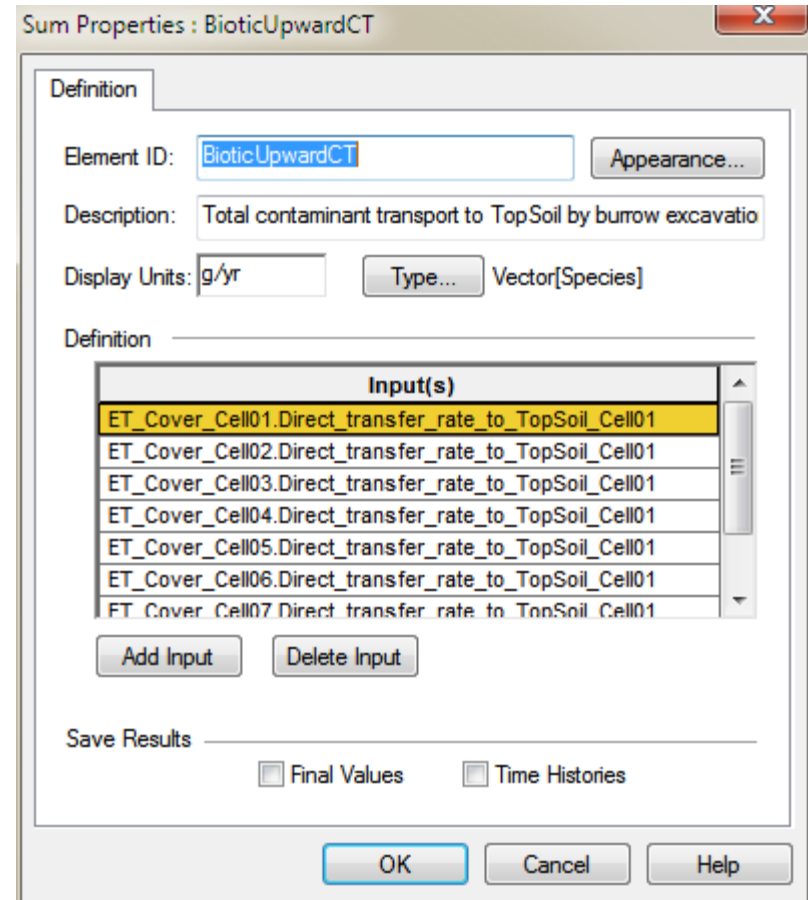


Transparency in GoldSim Coding

Tools at your disposal:

Use *Sum* elements for organizing summations.

(This would have helped the earlier code example.)



Transparency in GoldSim Coding

Don't cram too much into an expression or property.

Cell Pathway Properties : Cap_Layer_3

Definition Inflows Outflows Diffus

Element ID: Cap_Layer_3

Description: Cell representing cap layer 3.

Media in Cell

Medium	Amount	F	H	S
Water	Erosion_Model.Updated_Layer_Thickness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Crushed_Tuff	Erosion_Model.Updated_Layer_Thickness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Air_in_Crushed_Tuff	max(Erosion_Model.Updated_Layer_Thickness_6[Cap_3], Site_Geometry_and_Operations.Minimum_Air_Thickness) * Site_Geometry_and_Operations.Disposal_Unit_Area_7 * (Effective_Porosity[Crushed_Tuff]-Moisture_Content[Crushed_Tuff])	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Waste		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Add Medium

Cell Inventory

Cumulative Input

Discrete Changes: PV_Cap_3_Soil_Rads;PV_Cap_3_Water_Ra !!!

Save Masses in Pathway

Output Precipitated Mass

Final Values Time Histories

OK Cancel Help

Hard to follow

Cell Pathway Properties : ET_Cover_Cell02

Definition Inflows Outflows Diffus

Element ID: ET_Cover_Cell02

Description: Cell representing part of the ET Cover

Media in Cell

Medium	Amount	F	H	S
Water	CellWaterVolume_Local	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Air	CellAirVolume_Local	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ET_CoverMaterial	CellSolidMass_Local	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Add Medium Delete Medium

Cell Inventory

Initial Inventory

Discrete Changes:

Save Masses in Pathway

Output Precipitated Mass

Final Values Time Histories

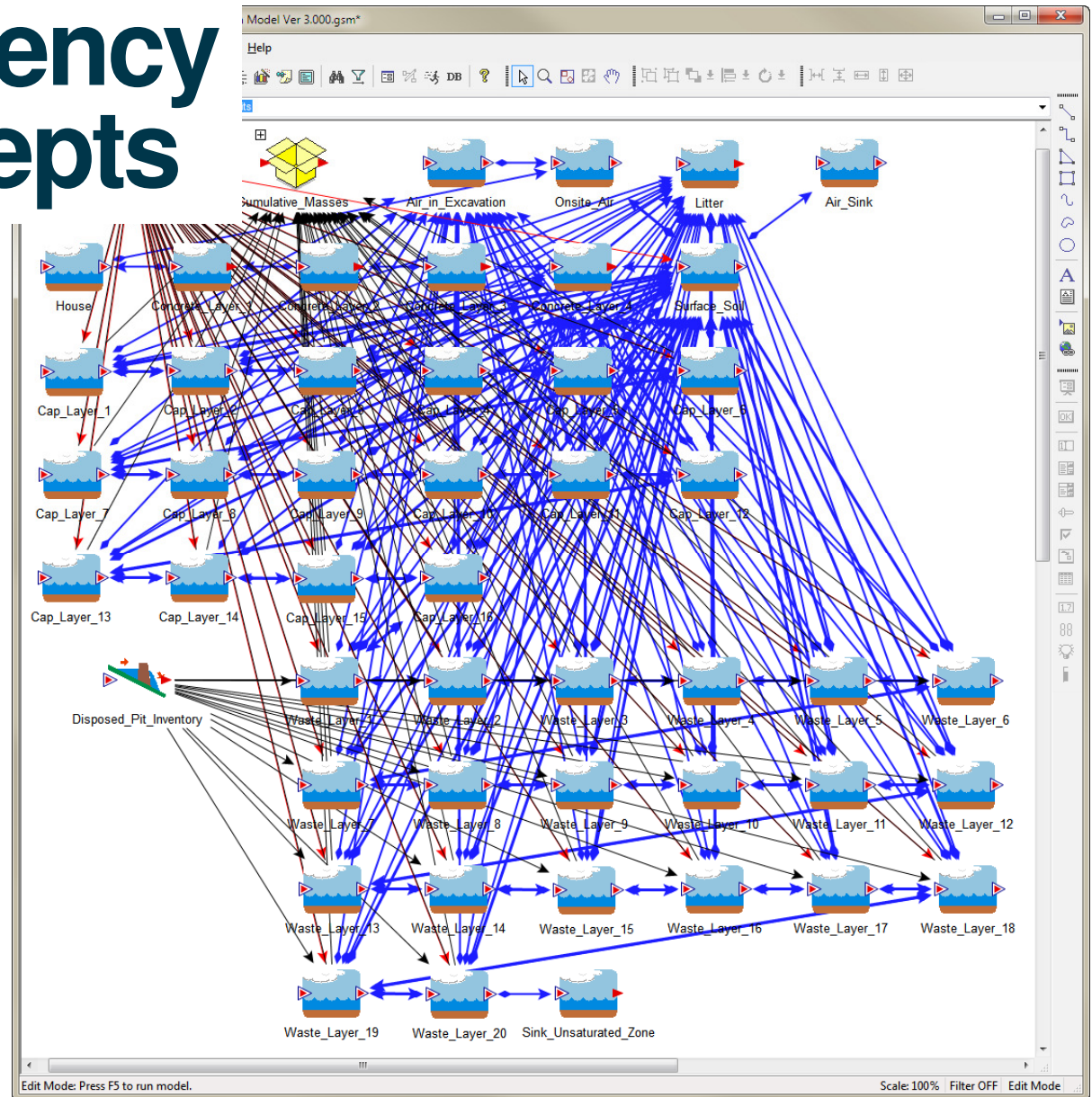
OK Cancel Help

Easy to read



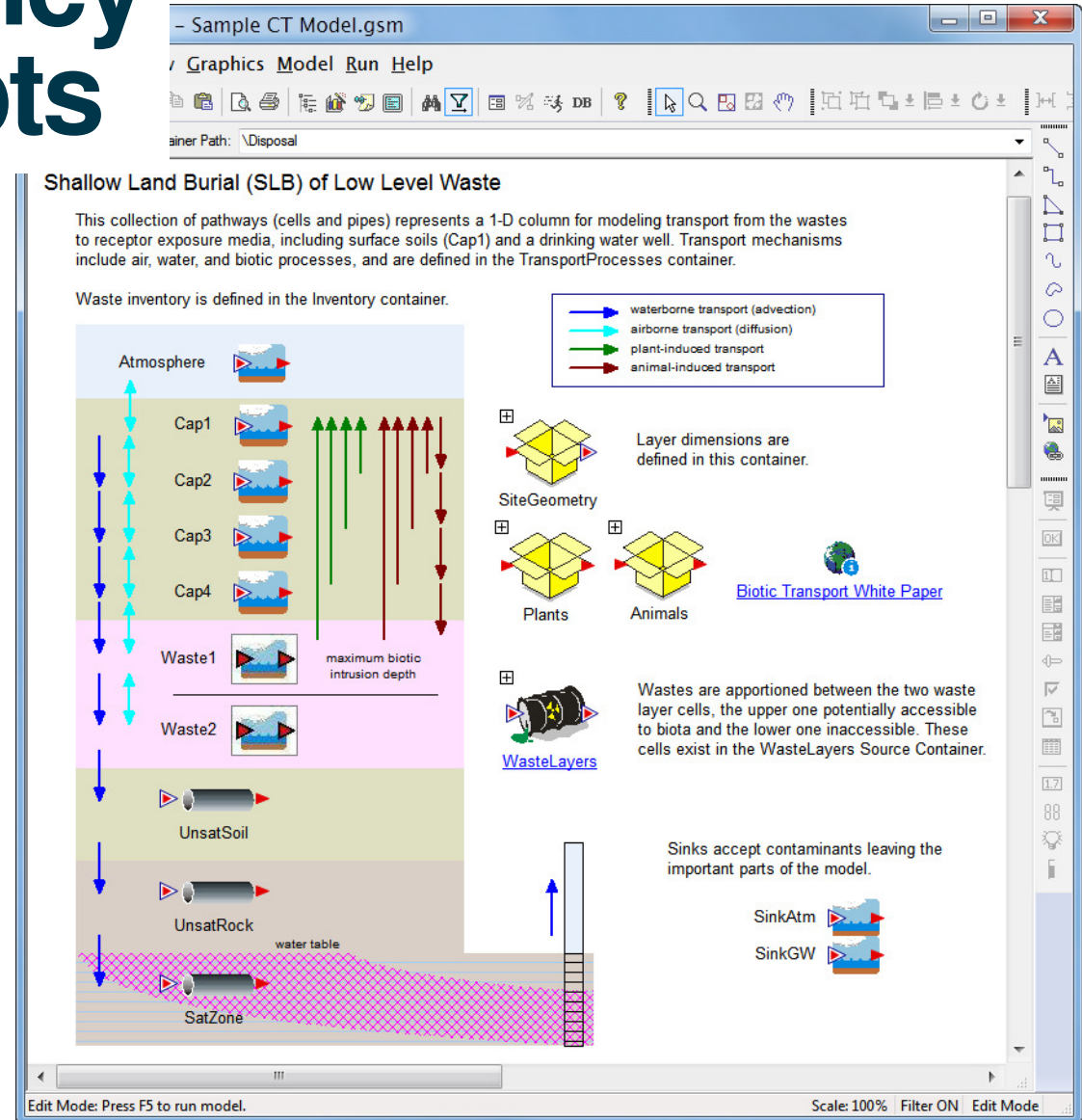
Transparency in Concepts

A mishmash of elements on the page is not useful to anyone trying to understand the model.



Transparency in Concepts

Use the drawing tools and a logical arrangement of elements shows what is going on in the model.



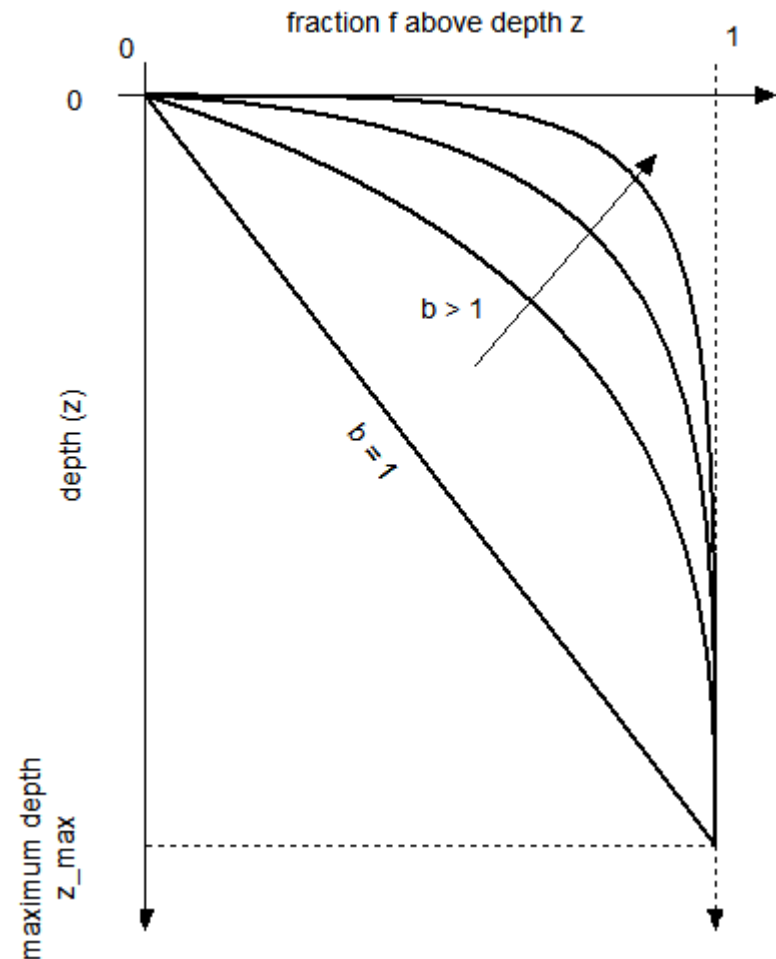
Transparency in Concepts

Plant root and burrow volume depth function

Given a maximum depth z_{max} and a shape parameter b , the fraction f of roots (or burrows) above any depth z is given by

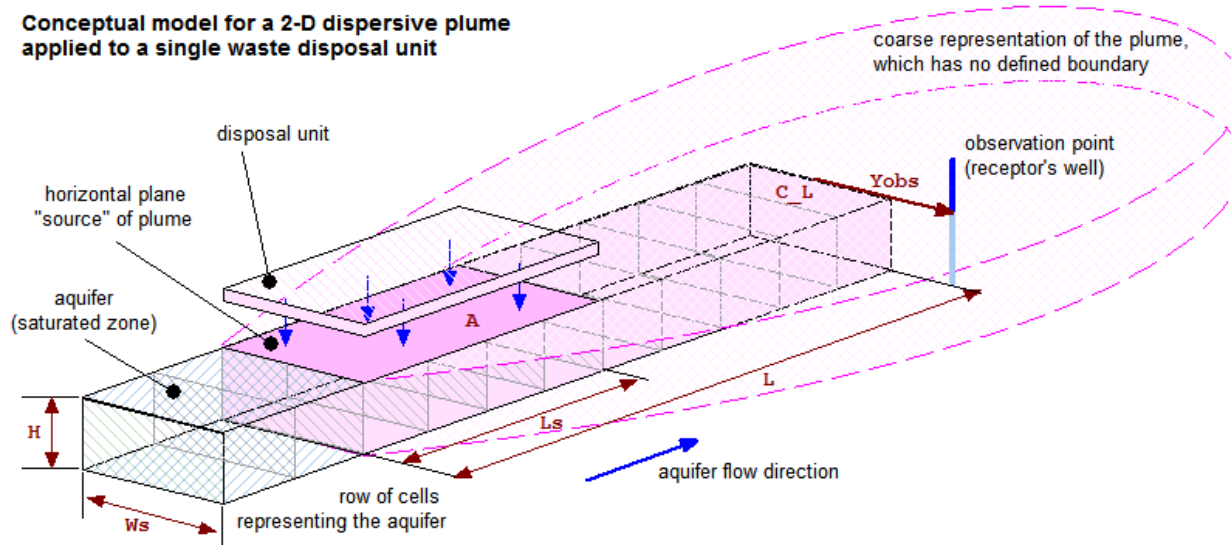
$$f = 1 - \left(1 - \frac{z}{z_{max}}\right)^b$$

A simple illustration c



Transparency in Concepts

Modeling tools can be described in the model itself:



Application of the GoldSim Plume Function

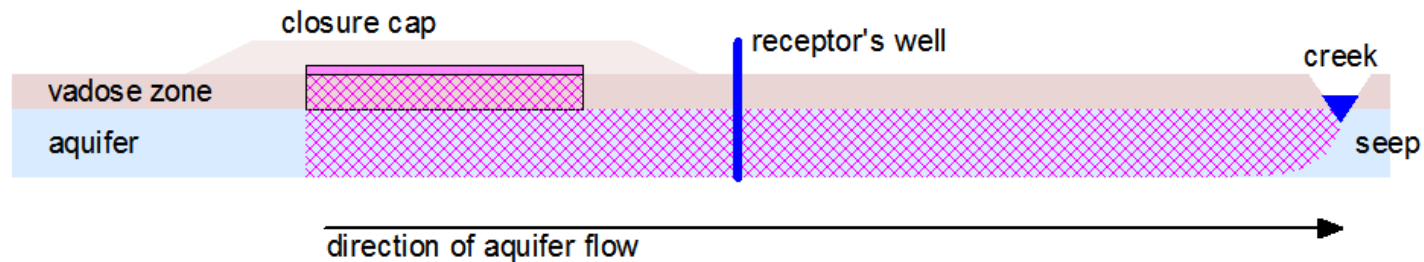
As described in the GoldSim on-line help (search for "plume"), the plume() function accepts 11 arguments. The description presented here is somewhat simplified for the case at hand. The arguments to the function are as follows, with comments following the "//". Footnotes are below.

```
plume (  
  L,          // length of the Pipe or row of Cells, as measured from  
              // the upstream end of the Source1  
  A,          // cross-sectional area of the Pipe or Cells  
  Ls,        // length of the Source set equal to the length of the  
              // overlying disposal unit, parallel to flow  
  0,         // vertical offset of observation point (zero)2
```



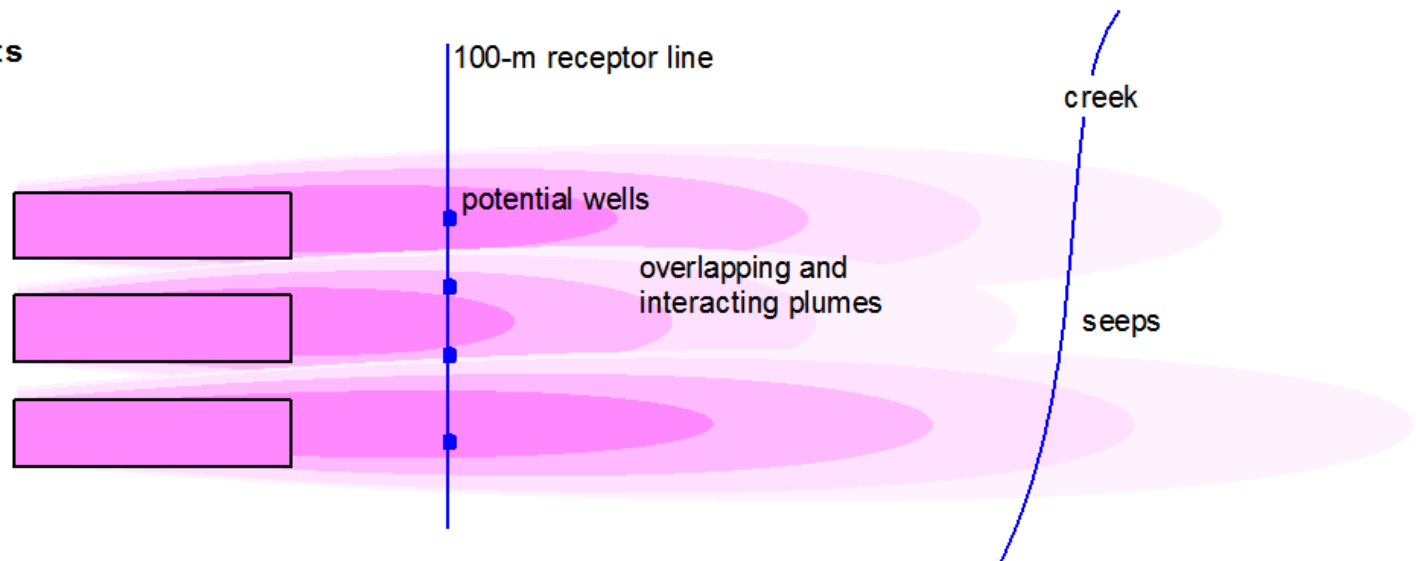
Transparency in Concepts

Elevation



Plan View

Multiple Trench Units



Transparency in Concepts

Master Species Properties : Species

Definition Clones

Element ID: Species Appearance...

Description: Radionuclides included in contaminant transport

Specify decay: Half-lives Species set ordering: Weight, ascending

Display: Modeled species Min half-life to show: 0 yr

Auto-include ICRP daughters with half-lives >= 1 yr and <= 1e+012 yr

Species List

Number of Modeled Species : 110

Include	Row #	ID	Weight	Half-Life	I	R	Modeled daughters (skipped intermediates)
<input checked="" type="checkbox"/>	56	Tb158	158 g/mol	HalfLife[Tb158]	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/>	27	Tc99	99 g/mol	HalfLife[Tc99]	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/>	76	Th228	228 g/mol	HalfLife[Th228]	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/>	77	Th229	229 g/mol	HalfLife[Th229]	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/>	78	Th230	230 g/mol	HalfLife[Th230]	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Ra-226
<input checked="" type="checkbox"/>	80	Th232	232 g/mol	HalfLife[Th232]	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Ra-228
<input checked="" type="checkbox"/>	11	Tl44	44 g/mol	HalfLife[Tl44]	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/>	65	Tl204	204 g/mol	HalfLife[Tl204]	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/>	58	Tm171	171 g/mol	HalfLife[Tm171]	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<input checked="" type="checkbox"/>	81	U232	232 g/mol	HalfLife[U232]	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Th-228
<input checked="" type="checkbox"/>	82	U233	233 g/mol	HalfLife[U233]	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Th-229
<input checked="" type="checkbox"/>	83	U234	234 g/mol	HalfLife[U234]	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Th-230
<input checked="" type="checkbox"/>	84	U235	235 g/mol	HalfLife[U235]	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Pa-231
<input checked="" type="checkbox"/>	87	U236	236 g/mol	HalfLife[U236]	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Th-232
<input checked="" type="checkbox"/>	91	U238	238 g/mol	HalfLife[U238]	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	U-234

Add... Delete Edit... Export... Import...

↑ Row ↓ Row

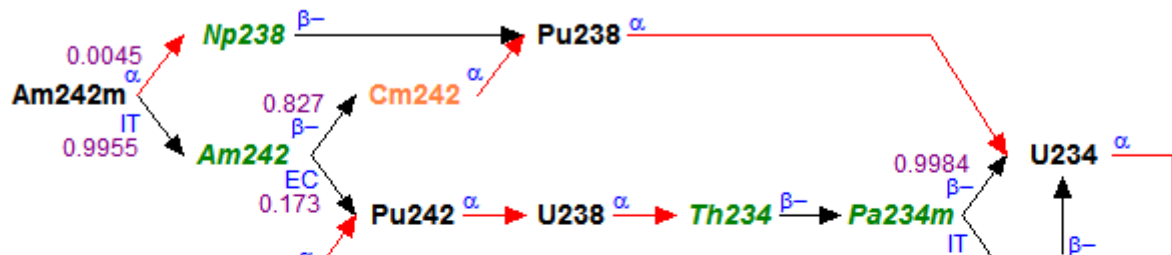
Close Help

The Species element may be fundamental to contaminant transport modeling, but it can be a challenge to interpret.

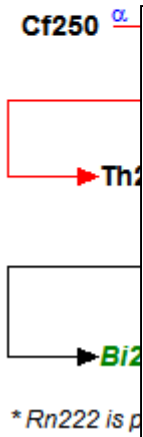


Transparency in Concepts

Uranium Series, simplified



The drawing tools can make this easier.



Decay chains implemented in contaminant transport and dose calculations

Note that the radionuclides and stable nuclides in black are maintained in the Species list. Any modification to the decay chain diagram needs to have an associated modification to the Species list, and vice versa.

The radionuclides noted in green italic are considered in the dose assessment only, through the "roll-up" of dose conversion factors. Environmental transport of these progeny is assumed to follow their respective parents, with which they are in secular equilibrium. Radionuclides in green italic need to have any reported inventory converted to the next long-lived progeny.

Radionuclides in olive are extremely long-lived, and do not have significant contributions to dose. These are not modeled.

Radionuclides in orange are short-lived, and if reported in inventory are to be converted to the next long-lived progeny on an activity basis (e.g. Bq for Bq).

Radionuclides, stable nuclides, and decay arrows in gray are not represented in the model, but are shown here for completeness. Details in the Actinoid_detail Container are also not modeled.

Each decay mode is shown in blue (alpha, beta, beta positron, isomeric transition, and electron capture), with modeled alpha decay arrows shown in red.

Branching fractions are shown in purple, and are assumed to be 1 unless a value is shown. Branching fractions less than 0.001 are identified as "~0" and are not modeled. Branching fractions are used in the dose roll up calculations (external to the model) and in the Stoichiometry definitions in the Species element specification. These come from Tuli's Nuclear Wallet Cards (2005).



Change Log

Change log:

(Tabs are entered as Ctrl+Tab).

JT John Tauxe
RP Ralph Perona
KC Kate Catlett

<u>date</u>	<u>ver</u>	<u>init</u>	<u>description</u>
12 Oct 11	0.001	JT	• Model-building begins, acknowledging previous work on the WCS LLW Model by Bill Dornsife (WCS), Abhishek Singh (Intera), Gary Merrell (URS Corp.), and John Tauxe (Neptune and Co.)
24 Oct 11		RP	• Work on N&Co dose model begins. Integrate CWF and FWF within a single dose container. Implement structure shown in receptor diagram_influences and well dose diagram_influences.
28 Oct 11	0.002	RP	• New model structure (including Switches for exposure conditions) and pathways have been incorporated. For this interim Dose_Assessment container, the scenarios and receptors used in the Fall 2011 PA model submitted to TCEQ have been retained.
28 Oct 11	0.003	JT	• Custodianship assumed by JT. Begin work on v0.003.
21 Nov 11	0.003	RP	• Custodianship assumed by RP. • Update dose model to include ranching and oil drilling scenarios while retaining receptors from the License Application PA model. • Restrict use of saline water from deeper aquifers (600 ft) to cattle. • Add all particulate inhalation and external DCFs. • Added a Chronology container for timed events (loss of institutional control and concrete failure for the containment system).
21 Nov 11	0.003	JT	• Custodianship assumed by JT.
28 Nov 11		JT	• Minor revision to decay chains illustration to list Sn126 in the category of non-actinide decay to short-lived progeny that are modeled in dose assessment.
19 Dec 11		JT	• Added initial structure for stochastic Kd values.
Jan/Feb 12		JT	• Extensive reorganizational revisions, including completely reorganizing the CWF and FWF containers, moving common elements out of them, and making extensive use of the UZ_Units array for storing information and for calculations

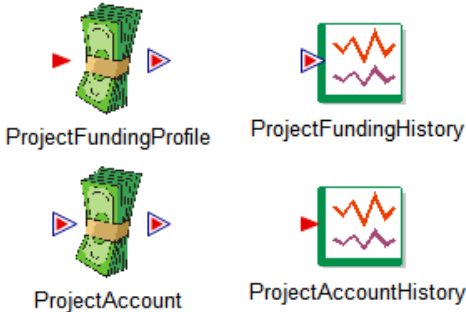


Readability

Project budget and accounting

The user can specify the funding profile, which constitutes annual increases to the project account. Costs are deducted from the project account as tasks start and complete.

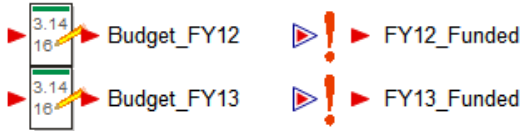
Main Project Account



The ProjectAccount has revenues added each FY, as worked out above.

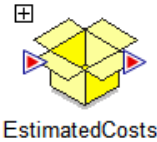
- It also has these deductions:
- each task deducts its estimated cost on task start
 - each task reconciles its actual costs with the estimated cost, and deducts the difference on completion of the task
 - penalties and fines are deducted as they occur

Funding Profile (set on Control Panel)



 [Control Panel](#)

Estimated expenses and allocation priorities



Estimated costs for each task are provided here. Each task must wait until sufficient funding is available before starting, and actual costs are reconciled with estimates on task completion.

Funding allocations are determined as annual spending rates.



The allocation of funds from the top Project level down to the individual tasks takes place hierarchically. This top level allocator takes the entire project budget (ProjectAccount) and allocates to the main activities. Each of those activities similarly allocates its share of the funds it was provided to its tasks, and so on.

-  [Waste Characterization Funding](#)
-  [Public Involvement Funding](#)
-  [Operations Funding](#)
-  [Compliance Activities Funding](#)
-  [Public Involvement Activities Funding](#)



Traceability Outside the Model

TABLE 7. HELP INFILTRATION MODEL LAYERS AND MATERIAL PROPERTIES

Layer	Material	Thickness (inches)	n (vol/vol)	θ_{fc} (vol/vol)	θ_{wp} (vol/vol)	Available Moisture (vol/vol)	θ_i (vol/vol)	K_s (cm/sec)	Layer Type	Size Range (inches)	Material Description n/a	Notes:
Layer 1	Type-B Rip Rap	18	0.190	0.024	0.007	0.017	initialized to ss	42	vertical percolation	0.75-4.5	1.25 inches	Size is nominal diameter
Layer 2	Type-A Filter (upper)	6	0.190	0.024	0.007	0.017	initialized to ss	42	vertical percolation	0.08-6.0	Coarse Sand - Fine Cobble	
Layer 3	Sacrificial Soil	12	0.31	0.2	0.025	0.175	initialized to ss	4.00E-03	vertical percolation	<0.75	Silty Sand and Gravel	Placed at 4×10^{-4} cm/sec; freeze/thaw reduces K to 4×10^{-3} cm/sec.
Layer 4	Type-B Filter (lower)	6	0.28	0.032	0.013	0.019	initialized to ss	3.5	lateral drainage	0.2-1.5	Coarse Sand - Fine Gravel	
Layer 5	Upper Radon Barrier	12	0.430	0.390	0.28	0.11	0.43	5.00E-08	barrier soil	n/a	Clay	
Layer 6	Lower Radon Barrier	72	0.430	0.390	0.28	0.11	0.39	1.00E-06	vertical percolation	n/a	Clay	
Layer 7	Waste	100	0.437	0.062	0.024	0.038	initialized to ss	5.00E-04	vertical percolation	n/a	Sand	Unit thickness for waste. Model is insensitive to waste thickness variation.
Layer 8	Clay Liner	24	0.430	0.390	0.28	0.11	0.43	1.00E-06	barrier soil	n/a	Clay	

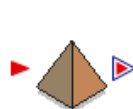
n = Porosity
 θ_{fc} = Field Capacity
 θ_{wp} = Wilting Point

θ_i = Initial Moisture Content
 K_s = Saturated Hydraulic Conductivity
 θ_i = Value for initialized steady-state moisture content are given in the model output files.

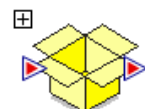
Available Moisture: = Moisture available to be evaporated is only applicable in the upper 18 inches of the model

Engineered material properties

Engineered materials are in a variety of forms serving various purposes. These are used in the construction of the cap (top slope and side slope) and liner layers.



RipRap



[RipRap_Properties](#)

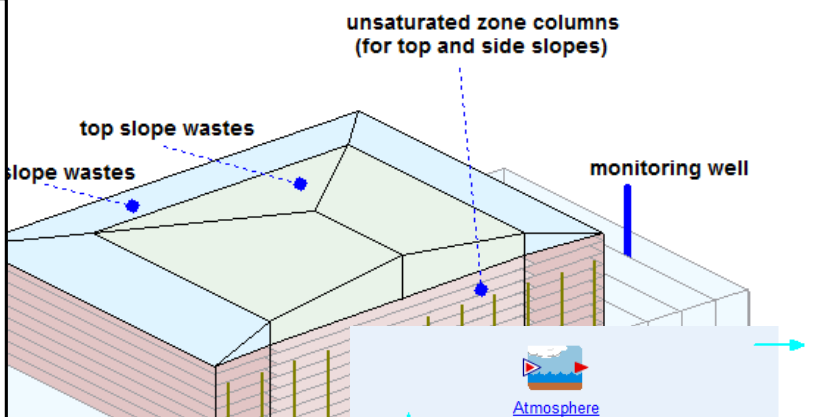
Rip Rap is used to construct the uppermost layer: Armor. It quickly becomes infilled with Loess. The Rip Rap itself is assumed to be an inert material.



Annals of the I
 Age-dependent Dos
 Members of the P
 from Intake of
 Radionuclides
 Part 1

Pacific Northwest
 National Laboratory
 A Compendium of Transfer
 Factors for Agricultural and
 Animal Products
 L. H. Stearns E. B. Bland
 B. A. Naylor D. L. Torrey
 June 2003
 Prepared for the U.S. Department of Energy
 under Contract DE-AC06-80OR21400

PERMEABILITY OF POROUS SOLIDS
 By R. J. MILLINGTON AND J. P. QUAK
 Departments of Agronomy and Agricultural Chemistry, Waite Institute,
 University of Adelaide
 Received 20th June, 1960
 An expression has been derived to describe both saturated and unsaturated permeability
 porous media in terms of the pore size distribution as obtained from mercury-injection
 in or water-desorption isotherms. An interaction model has been adopted wherein
 the pore radius and effective area available for flow have been considered. The permeability
 values obtained using this expression have been compared with water and gas
 permeabilities of a variety of porous media. Satisfactory agreement is found between
 permeability and calculated values over a wide range of permeability.
 The flow of fluids through porous materials is of great significance in the fields
 industrial chemistry, oil technology and agriculture. In general, it may be
 stated that the principal interest is in the transport through reactive materials,
 however, interpretation of transport data is complicated by the fact that at the
 present time no entirely adequate description of flow through inert granular
 materials exists. Two main types of approach are at present being used in this
 connection. The first is the Kozeny-Carman equation (1) which is derived using
 tortuosity concepts. It has been assumed that tortuosity is proportional to the
 electrical resistivity measurements. This approach has been used by
 and Spangler (2) and Farris *et al.* (3). The other treatment
 of the problem is that of Childs and Collis-George (4) and is
 based on the concept of the continuity of pores in adjacent places within the
 porous medium but that of Childs and Collis-George (4) is related
 to the pore size distribution, and requires no additional data such as the
 tortuosity factor. A further development of the pore size distribution
 approach is that of Childs and Collis-George (4) and is related
 to the pore size distribution, and requires no additional data such as the
 tortuosity factor. A further development of the pore size distribution
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 to the pore size distribution, and requires no additional data such as the
 tortuosity factor.



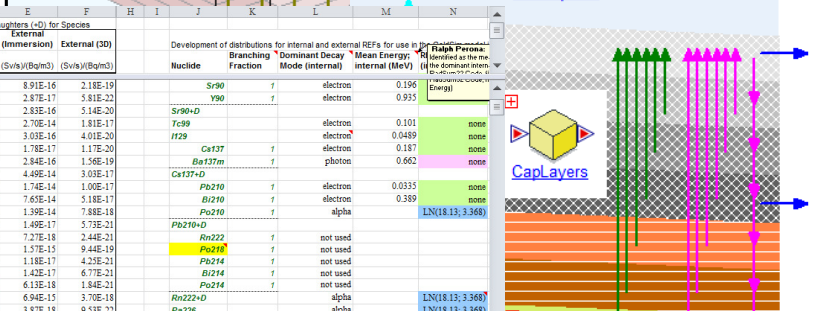
Model Parameters for the
 11 May 2011
 Prepared by
 Neptune and Company, Inc.

THEORY

7. These REFs provide the contribution of short-lived radioactive daughters (LD) for Species

8 9	Radionuclides			External		Development of distributions for internal and external REFs for use in the Branching Fraction Dominant Decay Mode (internal) Release Energy (MeV) Half Period (years) Classified as the most hazardous of the dominant species
	Inh (particle)	Inh (gas)	Ingestion	External (3D)	External (3D)	
10	Sr90-D	3.70E-08	3.04E-08	8.91E-16	2.18E-19	Sr90 electron 0.196
11	Tc99	4.03E-09	6.42E-10	2.87E-17	5.81E-22	Y90 electron 0.935
12	112m	3.59E-08	9.59E-08	1.06E-07	2.83E-16	Sr90+D electron 0.0489
13	Cs137-D	4.67E-09	1.34E-08	2.70E-14	1.81E-17	Tc99 electron 0.187
14	Pb210-D	4.46E-06	9.42E-07	3.03E-16	4.01E-20	electron 0.662
15	Ra228-D	0	2.80E-08	1.78E-17	1.17E-20	Cs137 photon 0.662
16	Ra226	3.46E-06	2.80E-07	2.84E-16	1.56E-19	Ba137m photon 0.662
17	Ra228-D	2.65E-06	6.97E-07	4.49E-14	3.03E-17	Cs137-D electron 0.0335
18	Ac227-D	9.05E-05	4.36E-07	1.74E-14	1.00E-17	Pb210 electron 0.389
19	Th230-D	4.29E-05	1.45E-07	7.65E-14	5.18E-17	Bi210 alpha LN(18.15; 3.568)
20	Th230-D	6.48E-05	4.38E-07	1.39E-14	7.88E-18	Pb210 alpha LN(18.15; 3.568)
21	Pa231-D	1.14E-07	1.49E-17	5.73E-21	3.70E-24	Rn222 not used
22	U235-D	2.31E-07	7.27E-18	2.44E-21	1.56E-24	Pb214 not used
23	U235-D	4.79E-07	1.57E-15	9.44E-19	6.07E-22	Pb214 not used
24	U235-D	3.34E-07	1.18E-17	4.23E-21	2.74E-24	Bi214 not used
25	U235-D	5.13E-08	1.42E-17	6.77E-21	4.30E-24	Po214 not used
26	U235-D	4.93E-08	6.13E-18	1.84E-21	1.19E-24	Rn222-D alpha LN(18.15; 3.568)
27	U235-D	4.70E-08	6.94E-15	3.70E-18	2.37E-21	Ra226 alpha LN(18.15; 3.568)
28	U235-D	4.60E-08	3.87E-18	9.53E-22	6.13E-25	Ra228 electron 0.00987 LN(2.415; 1.438)
29	U235-D	4.79E-08	1.51E-15	6.42E-19	4.18E-22	Ac228 photon 0.771
30	U235-D	1.08E-07	9.46E-15	5.41E-18	3.49E-21	
31	U235-D	2.28E-07	3.51E-18	6.23E-22	4.03E-25	

NUREG CR-6806
 EPA
 Cancer Risk Coefficients for Environmental Exposure to Radionuclides
 Federal Guidance Report No. 13



Final
 Environmental Impact Statement
 to Construct and Operate a
 Facility to Receive, Store, and
 Dispose of 11c.(2) Byproduct
 Material Near Clive, Utah
 Docket No. 40-8989
 Envirocare of Utah, Inc.
 U.S. Nuclear Regulatory Commission
 Office of Nuclear Materials Safety and Safeguards
 August 1993

A Comprehensive Strategy
 of Hydrogeologic Modeling
 and Uncertainty Analysis
 for Nuclear Facilities and Sites
 University of Arizona
 U.S. Nuclear Regulatory Commission
 Office of Nuclear Regulatory Research
 Washington, DC 20555-0001

NUREG-1476
 MASTER
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Table 2
 Classification of waste by hazard class

Radionuclide	Classification	Class	Code
U-235	High level waste	Class 1	1H
U-238	High level waste	Class 1	1H
Th-230	High level waste	Class 1	1H
Th-232	High level waste	Class 1	1H
Pa-231	High level waste	Class 1	1H
Ac-227	High level waste	Class 1	1H
Ac-228	High level waste	Class 1	1H
Th-230	High level waste	Class 1	1H
Th-232	High level waste	Class 1	1H
Pa-231	High level waste	Class 1	1H
Ac-227	High level waste	Class 1	1H
Ac-228	High level waste	Class 1	1H
U-235	Intermediate level waste	Class 2	2H
U-238	Intermediate level waste	Class 2	2H
Th-230	Intermediate level waste	Class 2	2H
Th-232	Intermediate level waste	Class 2	2H
Pa-231	Intermediate level waste	Class 2	2H
Ac-227	Intermediate level waste	Class 2	2H
Ac-228	Intermediate level waste	Class 2	2H
U-235	Low level waste	Class 3	3H
U-238	Low level waste	Class 3	3H
Th-230	Low level waste	Class 3	3H
Th-232	Low level waste	Class 3	3H
Pa-231	Low level waste	Class 3	3H
Ac-227	Low level waste	Class 3	3H
Ac-228	Low level waste	Class 3	3H

Utility: Input Dashboards

RCRA Landfill Waste Concentration Limit Determination Control Panel

DISCLAIMER

The goal of the *RCRA Landfill Radiological Impacts Analysis Waste Concentration Limits Calculation* is to identify those inventory activity concentrations of specific radionuclides that correspond to specified peak annual doses to any receptor within the RCRA time of compliance. These are Waste Concentration Limits (WCLs). **Instructions follow:**

RCRA WCL Setup

Set RCRA WCL Determination Mode
While in RCRA WCL mode, standard modeling is disabled.

Set desired time of compliance (TOC): years

Set desired dose limit: mrem/yr

Set clay fill thickness ft

RCRA Landfill Layout

Select which RCRA Cells to include: RCRA Layout Diagrams

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	

Clay fill thickness: 3.82 ft Waste area: 53906.7 m² Waste volume: 934911 m³

Cells A - D are disabled.

RCRA WCL Determination Settings

Select the decay chain member for which the WCL is to be determined.

For most radionuclide Species, there are no modeled parents or progeny, and determination of the WCL corresponding to the specified dose limit is

Fe60 > Co60	Co60
Zr93/Mo93 > Nb93m	Zr93
Pm146 > Sm146	Sm146
Sm145 > Pm145	Pm145
Po209 > Pb205	Pb205
Actinium Series	Ac227
Thorium Series	Ra228
Uranium Series	Pb210
Neptunium Series	Th229

Decay Chains Reference Diagram

RCRA WCL Iterative Calculation

Iterate until estimated WCLs are within this percent error:

Run Model... • Run the model (F5),

Copy this vector... • copy (ctrl C) the contents of this vector,

...enter Edit Mode... • set to Edit Mode (F4)

...paste into this vector • paste (ctrl V) the vector values into this one, and

Rerun model. • run the model again.

Check RCRA WCL Results (button below) to see which receptor and which radionuclide in the decay chain is controlling the WCL.

- Control Panel
- RCRA WCL Results
- RCRA Decay Chain Behavior
- Dose Details
- Browse Model
- Run Model



Utility: Results Dashboards

RCRA Landfill Waste Concentration Limit Determination Results

DISCLAIMER

Results of the RCRA Landfill WCL determination are organized in several tables, organized by radionuclide.

RCRA Landfill Inventory Concentration Results

nuclide*	activity conc.	disposed act.	max. peak dose	max. exposed receptor**							ratio of max peak dose to inventory concentration	inventory concentration for dose limit (or SA)***
				AR	NR	SR	OW	F	H	R		
Pb205	0 pCi/g	0 Ci	1.32e-13 mrem/yr	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0 (mrem/yr)/(pCi/g)	0 (pCi/g)
Pb210	0 pCi/g	0 Ci	3.28e-24 mrem/yr	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0 (mrem/yr)/(pCi/g)	0 (pCi/g)
Bi207	40297 pCi/g	69677 Ci	1 mrem/yr	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2.482e-5 (mrem/yr)/(pCi/g)	40289 (pCi/g)
Bi210m	21870 pCi/g	37815 Ci	1 mrem/yr	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4.573e-5 (mrem/yr)/(pCi/g)	21865 (pCi/g)
Po208	5.93e14 pCi/g	1.03e15 Ci	0 mrem/yr	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0 (mrem/yr)/(pCi/g)	5.93e14 (pCi/g) <input checked="" type="checkbox"/>
Po209	1 pCi/g	1.73 Ci	0 mrem/yr	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1.321e-13 (mrem/yr)/(pCi/g)	7.57e12 (pCi/g)
Rn222	0 pCi/g	0 Ci	7.5e-24 mrem/yr	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0 (mrem/yr)/(pCi/g)	0 (pCi/g)
Ra226	0 pCi/g	0 Ci	3.24e-25 mrem/yr	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0 (mrem/yr)/(pCi/g)	0 (pCi/g)
Ra228	0 pCi/g	0 Ci	1.83e-21 mrem/yr	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0 (mrem/yr)/(pCi/g)	0 (pCi/g)
Ac227	0 pCi/g	0 Ci	5.08e-23 mrem/yr	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0 (mrem/yr)/(pCi/g)	0 (pCi/g)
Th228	0 pCi/g	0 Ci	0 mrem/yr	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0 (mrem/yr)/(pCi/g)	0 (pCi/g)
Th229	0 pCi/g	0 Ci	2.81e-16 mrem/yr	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0 (mrem/yr)/(pCi/g)	0 (pCi/g)
Th230	0 pCi/g	0 Ci	1.12e-24 mrem/yr	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0 (mrem/yr)/(pCi/g)	0 (pCi/g)
Th232	0 pCi/g	0 Ci	1.5e-22 mrem/yr	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0 (mrem/yr)/(pCi/g)	0 (pCi/g)
Pa231	0 pCi/g	0 Ci	5.41e-23 mrem/yr	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0 (mrem/yr)/(pCi/g)	0 (pCi/g)

[Po209 > Pb205](#)
[Actinium Series](#)
[Thorium Series](#)
[Uranium Series](#)
[Neptunium Series](#)

* Radionuclides identified in the same color are members of a decay chain and require individual WCL development.
 ** Receptors: AR adjacent resident, NR nearest resident, SR on-site resident, OW oilfield worker (driller), F farmer, H hunter, R rancher
 *** A value of 0 pCi/g means that the WCL for this radionuclide is not evaluated. A checkmark indicates that the WCL is from specific activity.

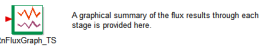


Bringing it Together

Radon flux estimates according to NRC Uranium Mill Tailings Cover Guidance

These radon flux calculations are based in the U.S. Nuclear Regulatory Commission Regulatory Guide 3.64, "Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers" (NRC 1989), and "NUREG/CR-3533 Radon Attenuation Handbook for Uranium Mill Tailings Cover Design" (NRC 1984). Since all embankment cover designs are quite similar, this calculation is performed only for the TopSlope of the Class A South embankment, and is applied to other columns.

The calculation proceeds from the bottom up (waste to surface), as outlined on page 14 and Example 2 in Appendix A of NRC (1989). First is calculated a flux from the DU waste itself, assuming no overlying barrier. That flux is used as an input boundary condition for the subsequent calculation, which estimates the flux



Background calculations

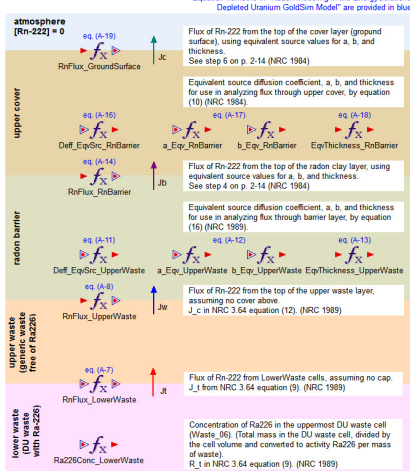
- The layers that this radon diffusion calculation considers are:
- near-surface soils (all cover materials above the clay)
 - compacted clay radon barrier
 - inert waste (with no radon parents) - similar to soil (UpperWaste)
 - DU waste containing radon parents (LowerWaste)

The bottommost layer has a radium-226 concentration that drives the radon production

- All layers have the following background calculations, defined below:
- thickness (obtained from disposal facility dimensions)
 - interface constant a , from NRC 3.64 eq. (11)
 - inverse relaxation length b , from NRC 3.64 eq. (10)

layer thickness	interface constant a	inverse relaxation length b
$f_{x_{Cover_Thickness}}$	$f_{x_{a_Cover}}$	$f_{x_{b_Cover}}$
$f_{x_{RnBarrier_Thickness}}$	$f_{x_{a_RnBarrier}}$	$f_{x_{b_RnBarrier}}$
$f_{x_{UpperWaste_Thickness}}$	$f_{x_{a_UpperWaste}}$	$f_{x_{b_UpperWaste}}$
$f_{x_{LowerWaste_Thickness}}$	$f_{x_{a_LowerWaste}}$	$f_{x_{b_LowerWaste}}$

Radon flux calculations



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U.S. NUCLEAR REGULATORY COMMISSION

June 1989

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 3.64
(Task WM 503-4)

CALCULATION OF RADON FLUX ATTENUATION BY EARTHEN URANIUM MILL TAILINGS COVERS

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[Deff for Radon](#)

[Radon Flux Calibration](#)

[NRC Reg. Guide 3.64](#)

[NUREG/CR-3533](#)

[GoldSim Model Calculations](#)

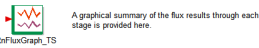
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Background calculations

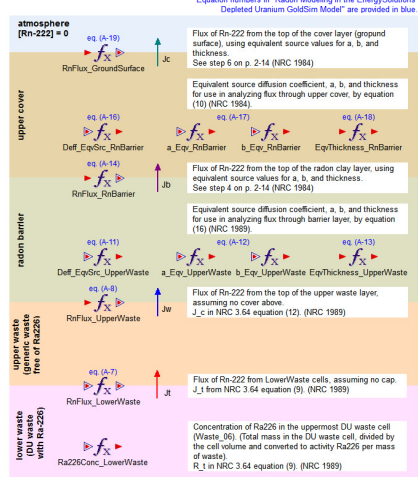
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- thickness (obtained from disposal facility dimensions)
 - interface constant a , from NRC 3.64 eq. (11)
 - inverse relaxation length b , from NRC 3.64 eq. (10)

layer thickness	interface constant a	inverse relaxation length b
f_x → Cover_Thickness	f_x → a_Cover	f_x → b_Cover
f_x → RnBarrier_Thickness	f_x → a_RnBarrier	f_x → b_RnBarrier
f_x → UpperWaste_Thickness	f_x → a_UpperWaste	f_x → b_UpperWaste
f_x → LowerWaste_Thickness	f_x → a_LowerWaste	f_x → b_LowerWaste

Radon flux calculations



NOT TO SCALE

layer thickness

- f_x → Cover_Thickness
- f_x → RnBarrier_Thickness
- f_x → UpperWaste_Thickness
- f_x → LowerWaste_Thickness

interface constant a

- f_x → a_Cover
- f_x → a_RnBarrier
- f_x → a_UpperWaste
- f_x → a_LowerWaste

inverse relaxation length b

- f_x → b_Cover
- f_x → b_RnBarrier
- f_x → b_UpperWaste
- f_x → b_LowerWaste

Sometimes simply organizing the appearance of calculations can help in communicating their role.



Bringing it Together

Expression Properties : RnFlux_UpperWaste

Definition

Element ID: RnFlux_UpperWaste

Description: Radon flux from the Upper Waste layer

Display Units: pCi/m2/s

Type... Scalar

Current Value = 0 pCi/m2/s

$$\left(\frac{2 * \text{RnFlux_LowerWaste} * \exp(-b_UpperWaste * \text{UpperWaste_Thickness})}{1 + \sqrt{a_LowerWaste / a_UpperWaste}} * \tanh(b_LowerWaste * \text{LowerWaste_Thickness}) + (1 - \sqrt{a_LowerWaste / a_UpperWaste}) * \tanh(b_LowerWaste * \text{LowerWaste_Thickness}) * \exp(-2 * b_UpperWaste * \text{UpperWaste_Thickness}) \right)$$

Final Values Time Histories

OK Cancel Help

This flux is given by NRC (eq. 3 in NRC, 1984 and eq. 9 in NRC, 1989) as

$$J_t = R_t \rho_t E_t \sqrt{\lambda D_t} \tanh(x_t \sqrt{\lambda / D_t}) \quad (\text{A-7})$$

is used in the second step to solve for the surface flux of radon assuming continuity of concentration across the tailings-cover interface (eq. 4 in NRC, 1984 and NRC, 1989):

$$J_c = \frac{2 J_t \exp(-b_c x_c)}{1 + \sqrt{\frac{a_t}{a_c}} \tanh(b_t x_t) + \left[1 - \sqrt{\frac{a_t}{a_c}} \tanh(b_t x_t) \right] \exp(-2 b_c x_c)} \quad (\text{A-8})$$

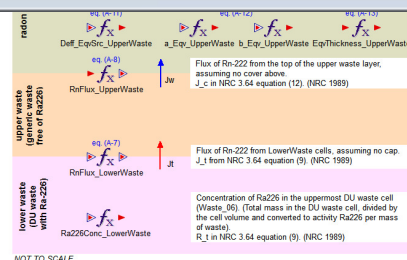
subscript c refers to the cover (in this case, the bottommost layer of inert Class A) and the inverse relaxation lengths are defined as

$$b_t = \sqrt{\lambda / D_t} \quad \text{and} \quad b_c = \sqrt{\lambda / D_c} \quad (\text{A-9})$$

NRC, 1989) and the interface constants are defined (eq. 11 in NRC, 1989) as

$$a_t = n_t^2 D_t [1 - (1 - k) m_t]^2 \quad \text{and} \quad a_c = n_c^2 D_c [1 - (1 - k) m_c]^2 \quad (\text{A-10})$$

where k is the equilibrium distribution coefficient for radon in water and air (pCi cm⁻³ water per pCi cm⁻³ air).



waste
c waste
Ra226)

Radon Modeling

15

$$J_c = \frac{2 J_t \exp(-b_c x_c)}{1 + \sqrt{a_t / a_c} \tanh(b_t x_t) + \left[1 - \sqrt{a_t / a_c} \tanh(b_t x_t) \right] \exp(-2 b_c x_c)} \quad (12)$$

QA Tools in GoldSim

- Use the tools provided within GoldSim for QA:
- Note Panes
- Versioning
- Version change notes



The Note Pane

The screenshot displays a software window titled "Materials and Species Definitions" with a container path of "\Materials". The main content area contains a descriptive paragraph and three sub-sections: "Contaminant Species", "DecayChains", and "HalfLives". A note pane at the bottom, titled "Element: Species", contains a verification note and the name "John Tauxe" with the date "11 May 2011".

Materials and Species Definitions

This container includes definitions of contaminant species and their decay rates, the material properties of the physical solid materials making up the cap, waste, unsaturated and saturated zones, and properties of the fluid media Air and Water. Soil/water partition coefficients (Kds) and solubilities are associated with the definition of Water below, and Henry's Law constants with Air.

Contaminant Species

The list of contaminant species is defined in the Species element. The list of radionuclide Species is derived from the waste profile for depleted uranium from the Savannah River Site (Waste Profile Record SRS DU 9021-33_r0.pdf), attachments 1 and 2.

DecayChains

Half-lives are defined in their own vectors to assist with QA.

HalfLives

Element: Species

The values in this Species element were checked against the Model Parameters document and workbook v0.903
John Tauxe
11 May 2011

Edit Mode: Press F5 to run model. Scale: 100% Filter ON Edit Mode



Model Versioning

The image displays a software interface for model versioning. On the left, a 'Version Manager' dialog box is open, showing a list of versions with '1.200' selected. Below the list are fields for 'Version Description', 'User Name', and 'Description'. A 'Changes for' dialog is also partially visible, showing a 'Content:' field with a 'Change' button.

The main window is a Notepad++ editor titled 'D:\ES\energysolutions\DU\GoldSim\GoldSim Version Difference.txt - Notepad++'. It contains a log of model changes with the following text:

```
84 [Begin Element 'UpperRnBarrierKsat_Nat']
85 Path: \Materials\UpperRnBarrierClay_Properties\
86 Type: Expression
87 Changes:
88 The element was added.
89 A description was added to the element.
90 After changing the element the following note was attached: 'revised for HYDRUS ET
cover modeling implementation
91 v1.2
92 8 May 2014
93 Kate Catlett'
94
95 [Begin Container 'Unit4_Properties']
96 Path: \Materials\
97 Changes:
98 -none-
99 Element(s) added:
100 'log_vG_Alpha' (Type: Stochastic)
101 'vG_Alpha' (Type: Expression)
102 'log_vG_n' (Type: Stochastic)
103 'vG_n' (Type: Expression)
104
105 [Begin Element 'log_vG_Alpha']
106 Path: \Materials\Unit4_Properties\
107 Type: Stochastic
108 Changes:
109 The element was added
```

The status bar at the bottom of the Notepad++ window indicates: 'Normal text file nb char: 163724 nb line: 4668 Ln: 1 Col: 1 Sel: 0 Dos\Windows ANSI INS'.



More GoldSim QA Tricks

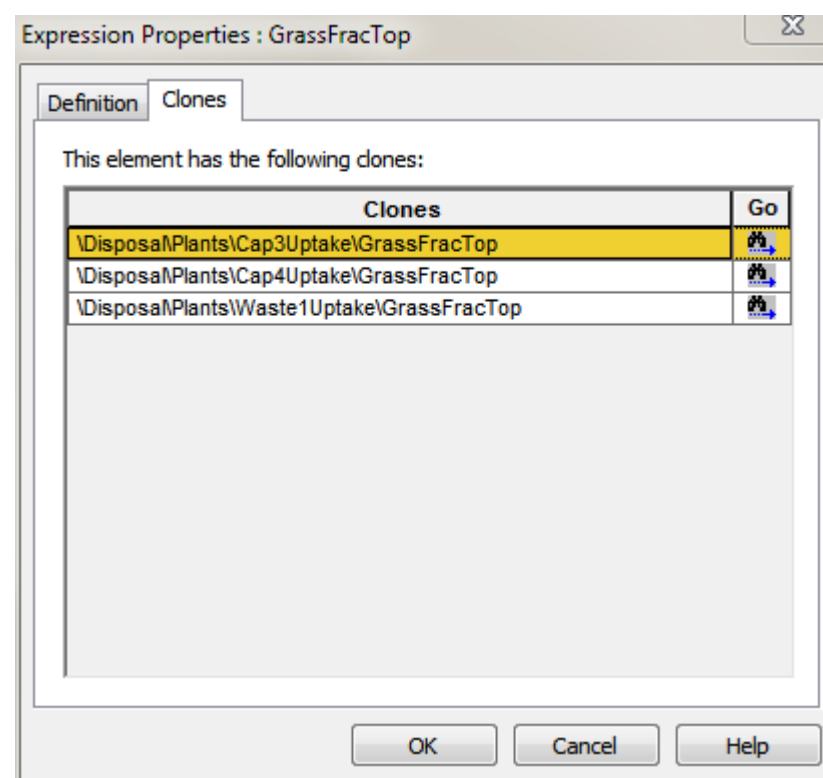
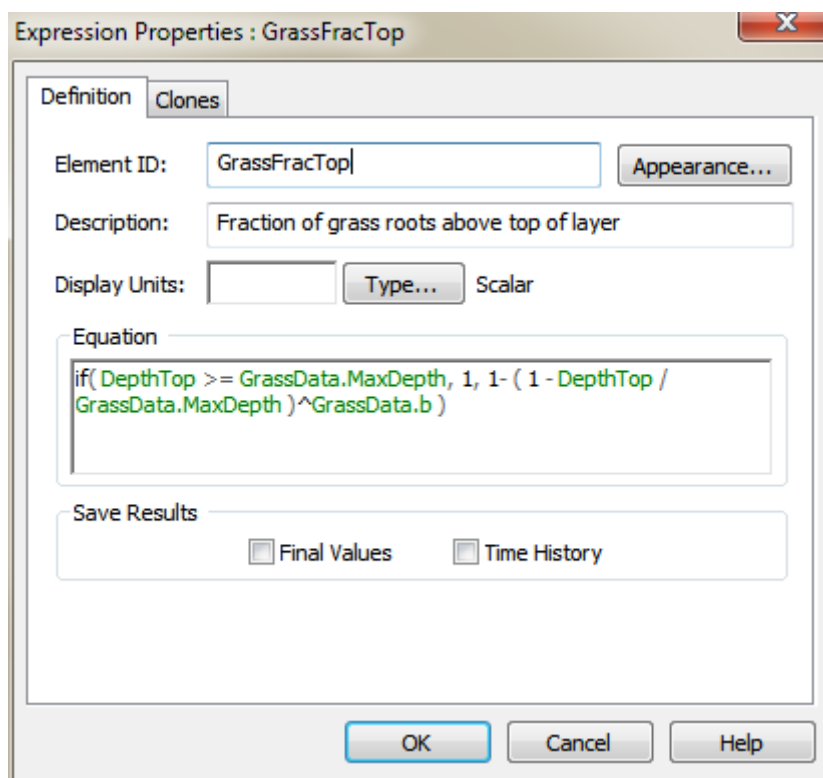
Additional QA tricks:

- Cloned elements
- Referenced units
- Graph footer information



Clones for QA

If an equation is used in more than one place, cloning it guarantees that it will be the same for all clones. That makes QA easier.



Units from References

The screenshot shows the GoldSim Pro interface for a model named "WCS Site Model v0.3.gsm". The main window displays a schematic diagram of a cylindrical structure with three main components: "lid", "MCC", and "footing pad". Dimensions are indicated with arrows and linked to calculation cells. A "Data Properties" dialog box for "FloorHeight_Cyl" is open, showing the current value as 0.3556 m and the original source as "1 ft + 2 in".

...but of course we want meters

original units are in ft. and in...

A reviewer will need to check those original units against the source.

GoldSim Pro - WCS Site Model v0.3.gsm*

File Edit View Graphics Model Run Help

Container Path: \Miscellaneous\MCC_Calculations\MCC_Cylinder

lid

MCC

footing pad

OutsideRadius_Cyl

OutsideHeight_Cyl

FloorHeight_Cyl

ThicknessPad_Cyl

Data Properties : FloorHeight_Cyl

Definition

Display Units: m

Current Value = 0.3556 m

1 ft + 2 in

Data Source

Type: None

OK Cancel Help

Edit Mode: Press F5 to run model. Scale: 100% Filter ON Edit Mode



Run Stamps for Traceability

