# **Environmental Sciences Laboratory**

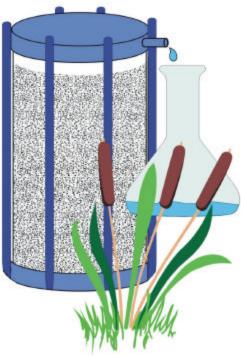
**Final Report** 

Rejuvenating Permeable Reactive Barriers by Chemical Flushing

# U.S. Environmental Protection Agency Region 8 Support

August 2004

Prepared for U.S. Department of Energy Grand Junction, Colorado





Work Performed Under DOE Contract No. DE-AC01-02GJ79491 for the U.S. Department of Energy Approved for public release; distribution is unlimited.

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#### August 2004

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Appendix A Environmental Sciences Laboratory Notes

# Acronyms

AFO Ca CBD CCD yd <sup>3</sup> °C DOE DTPA EDTA EDTA EPA ESL Fe g g/mL HCl in. L HCl in. L HCl in. L HCl in. M mg mg/L min mL mL/min mV μg/L ORP pCi/L PRB U	amorphous ferric oxyhydroxide calcium citrate bicarbonate dithionite cubic yards degrees Celsius U.S. Department of Energy diethylenetriamine pentaacetic acid ethylenediaminetetraacetic U.S. Environmental Protection Agency Environmental Sciences Laboratory iron grams grams per milliliter hydrochloric acid inch liters pounds microsiemens per centimeter molar milligrams milligrams per liter minutes milliliters milliliters milliliters per minute millivolts micrograms per liter oxidation-reduction potential picocuries per liter permeable reactive barrier uranium
U UMTRA ZVI	uranium Uranium Mill Tailings Remedial Action zero-valent iron
	zero-valent from

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### **Executive Summary**

A permeable reactive barrier (PRB) is an engineered zone of chemically reactive material placed in the flow path of contaminated ground water to stabilize or degrade contaminants as ground water moves through the zone. The most common reactive material employed in PRBs is zerovalent iron (ZVI). PRBs are rapidly becoming widely used means to remediate ground water.

Unfortunately, reactions of ZVI with contaminants, dissolved oxygen, and water molecules result in an increase in pH values that cause carbonate minerals to precipitate in the ZVI. Alkalinity decreases of as many as several hundred milligrams per liter (as calcium carbonate) from influent to effluent indicate that large volumes of carbonate minerals have precipitated in the PRBs. In addition to carbonate precipitation, oxidation causes the precipitation of iron oxide minerals. The buildup of carbonate and oxide minerals within the reactive zone could disrupt the performance of the PRB by causing (1) preferential pathways within the reactive zone, (2) ground water mounding and bypassing the PRB, and (3) a reduction in the reactivity of the media because of mineral deposition on the ZVI surfaces.

The U.S. Environmental Protection Agency funded this project to investigate chemical methods of rejuvenating ZVI-based PRBs. The work was conducted by Environmental Sciences Laboratory personnel at the U.S. Department of Energy office in Grand Junction, Colorado. A portion of this work was reported previously in *The Final Report: Phase II, Performance Evaluation of Permeable Reactive Barriers and Potential for Rejuvenation by Chemical Flushing* (DOE 2004). For completeness, the results of the PRB rejuvenation project are reported here in their entirety.

Bench-scale tests were conducted to evaluate the potential for rejuvenation of ZVI PRBs using chemical solvent flushing. We tested various solvents, including free acid ammonium oxalate, diethylenetriamine pentaacetic acid (DPTA), disodium EDTA, ethylenediaminetetraacetic acid (EDTA), hydroxylamine hydrochloride, sodium citrate, sodium dithionite, and tetrasodium EDTA, and the commercial products Lime Away, and Lime Out (designed to remove calcium and iron scale deposits). Some tests were conducted with combinations of these solvents and sometimes included bicarbonate or carbonate as a pH buffer. Rejuvenation agents are considered more favorable if they dissolved more calcite (a ZVI corrosion product that occludes porosity), less ZVI, and have low toxicity. The ability to dissolve amorphous ferric oxyhydroxide, hematite and magnetite was also considered favorable. Most of the individual solvents and combinations of solvents were able to dissolve some calcite, but they also dissolved some ZVI.

Of the solvents tested in batch mode, disodium EDTA and tetrasodium EDTA were considered to be the most suitable and were selected for preliminary column tests. The column test results indicate that EDTA was able to remove all the calcite deposited during ZVI corrosion and some of the calcite initially present in the column fill material. While some iron was also dissolved by EDTA, the change in the iron inventory was insignificant.

A portion of ZVI from the Monticello, Utah, PRB was treated with disodium EDTA to determine if the treatment would improve the ability of the ZVI to remove uranium. Unfortunately, the results were inconclusive because the ZVI in both the treated and untreated columns removed uranium at a fast rate. Longevity calculations made by Morrison (2003) assumed that the ZVI

would lose reactivity at a much higher rate than indicated by the column results. The data on the untreated column presented in this report suggest that the PRB continues to remove uranium at a high rate, implying that the previous calculations of longevity should be revisited.

This project was funded through an Interagency Agreement with the Environmental Protection Agency. DOE would like to thank Charles Sands and Robin M. Anderson from the Office of Emergency Response and Remediation, Response Decision Team for their support in this project. DOE would also like to acknowledge the efforts of Paul Mushovic, Richard Muza, and Jay Silvernale from the Office of Ecosystems Protection and Remediation, Region VIII, for their technical support and review of this document.

### **1.0 Introduction**

A permeable reactive barrier (PRB) is a zone of chemically reactive material placed in the flow path of contaminated ground water to stabilize or degrade contaminants as ground water moves through the zone. The most common reactive material employed in PRBs is zero-valent iron (ZVI). PRBs are rapidly becoming a widely used means of remediating ground water. ZVI can treat both organic and inorganic contaminants including uranium.

Unfortunately, reactions of ZVI with contaminants, dissolved oxygen, and water molecules result in an increase in pH values that cause carbonate minerals to precipitate within the ZVI. Alkalinity decreases of as many as several hundred milligrams per liter (mg/L) (as calcium carbonate) from influent to effluent indicate that large volumes of carbonate minerals have precipitated in the PRBs. In addition to carbonate precipitation, oxidation causes the precipitation of iron oxide minerals. The buildup of carbonate and oxide minerals within the reactive zone could disrupt the performance of the PRB by causing (1) preferential pathways within the reactive zone, (2) ground water mounding and bypassing the PRB, and (3) a reduction in the reactivity of the media because of mineral deposition on the ZVI surfaces.

The U.S. Environmental Protection Agency (EPA) funded this project to investigate chemical methods of rejuvenating ZVI-based PRBs. The work was conducted by Environmental Sciences Laboratory (ESL) personnel at the U.S. Department of Energy (DOE) office in Grand Junction, Colorado. A portion of this work was reported previously in *The Final Report: Phase II, Performance Evaluation of Permeable Reactive Barriers and Potential for Rejuvenation by Chemical Flushing* (DOE 2004). For completeness, the results of the PRB rejuvenation project is reported here in its entirety. Appendix A contains copies of the ESL notes.

Ground water chemistry data for samples from the PRB at Monticello, Utah, show that reactivity has decreased and that carbonate minerals and iron oxide corrosion products have precipitated in the ZVI matrix (Morrison 2003). Other PRB sites have experienced similar decreases in reactivity and precipitation of corrosion products (e.g., Wilkin and Puls 2003). Data presented by DOE (2004) indicate that some reactive ZVI is still present in zones that have lost reactivity. If the corrosion products could be removed while leaving ZVI intact, the reactivity of the PRB may be improved. In the present study, preliminary laboratory tests were conducted to evaluate the efficiency of several solvents for rejuvenating ZVI-based PRBs. Batch tests using standard specimens of ZVI and corrosion products were performed to determine the amount of mineral dissolution after a specific time period. Subsequently, two solvents were used in column tests to determine rejuvenation efficiency under flow conditions.

### 1.1 Background on Permeable Reactive Barriers Used To Treat Ground Water for Uranium

More than 150 million tons of uranium mill tailings have been removed from 22 former uranium ore-processing sites in the United States. Remediation of ground water at these sites is mandated by Congress and was formerly conducted by the DOE Uranium Mill Tailings Remedial Action (UMTRA) Ground Water Project (NRC 1980) and now is being performed by the DOE Office of Legacy Management. EPA promulgated a ground water concentration limit of 30 picocuries per liter (pCi/L) (approximately 44 micrograms per liter [ $\mu$ g/L]) for uranium (U) to ensure protection of human health and the environment near these sites (EPA 1995); this U concentration is also

being used as a ground water cleanup goal at a former uranium-ore processing site near Monticello, Utah. At many of these former ore processing sites, U has entered the ground water system and has contaminated more than 10 billion gallons of ground water (DOE 1996). Uranium ore processing outside the United States, particularly in Australia, Canada, South Africa, and Europe, has also resulted in significant ground water with U contamination. In addition to tailings sites, U has been reported in ground water at 12 of 18 major DOE facilities because of contamination from the weapons production cycle (Riley et al. 1992).

Cost-effective means of cleaning up ground water contaminated by U are needed. Ground water at some of the tailings sites is being extracted and treated ex situ, but costs for ex situ treatment are high and no site has yet been remediated to EPA's prescribed standards. PRBs to treat ground water contaminated by U are currently being tested at four sites (Monticello, Utah; Fry Canyon, Utah; Durango, Colorado; and Oak Ridge National Laboratory Y-12 Plant, Tennessee) as a low-cost alternative to pumping and treating ground water.

ZVI, a scrap-metal product that is available from the automotive industry, is being used as a reactive material in the PRBs at these four sites. Contact with ZVI causes U concentrations in ground water to decrease to a few micrograms per liter. Results of numerous laboratory experiments have confirmed the ability of ZVI to remove U from ground water. Because of the promising results of laboratory and field studies, project managers are expressing increasing interest in using ZVI to treat U contamination in ground water. Research is still needed, however, to understand the mechanisms of U uptake to support optimal designs for remediation systems and to make accurate predictions of the length of time that PRBs will remain effective.

### 1.2 Background on Monticello Permeable Reactive Barrier

This project is directly applicable to the Monticello, Utah, Mill Tailings National Priorities List site. An in situ PRB was installed hydraulically downgradient of the Monticello site in 1999; it is a funnel-and-gate system with a three-zone PRB (Morrison et al. 2002). The furthest upgradient zone (the pretreatment zone) has 13-percent ZVI by volume mixed with pea gravel. Downgradient from the pretreatment zone is a zone of 100-percent ZVI, followed by the third zone that contains 100-percent gravel and an air sparging unit (Figure 1).

# 2.0 Batch Test Results

Bench-scale tests were conducted to evaluate the potential for rejuvenation of ZVI PRBs using chemical solvent flushing. We tested various solvents, including free acid ammonium oxalate, diethylenetriamine pentaacetic acid (DPTA), disodium EDTA, ethylenediaminetetraacetic acid (EDTA), hydroxylamine hydrochloride, sodium citrate, sodium dithionite, and tetrasodium EDTA, and the commercial products Lime Away, and Lime Out (designed to remove calcium and iron scale deposits). Some tests were conducted with combinations of these solvents and sometimes included bicarbonate or carbonate as a pH buffer. Rejuvenation agents are considered more favorable if they dissolved more calcite (a ZVI corrosion product that occludes porosity), less ZVI, and have low toxicity. The ability to dissolve amorphous ferric oxyhydroxide, hematite and magnetite was also considered favorable. Most of the individual solvents and combinations of solvents were able to dissolve some calcite, but they also dissolved some ZVI.

Batch tests were conducted by combining a solid material (Table 1) with a solvent, agitating for a period of time, filtering, and then analyzing the filtrate for calcium (Ca) and iron (Fe). The amount of Ca or Fe removed was used as an indication of the amount of solid material that dissolved. Except where indicated otherwise, standard batch tests were conducted by combining 40 milliliters (mL) of the solvent with 0.5 gram (g) of a standard specimen of either powdered amorphous ferric oxyhydroxide (AFO), calcite, hematite, magnetite, or granular ZVI. Agitation was conducted in 50-mL glass Erlenmeyer flasks using an orbital motion in a temperature-controlled bath (Precision Model 25) at 25 °C. The mixtures were centrifuged, and the supernatant solution were analyzed for Ca and Fe by flame atomic absorption spectroscopy (DOE 2003; ESL Procedures AP[Ca-1] and AP[Fe-1]).

#### 2.1.1 Sodium Acetate Buffer

Sodium acetate (NaOAc) adjusted to a pH value of 5 using glacial acetic acid (NaOAc buffer) is often used to remove calcite from clay samples in preparation for hydrometer tests (Jackson 1979). The NaOAc buffer is used because it can remove calcite without affecting the clay mineral composition.

NaOAc buffer (50 mL) was combined with 50 milligrams (mg) of powdered calcite in a 50-mL plastic centrifuge tube. Three additional tubes contained 2 grams (g) of the fresh (this report uses the term 'fresh' to indicate material that has not been used in a PRB) gravel/ZVI mixture used in the gravel/ZVI zone in the Monticello PRB and 50 mL of NaOAc buffer. The tubes were agitated end-over-end for various periods of time at room temperature. After agitation, they were centrifuged, decanted, preserved with nitric acid, and analyzed for Ca and Fe.

Gas was generated, and, consequently, an increase in pressure occurred during agitation in the tests with gravel/ZVI; a small amount of liquid was lost by leakage. The pressure increase was probably due to generation of hydrogen (H<sub>2</sub>) gas from ZVI corrosion. About 88 percent of the calcite was dissolved, indicating that NaOAc was effective at removing calcite from the mixture (Table 2). Calcium was also removed from the three gravel/ZVI samples in approximately equivalent amounts, suggesting that all the calcite in the samples was dissolved. As much as 301 mg of ZVI was also dissolved. For the sample that agitated for 39 hours, about 86 percent of the ZVI was dissolved based on 13 percent by volume ZVI in the gravel/ZVI; the density of the

ZVI was 2.4 grams per milliliter (g/mL), and the density of the gravel was 1.7 g/mL. Because NaOAc dissolves ZVI, it is not suitable as a chemical rejuvenation agent.

### 2.1.2 EDTA and DTPA

Ethylenediaminetetraacetic acid (EDTA) and diethylenetriamine pentaacetic acid (DTPA) are industrial organic chelating agents used in cleansers, vegetable oils, and pharmaceuticals; they are also used to decontaminate radioactive surfaces and to remove insoluble deposits of Ca. The use of EDTA and DTPA in many consumable items suggests low toxicity. Free acid EDTA with a formula  $C_{10}H_{16}O_8N_2$  (Fisher Scientific, BP118), tetrasodium EDTA with a formula of (NaOCOCH<sub>2</sub>)<sub>2</sub>NCH<sub>2</sub>CH<sub>2</sub>N(CH<sub>2</sub>COONa)<sub>2</sub> • H<sub>2</sub>O (Baker Chemicals I693-7), disodium EDTA with a formula of  $C_{10}H_{14}N_2Na_2O_8 \cdot 2H_2O$  (Baker Chemicals, 4040-01), and DTPA with a formula  $C_{14}H_{23}N_3O_{10}$  (Acros Organics) were tested in this study as potential ZVI PRB rejuvenation agents. The 0.1 molar (M) solutions of EDTA, tetrasodium EDTA, disodium EDTA, and DTPA have pH values of about 2.8, 10.8, 5.3, and 2.5, respectively. All chemicals were reagent grade.

In one set of tests, 50 mL of 0.1 M tetrasodium EDTA was combined with 2 g of fresh gravel/ZVI samples and various amounts of concentrated hydrochloric acid (HCl) to adjust the pH value (Table 3; tests 1 through 3). The mixtures were agitated end-over-end for 9 hours, centrifuged, and decanted. Values of final pH ranged from 8.25 to 11.02. The amount of Ca removed from the samples was similar at all three pH values and was more than the amounts removed by NaOAc (Table 2). The amount of Fe removed from the gravel/ZVI mixtures increased significantly as pH decreased (Table 3; tests 1 through 3).

Another set of tests evaluated the ability of 0.1 M tetrasodium EDTA to dissolve powdered calcite, hematite, magnetite, and ZVI from standard specimens. The tetrasodium EDTA was moderately effective at dissolving calcite, but it did not dissolve much of the Fe minerals (Table 3; tests 4 through 7). In another set of tests, the effect of the tetrasodium EDTA concentration on dissolution of a mixture of calcite and ZVI was examined. Lowering the tetrasodium EDTA concentration from 0.1 to 0.025 M caused a decrease in the dissolution of both calcite and ZVI (Table 3; tests 7 through 10). The combined results indicate that tetrasodium EDTA in a solution with a high pH value may be beneficial for ZVI PRB rejuvenation because it can remove large amounts of calcite while leaving most of the ZVI intact.

Table 4 displays the results of the dissolution of standard test specimens by free acid EDTA. A 0.1 M solution of free acid EDTA was oversaturated, as indicated visually by the occurrence of residual powder and by low electrical conductivity values of the solutions. Values of electrical conductivity in the free acid EDTA solutions ranged from 227 to 662 microsiemens per centimeter ( $\mu$ S/cm) (Table 4) compared to a range of 10,940 to 11,160  $\mu$ S/cm in a 0.1 M solution of disodium EDTA (Table 5). Thus, the free acid EDTA tests were conducted with a saturated solution. The saturated solution of free acid EDTA did not remove much calcite and would not be effective for PRB rejuvenation.

A 0.1 M solution of disodium EDTA was effective in removing at least 80 percent of the calcite (Table 5). There was a small amount of solution loss, and it is likely that all the calcite was actually dissolved. About 3 percent of the ZVI was dissolved by the disodium EDTA. The much higher removal of calcite compared to ZVI suggests that disodium EDTA may be effective in rejuvenating PRBs. Unfortunately, only a small amount of the Fe oxides was dissolved.

Similar to free acid EDTA, a 0.1 M solution of DTPA could not be made because its solubility is too low. A saturated solution of DTPA dissolved about 13 percent of the calcite and 3 percent of the ZVI (Table 6). The results suggest that DTPA is less efficient than disodium EDTA and tetrasodium EDTA for removing calcite.

#### 2.1.3 Ammonium Oxalate

Ammonium oxalate  $[(NH_4)_2C_2O_4 \cdot H_2O]$  solution buffered with oxalic acid to a pH value of 3 is used to selectively remove amorphous, or poorly crystalline ferric oxides from soil samples (Smith and Mitchell 1987). The extractant is prepared by mixing 0.2 M ammonium oxalate solution with 0.2 M oxalic acid in the proportion 4:3 by volume.

Despite the low pH value, the buffered ammonium oxalate extractant was ineffective at removing calcite (Table 7). In the rejuvenation tests with iron-based materials, it was most effective in removing Fe from AFO and magnetite. In addition to its ineffectiveness at removing calcite, ammonium oxalate is one of the most toxic of the compounds tested. Ammonium oxalate is not suitable for ZVI PRB rejuvenation.

#### 2.1.4 Buffered Sodium Dithionite and Sodium Citrate

Sodium dithionite ( $Na_2S_2O_4$ , also called sodium hydrosulfite) is commonly used with sodium citrate and sodium bicarbonate to selectively remove crystalline ferric iron from soil samples (Jackson 1979). This extractant is often referred to as citrate bicarbonate dithionite (CBD). Each constituent of the CBD extractant has a purpose in helping to dissolve ferric minerals; the citrate chelates Fe, dithionite chemically reduces ferric iron to ferrous iron, and bicarbonate buffers the pH. Citrate, by itself, is often used to chelate metals and is also used in many consumable products. Citrate and bicarbonate are nontoxic.

Injection of a dissolved form of sodium dithionite has also been used for remediating chromium contamination in ground water (Vermeul et al. 2002). As with CBD, sodium dithionite causes reduction of ferric iron to ferrous iron. In the subsurface, sodium dithionite decomposes rapidly to compounds with low toxicities.

Extraction of Fe and Ca was tested with mixtures containing sodium dithionite, sodium citrate, and/or sodium bicarbonate using the previously described standard procedure. Sodium dithionite, by itself, removed 6.8 mg Ca from the calcite sample (about 3 percent of the calcite) and 5.6 mg of Fe from the ZVI sample (Table 8; tests 1 through 5). It removed as much as 17.4 mg of Fe from AFO, 8.2 mg of Fe from magnetite, and 10.4 mg of Fe from hematite. Although the sodium dithionite was able to preserve the ZVI reasonably well, it was unable to dissolve a significant portion of calcite.

Sodium citrate, combined with sodium bicarbonate, extracted 10.0 mg of Ca from the calcite sample (about 5 percent of the calcite) and minimal Fe (Table 8; items 6 through 10). However, the dissolution of iron-based materials was highest for ZVI. These results suggest that sodium citrate may be useful in removing a small portion of calcite from a PRB but may dissolve some ZVI while leaving Fe corrosion products intact.

A solution of CBD (0.27 M sodium citrate, 0.11 M sodium bicarbonate, and 0.1 M sodium dithionite), mixed in the same proportions as used in Jackson (1979), was tested for extraction of calcite, Fe oxides, and ZVI (Table 8, items 11 through 15). CBD removed 8.4 mg of Ca from the

calcite sample (about 4 percent of the calcite). It also removed some of the ferric oxides, but the ZVI was least affected. The results with CBD are similar to those with dithionite alone, but more AFO was removed with CBD.

Results of some of the previous tests suggest that an increase in pH values in a CBD extractant may have a positive effect on calcite dissolution. Therefore, an extractant using citrate, carbonate, and dithionite (CCD) was designed that used carbonate (as potassium carbonate  $[K_2CO_3]$ ) instead of bicarbonate to buffer pH. The pH value of CCD is 9.70 compared to 6.98 for CBD. Tests were conducted in the same manner as previous tests, and the results are presented in Table 8 (items 16 through 20). Less calcite was dissolved using CCD than with CBD; no other significant changes were apparent.

#### 2.1.5 Sodium Dithionite and Tetrasodium EDTA

The CBD extractant previously discussed combines a chelating agent (citrate) with a chemical reductant (dithionite). The effects of using tetrasodium EDTA instead of citrate as the chelating agent were investigated. The same standard test procedure as described previously was used.

A solution containing low-strength 0.038 M tetrasodium EDTA and 0.025 M sodium dithionite was used. For additional control, tests were conducted simultaneously using only tetrasodium EDTA (Table 9). By comparing the Ca and Fe removal with tetrasodium EDTA alone (Table 9, tests 1 through 5) to tests with tetrasodium EDTA and dithionite (Table 9, tests 6 through 10), it was determined that the presence of dithionite had little effect on mineral dissolution.

Some of the previous test results suggest that the pH values of extractants composed of EDTA and dithionite may have an effect on the mineral dissolution capability. A titration of tetrasodium EDTA with a sodium dithionite solution was conducted to determine a solution composition that has a pH value greater than the 9.17 used in the previous tests. The selected high-strength solution contains 0.16 M tetrasodium EDTA and 0.057 M sodium dithionite and has a pH value of 9.69 (Table 10; tests 6 through 10). Tests were conducted with this high-strength mixture in the same manner as described for the low-strength tetrasodium EDTA and sodium dithionite solution.

Table 10 presents the results of the high-strength sodium dithionite and tetrasodium EDTA solution tests and the tests with 0.1 M tetrasodium EDTA. The test solutions containing sodium dithionite (Table 10; tests 6 through 10) dissolved essentially the same amounts of calcite as 0.1 M tetrasodium EDTA alone (Table 10; tests 1 through 5). Slightly more iron oxide minerals were dissolved by the high-strength solution than by the low-strength solution (compare data in Table 10 to data in Table 9). However, the results of the high-strength mixture do not represent a significant improvement over the low-strength mixture.

### 2.1.6 Hydroxylamine Hydrochloride

Hydroxylamine hydrochloride (NH<sub>2</sub>OH • HCl) mixed with acetic acid (CH<sub>3</sub>COOH) has been used as an extractant to selectively remove iron and manganese oxides from soil samples (Landa 1982). The solution used for the tests in this study was made by combining 1 M hydroxylamine hydrochloride solution with 25 percent (by volume) concentrated glacial acetic acid, the same as used by Landa (1982). The tests were conducted using the previously described standard batch test method.

The pH value of the hydroxylamine hydrochloride solution is 1.48. The solution removed 224.8 mg of Ca from the calcite sample, which is essentially total dissolution (Table 11). Unfortunately, this extractant also dissolved 86.4 mg of Fe from the ZVI sample (about 17 percent of the sample). The ferric oxides were relatively unaffected, bringing into question the use of this extractant for selective removal of ferric oxides. Hydroxylamine hydrochloride is more toxic than most of the other extractants tested.

#### 2.1.7 Lime Away and Lime Out

Lime Away (Reckitt Benckiser, Inc., Parsippany, New Jersey) and Lime Out (Iron Out, Ft. Wayne, Indiana) are commercial cleansers designed to remove calcium and iron scale in the home. These products were used full strength as purchased at a retail hardware store. The composition of these products is unknown. The pH values of Lime Away and Lime Out are 1.34 and 1.12, respectively. The tests were conducted using the previously described standard batch method.

Both products removed a significant amount of calcite (Table 12). The powdered calcite effervesced when contacted by both Lime Away and Lime Out, indicating the outgassing of carbon dioxide caused by the low pH. A small amount of material was spilled during the rapid effervescence, and the Ca values in Table 12 are probably low; it appeared that all the calcite dissolved. Lime Away was also able to dissolve a small amount of AFO. Both products dissolved a small amount of ZVI. Because of their ability to dissolve a large quantity of calcite while dissolving only a small amount of ZVI, these products may be suitable for PRB rejuvenation.

#### 2.1.8 Summary of Batch Rejuvenation Tests

All results reported in this section were conducted suing the same test method. This method consists of orbital agitation of a 40-mL sample in a 50-mL glass volumetric Erlenmeyer flask in temperature controlled bath at 25 °C for 2 hours. Figure 1 presents a summary of the results of these tests that had the same methodology. Extractants that remove large amounts of calcite and small amounts of ZVI are considered most favorable for rejuvenating a ZVI PRB. Removal of large amounts of AFO, hematite, and magnetite is also considered beneficial.

Hydroxylamine hydrochloride, disodium EDTA, DTPA, Lime Away, and Lime Out were the most effective extractants tested for the removal of calcite. Unfortunately, these same extractants also dissolved slightly more ZVI than other extractants; hydroxylamine hydrochloride removed the most ZVI. Tetrasodium EDTA removed some calcite while leaving the ZVI relatively intact. Therefore, disodium EDTA and tetrasodium EDTA were selected for preliminary column tests. Unfortunately, tetrasodium EDTA was relatively ineffective in removing ferric oxides. Disodium EDTA was also used in column tests to determine its ability to improve the reactivity of ZVI for uranium removal.

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### **3.0 Column Test Results**

Preliminary column tests were conducted to better evaluate the effectiveness of disodium EDTA and tetrasodium EDTA as extractants to rejuvenate ZVI PRBs.

#### 3.1.1 Column Test 1, Ca and Fe Removal by Tetrasodium EDTA

This test was designed to determine if tetrasodium EDTA could effectively remove Ca from the Monticello PRB gravel/ZVI mixture.

#### 3.1.1.1 Methods

This test was conducted in a 2-inch (in.)-diameter clear acrylic column packed with a fresh gravel/ZVI mixture (the same material that was emplaced in the gravel/ZVI zone of the Monticello PRB). The gravel/ZVI is a mixture of 2,500 pounds (lb) of -4 +20 Peerless ZVI to 9 cubic yards (yd<sup>3</sup>) of 3/8-in. pea gravel. Dry weight of the gravel/ZVI in the column was 1,602.5 g. A peristaltic pump was used to flow influent solution from the bottom to the top of the column.

Influent to the column was synthesized to be similar in major ion composition to the ground water collected from well R1-M3, located immediately hydraulically upgradient of the Monticello PRB. Table 13 presents the compositions of the R1-M3 ground water and the synthesized column influent water. Influent solution was stored in a 20-liter (L) plastic carboy feed tank that was constantly stirred with a magnetic stir bar. Gaseous carbon dioxide (CO<sub>2</sub>) flowing into the feed tank through a gas diffuser stone was used to control influent pH and alkalinity values. Flow rates for  $CO_2$  ranged from 0 to 20 milliliters per minute (mL/min).

A programmable fraction collector was used to collect samples for analysis. Calcium and Fe concentrations were determined by atomic absorption on samples preserved with nitric acid. Alkalinity was measured by titration with sulfuric acid. Inline probes measured pH and oxidation-reduction potential (ORP) values, and data were fed to an automated data collection system.

#### 3.1.1.2 Results

Synthetic ground water flowed through the column at 0.7 mL/min for about 12 days. During that time, the mean influent and effluent pH values were about 6.8 and 7.5, respectively (Figure 2). The mean ORP values were about +180 and less than -400 millivolts (mV), respectively. The Ca inventory in the column solids increased by about 1 g because of Ca-mineral precipitation (Figure 3). The Ca inventory was determined from the difference in influent and effluent Ca concentrations. There was no significant change in the Fe inventory during the flow of EDTA-free water (Figure 3).

After about 12 days (32 pore volumes), the influent was changed to 0.1 M tetrasodium EDTA and the flow rate was increased to 10 mL/min for about 5 pore volumes before switching back to synthetic ground water. During EDTA treatment, the pH value in the column effluent increased to about 11.5, similar to the EDTA influent value of about 11 (Figure 3). Calcium and Fe concentrations in the effluent EDTA solution increased to maximum values of 2,000 and 2,520 mg/L, respectively (Figure 2).

Although the concentration of Fe in the effluent increased substantially during EDTA injection, the inventory of Fe decreased only slightly (Figure 3). In contrast, all the Ca precipitated from the influent water and an additional 1.2 g (total of 2.2 g) was removed by the EDTA solution (Figure 3). The additional Ca was present in calcium carbonate minerals in the gravel. These results are encouraging for the use of tetrasodium EDTA as a rejuvenation agent.

### 3.1.2 Column Test 2, Ca and Fe Removal by Disodium EDTA

This test was designed to determine if disodium EDTA could effectively remove Ca from the Monticello PRB gravel/ZVI mixture.

#### 3.1.2.1 Methods

Column test 2 was conducted using the same apparatus and methods as column test 1 (see previous section). The test was conducted in a 2-in.-diameter clear acrylic column packed with a fresh gravel/ZVI mixture (the same material that was used in the gravel/ZVI zone of the Monticello PRB). The gravel/ZVI is a mixture of 2,500 lb of -4 +20 Peerless ZVI to 9 yd<sup>3</sup> of 3/8-in. pea gravel. Dry weight of the gravel/ZVI in the column was 1,537.6 g. A peristaltic pump was used to flow influent solution from the bottom to the top of the column.

Influent to the column was synthesized to be similar in major ion composition to the ground water collected from well R1-M3, located immediately hydraulically upgradient of the Monticello PRB. Table 13 presents the compositions of the R1-M3 ground water and the synthesized column influent water. Influent solution was stored in a 20-L plastic carboy feed tank that was constantly stirred with a magnetic stir bar. Gaseous  $CO_2$  flowing into the feed tank through a gas diffuser stone was used to control influent pH and alkalinity values. Flow rates for  $CO_2$  ranged from 0 to 20 mL/min.

A programmable fraction collector was used to collect samples for analysis. Calcium and Fe concentrations were determined by atomic absorption on samples preserved with nitric acid. Alkalinity was measured by titration with sulfuric acid. Inline probes measured pH and ORP values, and data were fed to an automated data collection system.

#### 3.1.2.2 Results

Synthetic ground water flowed through the column at 0.7 mL/min for about 7 days. During that time, the mean influent and effluent pH values were about 6.7 and 7.2, respectively (Figure 4). The mean ORP values were about +180 and less than -400 mV, respectively. The Ca inventory in the column solids increased by about 300 mg because of Ca-mineral precipitation (Figure 4). The Ca inventory was determined from the difference in influent and effluent Ca concentrations. There was no significant change in the Fe inventory during the flow of EDTA-free water (Figure 4).

After about 7 days (19 pore volumes), the influent was changed to 0.1 M disodium EDTA, and the flow rate was increased to 10 mL/min for about 5 pore volumes before switching back to synthetic ground water. The pH value in the column effluent decreased to about 5.3, similar to the EDTA influent value of about 5.1 (Figure 4). Calcium and Fe concentrations in the effluent EDTA solution increased to maximum values of 1,300 and 4,400 mg/L, respectively. Interestingly, the maximum effluent Ca concentration (1,300 mg/L) in the disodium EDTA column test was significantly less than the maximum effluent Ca concentration (2,000 mg/L) in the tetrasodium EDTA column test despite the greater effectiveness of the disodium form to dissolve calcite in the batch tests (Figure 1).

Although the concentration of Fe in the effluent increased substantially during EDTA injection, the inventory of Fe decreased only slightly (Figure 4). In contrast, all the Ca precipitated from the influent water and an additional 14,00 mg (a total of 1,700 mg) was removed by the EDTA solution (Figure 4). The additional Ca was present in calcium carbonate minerals in the gravel. These results are encouraging for the use of disodium EDTA as a rejuvenation agent.

### 3.1.3 Column Tests 3 and 4, Uranium Reactivity of a Column Treated With EDTA

These tests were designed to determine if the addition of disodium EDTA could improve the reactivity of ZVI for uranium removal. Two columns, one treated and one not, were run in parallel to evaluate the effectiveness of the treatment.

### 3.1.3.1 Methods

Column tests 3 and 4 were conducted in small (15-mm long, 22-mL volume) glass columns packed with a ZVI sample (sample PE-11-5, from about 6 in. from the contact with the gravel/ZVI zone) collected by coring the Monticello PRB in August 2003. The ZVI has been resident in the ground and reacting with ground water since 1999. A peristaltic pump was used to flow influent solution from the bottom to the top of the columns.

Column 3 was treated with 120 mL of 0.1 M disodium EDTA. The EDTA was flowed through the column at 3 mL/min. After this treatment, U-spiked synthesized ground water was flowed initially at 1.2 mL/min (residence time of about 13 min) through both columns in parallel. Because both columns removed U to less than detection, the flow rate was increased to 3.6 mL/min (residence time of about 4 min); about 90 percent of the test used a flow rate of 3.6 mL/min. The synthesized ground water had a major ion composition similar to ground water obtained from well R1-M3, located immediately hydraulically upgradient of the Monticello PRB. In contrast to column tests 1 and 3, this test used synthesized R1-M3 water that was spiked with about 1 mg/L U. Table13 presents the compositions of the R1-M3 ground water and the synthesized column influent water (without the U).

A programmable fraction collector was used to collect samples for analysis. Calcium and Fe concentrations were determined by atomic absorption on samples preserved with nitric acid. Uranium concentrations were determined by kinetic phosphorescence analysis (DOE 2003; ESL Procedure AP[U-2]).

#### 3.1.3.2 Results

Figure 5 presents the results of the uranium removal column tests. During EDTA treatment, 478 mg of calcite was removed from the ZVI sample in column 3. Most of the effluent U concentration were less than 10  $\mu$ g/L, considerably less than the influent concentration of 1,000  $\mu$ g/L. Despite the relatively short residence time of 4 min in contact with the ZVI, both columns removed more than 99 percent of the U for more than 300 pore volumes. The differences observed between the treated and untreated columns were insignificant. The U removal efficiency in the untreated column is too high to evaluate the effects of the EDTA treatment properly and, thus, the results are inconclusive. It is interesting, however, that the U removal rates in this sample from the PRB are still very high, suggesting that the PRB longevity may exceed the values estimated by Morrison (2003).

### 4.0 Conclusions and Recommendations

This report presents data from a preliminary evaluation of ZVI rejuvenation using various chemical solvents. Suitable rejuvenation agents were defined by the high ability to dissolve calcite (a ZVI corrosion product that occludes porosity), low dissolution of ZVI, and low toxicity; the ability to dissolve AFO, hematite, and magnetite was also considered favorable. Most of the solvents and combinations were able to dissolve some calcite, but most also dissolved some ZVI. Column test results indicate that both tetrasodium EDTA (pH about 11) and disodium EDTA (pH about 7) were able to remove all the calcite deposited during ZVI corrosion and some of the calcite initially present in the column fill material. While some ZVI was also dissolved by EDTA, the change in the Fe inventory was insignificant. Dissolved EDTA has minimal negative effects on human health. The results indicate that EDTA may be an effective chemical agent for PRB rejuvenation. A field pilot study is recommended to determine if rejuvenation with EDTA can improve PRB performance.

End of current text

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Name Vendor		Description
Calcite Powder	Aldrich	Reagent grade. Calcite only. <sup>a</sup>
AFO	Noah Industries	AFO slurry dried at room temperature.
Hematite	Fisher Scientific I-116-3	Reagent grade. Hematite only. <sup>a</sup>
Magnetite	American Chemical Enterprises A-310	Reagent grade. Magnetite only. <sup>a</sup>
ZVI	Fisher 40 Mesh	Reagent grade ZVI. Sieved to about 40 mesh.
Gravel/ZVI	ZVI = Peerless –8 +20	Mixture used in Monticello gravel/ZVI zone.

Table 1. Standard Materials Used in Batch Tests
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<sup>a</sup>The mineralogy of these materials was identified by X-ray diffraction analysis.

#### Table 2. Batch Tests Using 50 mL of Sodium Acetate Buffer

Gravel/ZVI <sup>a</sup> (g)	Calcite Powder (mg)	Shake Time (hours)	Ca Removed (mg)	Fe Removed (mg)	Final pH
0	50	14	17.6 <sup>b</sup>	0.1	5.01
2	0	14	5.1	132.5	5.10
2	0	20	4.6	163.5	5.14
2	0	39	3.8	301.0	5.36

<sup>a</sup>Fresh gravel/ZVI material used in the Monticello PRB. <sup>b</sup>20 mg of Ca is equivalent to 100 percent removal of the calcite.

Test	Solids	Tetrasodium EDTA Concentration	Concentration HCl (μL)	Shake Time (hours)	Start pH	Final pH	Ca Removed (mg)	Fe Removed (mg)
1	2 g gravel/ ZVI <sup>a</sup>	0.1 M	0	9	10.85	11.02	7.3	4.2
2	2 g gravel/ ZVI <sup>a</sup>	0.1 M	270	9	9.05	9.70	12.1	49.5
3	2 g gravel/ ZVI <sup>a</sup>	0.1 M	550	9	6.88	8.25	7.1	58.3
4	1 g Calcite	0.1 M	0	7.5	10.85	11.11	191	0.0
5	1 g ZVI <sup>b</sup>	0.1 M	0	7.5	10.85	11.13	0.1	4.0
6	1 g Hematite	0.1 M	0	7.5	10.85	10.76	0.1	0.1
7	1 g Magnetite	0.1 M	0	7.5	10.85	10.85	0.8	0.2
8	1 g Calcite + 1 g ZVI <sup>b</sup>	0.1 M	0	28	10.85	11.11	172.5	0.3
9	1 g Calcite + 1 g ZVI <sup>b</sup>	0.05 M	0	28	nm°	11.06	98.5	0.2
10	1 g Calcite + 1 g ZVI <sup>b</sup>	0.025 M	0	28	nm	10.90	46	0.1

Table 2	Datah	Tooto	Llaina	E0 ml	of 7	Fatragadium	
Table 3.	DatCII	resis	Using	50 ML	01	Tetrasodium	EDIA

<sup>a</sup>Fresh gravel/ZVI material, same as used at Monticello. <sup>b</sup> -6 + 10 mesh Peerless ZVI. <sup>c</sup> nm = not measured.

Test	Solids <sup>ь</sup>	Final Electrical Conductivity (μS/cm)	Start pH	Final pH	Ca Removed (mg)	Fe Removed (mg)
1	AFO	227	2.94	4.49	1.4	1.0
2	Hematite	584	2.94	2.88	0.0	0.1
3	Magnetite	595	2.94	2.90	0.3	0.3
4	Fisher 40 Mesh ZVI	662	2.94	2.80	0.0	2.9
5	Calcite	454	2.94	6.68	8.0 <sup>d</sup>	0.0

<sup>a</sup> Tests conducted with 40 mL of saturated free acid EDTA and 0.5 g of solids; 2-hour agitation at 25 °C. <sup>b</sup> Descriptions are provided in Table 1.

<sup>c</sup>  $\mu$ S/cm = microsiemens per centimeter.

<sup>d</sup>200 mg of Ca is equivalent to 100 percent removal of the calcite.

Test	Solids <sup>♭</sup>	Final Electrical Conductivity (μS/cm)	Start pH	Final pH	Ca Removed (mg)	Fe Removed (mg)
1	AFO	11,120	5.04	5.32	3.5	2.4
2	Hematite	10,940	5.04	5.12	0.1	0.1
3	Magnetite	10,960	5.04	5.13	0.4	0.3
4	Fisher 40 Mesh ZVI	11,040	5.04	5.30	0.1	16.4
5	Calcite	11,160	5.04	6.20	159.2 <sup>d</sup>	0.0

Table 5	Ratch	Tests	llsina	Disodium	FDTA
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<sup>a</sup> Tests conducted with 40 mL of 0.1 M disodium EDTA and 0.5 g of solids; 2-hour agitation at 25 °C. <sup>b</sup> Descriptions are provided in Table 1.

 $^{c}$  µS/cm = microsiemens per centimeter.

<sup>d</sup>200 mg of Ca is equivalent to 100 percent removal of the calcite.

Test	Solids <sup>ь</sup>	Final Electrical Conductivity (μS/cm)	Start pH	Final pH	Ca Removed (mg)	Fe Removed (mg)
1	AFO	2,170	2.27	2.39	2.5	3.8
2	Hematite	2,780	2.27	2.28	0.1	0.2
3	Magnetite	2,760	2.27	2.27	0.3	0.6
4	Fisher 40 Mesh ZVI	2,580	2.27	2.31	0.1	14.1
5	Calcite	1,774	2.27	5.79	66.4 <sup>d</sup>	0.0

#### Table 6. Batch Tests Using DTPA

<sup>a</sup> Tests conducted with 40 mL of saturated DTPA and 0.5 g of solids; 2-hour agitation at 25 °C.

<sup>b</sup> Descriptions are provided in Table 1.

<sup>c</sup>  $\mu$ S/cm = microsiemens per centimeter.

<sup>d</sup>200 mg of Ca is equivalent to 100 percent removal of the calcite.

Test	Solids <sup>b</sup>	Start Electrical Conductivity (μS/cm) <sup>c</sup>	Final Electrical Conductivity (μS/cm)	Start pH	Final pH	Ca Removed (mg)	Fe Removed (mg)
1	AFO	20,300	20,100	3.00	3.18	0.0	15.8
2	Hematite	20,300	20,100	3.00	3.05	0.0	0.8
3	Magnetite	20,300	20,100	3.00	3.13	0.0	13.8
4	Fisher 40 Mesh ZVI	20,300	20,200	3.00	3.12	0.0	3.9
5	Calcite	20,300	20,200	3.00	3.14	0.0	0.0

Table 7. Batch Tests Using 0.2	2 M Ammonium Oxalate
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<sup>a</sup> Tests conducted with 40 mL of 0.2 M ammonium oxalate buffered to a pH 3 value with 0.2 M oxalic acid and 0.5 g of solids; 2-h agitation at 25 °C. <sup>b</sup> Descriptions are provided in Table 1.

<sup>c</sup>  $\mu$ S/cm = microsiemens per centimeter.

Test	Solids <sup>b</sup>	Solvent <sup>c</sup>	Start pH	Final pH	Ca Removed (mg)	Fe Removed (mg)
1	AFO	D	4.53	5.85	0.8	17.4
2	Hematite	D	4.53	4.83	0.0	10.4
3	Magnetite	D	4.53	4.11	0.1	8.2
4	Fisher 40 Mesh ZVI	D	4.53	3.75	0.0	5.6
5	Calcite	D	4.53	4.22	6.8	0.0
6	AFO	CB	8.16	8.49	2.5	0.1
7	Hematite	CB	8.16	8.41	0.1	0.0
8	Magnetite	CB	8.16	8.44	0.7	0.1
9	Fisher 40 Mesh ZVI	CB	8.16	8.57	0.1	2.7
10	Calcite	CB	8.16	8.68	10.0	0.0
11	AFO	CBD	6.98	7.44	2.5	42.0
12	Hematite	CBD	6.98	7.19	0.1	16.2
13	Magnetite	CBD	6.98	7.08	0.5	9.4
14	Fisher 40 Mesh ZVI	CBD	6.98	7.08	0.1	6.0
15	Calcite	CBD	6.98	7.13	8.4	0.0
16	AFO	CCD	9.70	8.58	1.5	15.1
17	Hematite	CCD	9.70	8.56	0.1	2.8
18	Magnetite	CCD	9.70	8.63	0.2	3.0
19	Fisher 40 Mesh ZVI	CCD	9.70	8.83	0.0	4.0
20	Calcite	CCD	9.70	8.44	1.0	0.0

#### Table 8. Batch Tests Using Citrate Bicarbonate Dithionite-Type Solutions

<sup>a</sup>Tests conducted with 40 mL of solution, 0.5 g of solids, and 2-h agitation at 25 °C.

<sup>b</sup>Descriptions are provided in Table 1.

<sup>c</sup>D = 0.1 M sodium dithionite; CB = 0.27 M sodium citrate with 0.11 M sodium bicarbonate; CBD = same as CB but with 0.1 M sodium dithionite; and CCD = 0.27 M sodium citrate with 0.11 M potassium carbonate and 0.1 M sodium dithionite.

Test	Solids <sup>b</sup>	Solvent <sup>c</sup>	Start pH	Final pH	Ca Removed (mg)	Fe Removed (mg)
1	AFO	E	10.93	10.61	2.1	0.4
2	Hematite	E	10.93	10.79	0.1	0.0
3	Magnetite	E	10.93	10.82	0.3	0.0
4	Fisher 40 Mesh ZVI	E	10.93	10.88	0.1	1.0
5	Calcite	E	10.93	10.92	11.5	0.0
6	AFO	ED	9.17	9.30	1.7	0.5
7	Hematite	ED	9.17	9.25	0.1	0.0
8	Magnetite	ED	9.17	9.28	0.2	0.1
9	Fisher 40 Mesh ZVI	ED	9.17	9.37	0.0	4.3
10	Calcite	ED	9.17	9.36	9.0	0.0

Table 9. Batch Tests Using Low-Strength Sodium Dithionite and Tetrasodium EDTA

<sup>a</sup> Tests conducted with 40 mL of solution, 0.5 g of solids, and 2-h agitation at 25 °C. <sup>b</sup> Descriptions are provided in Table 1.

 $^{\circ}$ E = 0.05 M tetrasodium EDTA; ED = 0.038 M tetrasodium EDTA with 0.025 M sodium dithionite.

Table 10 Dateb	Tests Using High-Strengt	h Cadiuma Dithiamita and	Tatraga di una EDTA
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Test	Solids <sup>b</sup>	Solvent <sup>c</sup>	Start pH	Final pH	Ca Removed (mg)	Fe Removed (mg)
1	AFO	E	10.95	10.66	2.4	0.4
2	Hematite	E	10.95	10.80	0.1	0.0
3	Magnetite	E	10.95	10.85	0.4	0.1
4	Fisher 40 Mesh ZVI	E	10.95	10.97	0.1	1.1
5	Calcite	E	10.95	10.88	10.1	0.0
6	AFO	ED	9.69	9.21	1.5	6.7
7	Hematite	ED	9.69	9.19	0.1	4.8
8	Magnetite	ED	9.69	9.16	0.3	4.7
9	Fisher 40 Mesh ZVI	ED	9.69	9.16	0.1	4.2
10	Calcite	ED	9.69	9.20	7.3	0.0

<sup>a</sup> Tests conducted with 40 mL of solution, 0.5 g of solids, and 2-h agitation at 25 °C. <sup>b</sup> Descriptions are provided in Table 1. <sup>c</sup> E = 0.1 M tetrasodium EDTA; ED = 0.16 M tetrasodium EDTA with 0.057 M sodium dithionite.

Test	Solids <sup>b</sup>	Start pH	Final pH	Ca Removed (mg)	Fe Removed (mg)
1	AFO	1.48	1.52	1.9	7.4
2	Hematite	1.48	1.32	0.0	0.1
3	Magnetite	1.48	1.33	0.1	0.5
4	Fisher 40 Mesh ZVI	1.48	2.20	0.0	86.4
5	Calcite	1.48	2.67	224.8	0.1

Table 11. Batch Tests Using Hydroxylamine Hydrochloride
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<sup>a</sup>Tests conducted with 40 mL of solution, 0.5 g of solids, and 2-h agitation at 25 °C. <sup>b</sup>Descriptions are provided in Table 1.

Test	Solids <sup>b</sup>	Solvent	Start pH	Final pH	Ca Removed (mg)	Fe Removed (mg)
1	AFO	Lime Away	1.34	1.47	2.9	16.4
2	Hematite	Lime Away	1.34	1.40	0.1	0.7
3	Magnetite	Lime Away	1.34	1.39	0.4	1.4
4	Fisher 40 Mesh ZVI	Lime Away	1.34	1.37	0.1	24.0
5	Calcite	Lime Away	1.34	1.37	131.2	0.3
6	AFO	Lime Out	1.12	1.25	1.2	1.5
7	Hematite	Lime Out	1.12	1.22	0.9	0.4
8	Magnetite	Lime Out	1.12	1.23	1.0	0.4
9	Fisher 40 Mesh ZVI	Lime Out	1.12	1.24	1.9	15.2
10	Calcite	Lime Out	1.12	1.27	146.8	0.2

<sup>a</sup> Tests conducted with 40 mL of full-strength Lime Away or Lime Out and 0.5 g of solids; 2-h agitation at 25 °C.

<sup>b</sup> Descriptions are provided in Table 1.

#### Table 13. Composition of Well R1-M3 Ground Water (sampled January 14, 2003) and Synthesized Ground Water Used in Column Tests

Constituent	Units	Actual Concentration	Synthesized Concentration
Na	mg/L	111.00	150.60
К	mg/L	11.3 <sup>a</sup>	11.22 <sup>a</sup>
Са	mg/L	213.00 <sup>a</sup>	222.88 <sup>a</sup>
Mg	mg/L	52.80	53.28
SO <sub>4</sub>	mg/L	677.00	655.21
CI	mg/L	76.60	76.09
TIC <sup>b</sup>	mg/L	76.00 <sup>c</sup>	78.57
рН	s.u.	6.65	6.65 <sup>ª</sup>
Alkalinity	mg/L as CaCO <sub>3</sub>	317.00	279 <sup>d</sup>

<sup>a</sup>Corrected from DOE 2004

<sup>b</sup> Total inorganic carbon. <sup>c</sup> Estimated from alkalinity.

<sup>d</sup> Varies with CO<sub>2</sub> flow.

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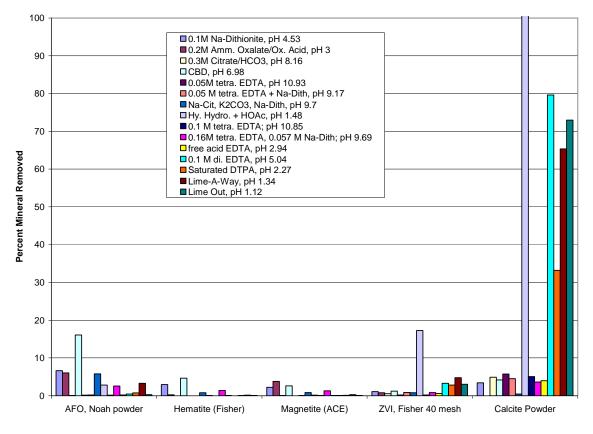


Figure 1. Results of Batch Tests

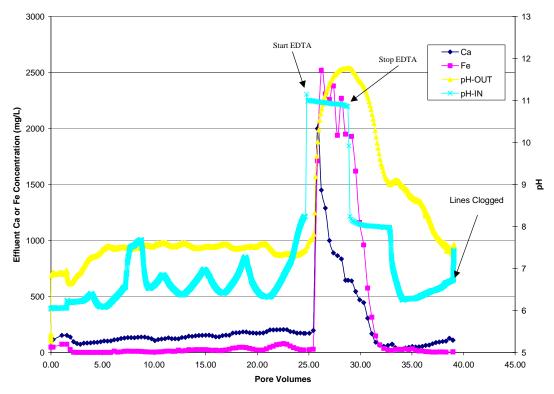


Figure 2. Results of Column 1: Tetrasodium EDTA

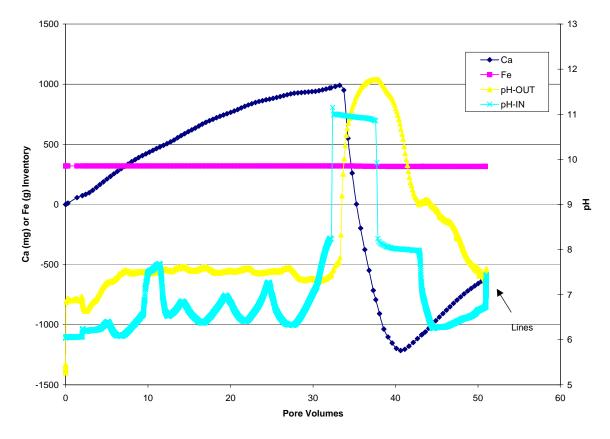
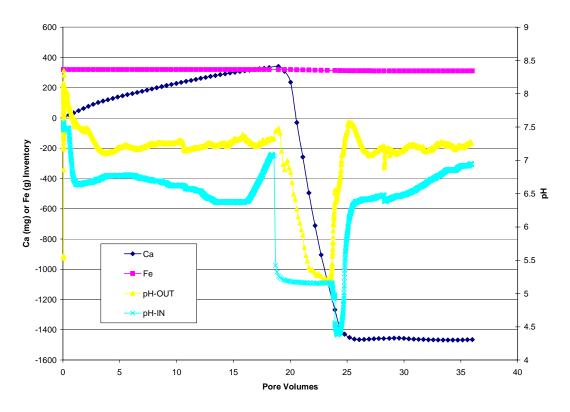
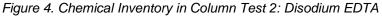


Figure 3. Chemical Inventory in Column Test 1





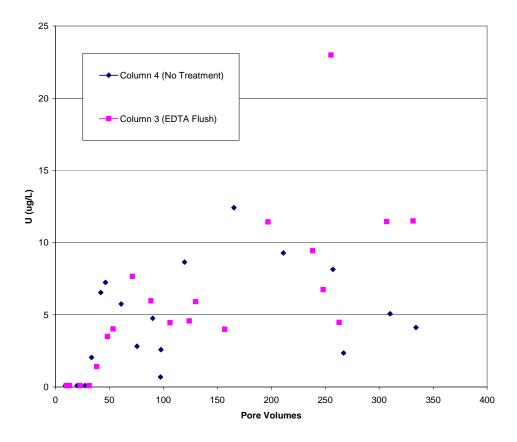


Figure 5. Effluent Uranium in Column Tests 3 and 4. Column 3 was flushed with disodium EDTA.

Appendix A

**Environmental Sciences Laboratory Notes** 

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31.	add ac	1. Sec. 1.	15 <sup>15 -</sup> 7715 - 7	Sector States	Ste, Alertin	mora	Carl	and 1	2 903	Min da	em/35	min Ca	fle.
						<u> </u>	7				14-14-14-14-14-14-14-14-14-14-14-14-14-1		Kat .
							15	P (	/				

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EFFICIENCY LINE® 22-210

MPERT 01-09-06

5/13/03 :	160	122 002		1 X 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	2 2	• • • • • • • • • • • • • • • • • •	7	B	P	10	11	12	1
2	1627	(32.28)	file to	ne)	alumin	V Nunci	in well	1, will	leav	e Carto	) lome	Jun.	
<b>.</b> .	te sont soldt		A Starting				1					/	
5/14/031	0723	Como	sted Tu	Bo al	The second	Concentration of the second	d ~ 4 2					· .	
. 5.		Constant State					<u>8.005</u>	f that she is a straight of a	a and the same				
¢	1123	cond	ta tu	6.97	file hn	u - 8	2.083	<u>1998 - 1997 - 1997 - 1997</u>					┢
						1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	3		ar i a di a	gan dina (Ma		<del> </del>	
	acidi	- hille	579-92	- (net	persified	etime o	collect	conto rea	in Fe C	_ use	0 See 0	lon II. I	4
	-11-	A 10 1	-1	arter da - da j	1. (7 9. 17 S. 2. 16		and the second	12.200			//w.x	CINC HAVE	13
10	un a	HALL H	NO2 to 1	rules 7	4-78	pHuri	~7 mio	toadde	tim)	alli	LOW pH 4	2.	+
12		lan santa jaga shi shika a ba <b>asa</b> Tira a san aang biya a baasha Tira a san		0-04 7-20 (11 <b>1</b> -20 ).								en. 9	
13	Kni	D.to.	4. 1.10	and the second	vie en de service de la companya de	And Sport Mapping Stations					_		
14	1-1/2-	111m	te colle	2 1 . 1	1=03	TPARE TOTA	SS SS	p ruch	kt MAY!	1=03 A	ince clo	extime	2
16	-	- All	RJV098	cauci			to collect	) Alexandri (1997)	5 <u>4. 5 18</u> . 19				Ľ
16	• • • • • • • •	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1		States and the state	<u>: 6 - 6 6 6 2</u> 2	i proper Britan a tari	erten her och har beiden. T	ana na ana ang ing ing ing ing ing ing ing ing ing i	<u>Managari P</u>	an an a th	the strategy of the		
17						Selection and s		nation keelingette e					
18							<u>, , , , , , , , , , , , , , , , , , , </u>	<u> </u>	<u>a 1937 yılı a 1</u>	<u>, 9</u>	here the second	200 B.	-
19						1.420		<u> Agenci</u>	918 B B B B	i)		2%	┢
20						÷					a ta parta ta	<u></u>	
21	2	-	<u> </u>	· · · · · ·	and the same				na na ka <sub>na</sub>	a de la compañía de l	ee Suree	-	
22				-	100 g (10 - 10								
24			y ng bi	in a su			in a gréan a la China anna an ta	n an de la construcción de la cons Na construcción de la construcción d Na construcción de la construcción d					
28					a ja sua a substant	<u></u>	e <u>terret</u> , en terret						
28			2	<u>Charlen an Share a</u>			n an	n alls a said i			2 3 3 220 		
27					an a	Na sanakati i	and any set of the set of the	9530		a baitan ar	Vilen Kara		
28					<u> </u>	<u>wa 1991, 1, 1, 1999</u>	<u>, a sta di paga da sa dag</u>	832- <u>1-1-1</u> -2	<u>n a</u> 1	ha <u>n a</u> n an	a di su da su Martino da su	<u> </u>	
29			din.	-	्य केले थे। जन्म अनुस्तित्वर						a Silan Basi		
30				20 							the state of the s	···	<u> </u>
					S. States		en de la composition					Salaria da	-
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ч,		~				$\sim$					$\hat{O}$	_	
		AMBAD EFFICI	ENCY LINE®	22.210		о <sup>16</sup>					÷		
								~		0			
0	~			$\sim$	Ca (so	urce ten	12) = 21	4 mg/L	(measu	ud 2			5
Column K	einvin	tim	1 0	win)		2	= 21	23 mg/L	(Calculo	MA MA	ERT 01-09	-1-1	
ullow/tube		2 Cum Vs	e hate	1 167. 6								-0/	
				· fv 1=517	Color.	Ca (rol L)			9	10	11	13	13
1st outflow	25	25	4	0.05	Red	115	47.5						
diain 2	516	541	_ +	1.06				  -	1				1
RJV001 1	24	565	4	1.10	Red	153	72.6						
diain *	224	789	4	1.54		ļ							1
	18	807 909	0.7	1.58			~~~~						1
Rovor "	23		0.7	1.78									
diain .	144	932	0.7	1.82	red	139	26.0						
RJV 003 .			0.7	2.10									T
diain 10	23	1099 1243	0.7	2.15	clear.	96	1.48	<u></u>					5 2 1000 10 10
RJV 004 "	23		0.7	2.43		-							
drain 22	TŸŶ	1266	0.7	2.47		80	0.91						
RJV 005 23	23	1433							<u>_</u>	·			
auin"	144	1577	0.7	2.80	<del>\</del>		0.52		<u> </u>				
RJV 006 10	23		0.7	3.08									
arein "	144	1600 1744	0.7	3.13		- 84	0.43						
RJV 007 1	23	1767	0.7	<u>3.41</u> 3.45			- 7-7						
drain 10	144	1911	0.7			85	0.21	<del></del>					
RSV 008 10	23	1934	0.7	3.73					l				
drain 20	TYY	2018	0.7	4.06		87	0.23			uluu su		о. 101 г. на н	<b></b>
RSV 0092	23	2101	0.7	4.10			0 - 10 -		. w				c.
drain 22	144	2245	0.7	4.38		90	0.78-	•					
RJV 010 23	23	2268	0.7	4.43			0.99-						
drain 24	ŤÝÝ	2412	0.7	4.71	h	91	0. 1-1						ww
RJV 011 25	23	2435	0.7	4.76		97	0.10						
drain 20	144	2579	0.7	5.04		77	<u>N.10</u>		and write a		<b>_</b>	- ano,	
RJV 012 ==	23	2603	0.7	5.08	8.9	- 1-7	0.12						
drain 28	144	2746	0.7	5.36		103	0.10	a natio			- <u></u>	L	
ROV 013 20	23	\$169	0.7	5.41		102	0.42			h			
drain 20	Tur	2913	0.7	5.69		104	U. TL						
ROV 014 =	23	2936	00	5.73		104	0.85		<u> </u>	·			
				9.12	ar, Tan ang	107	20.0				<u> </u>		
		т	т.					e					
, <u>п</u>		1		1	* - 1	N N	8		8	4			
8.					1.07.07	4 4 9 2	÷						

EFFICIENCY LINE® 22-210

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				22-210		· · · · ·		.1		21 21	Ð	,	
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Column K	ejuvine	tion (al	) Jackni	m) (	۵				MIERI	01-00	1-08		
		2 Cum Vol	kite	+PV1=517	Color	Ce hagle	Fe fryle			10	11	12	13
disin '	144	3080	0.7	6.02				£			<u> </u>		
RJV015 2	23	3103	0.7	6.06	Red	114.	12.3					· · · · ·	
driin .	144	32-47	0.7	6.34	1							a	
REVOIG .	23	3270	0.7	6.39		117-	3.77						1. 1.1.1.1
diain : R5V017 :	144	3414	0.7	6.67									
	23	3437	0.7	6.71		125	5.42						11 mm
Rain '	144	3581	0.7	6.99					-				
	23	3604	0.7	7.04		129	9.6						-
diain . RSV 019 10	144	3748	0.7	7.32								00 - 120 - MERICAN	0.0. <del></del>
	23	3771	0.7	7.37		133	11.4			100 00 00 00 00 00 00 00 00 00 00 00 00			
drain "	144	3915	0.7	7.65							·		
ROV no "	23	3938	0.7	7.69		/33	10.3						
RJV 02/ 24	1.44	4082	0.7	7.97							-	•	
	23	4105	0.7	8.02		132	10.0				··· · ···		
Arain 15 RJV 022 18	144	4249	0.7	8.30					(11.0-1)				
	33	4272	0.7	8.34		136'	10.2				1		2 4 V
ETV or tra		4416	0.7	8.63								00.0	des r
R5V 02 320	33	4439	0.7	8.67		139	9.5		17 CO	r m <sub>e</sub> nors		10010 10	
RIV 024 20	144	4583	0.7	8.95								1	interna en la
the second se	24	4607	0.7	9.00		138.	6.7				3	· • •	
arin 2	144	4751	0.7	9.28					1			n s x	1 X - 3
RJV Ors 22	24	4775	0.7	9.33	V	131.	4.78						
drain?	144	4919	<u> </u>	9.61					1				a a
R5V02-6 24	22	4941	0.6	9.65	Pale yello	\$ 124	4.00						1
diain 25 RJV 027 28	144	5085	0.7	9.93	. (0			-/		······································		···	ann a m
drain 27	<u>as</u>	5110	0.7	9.98		107	3.72						an a
RJV 028 28	144	5254	0:7	10.26						1	T		
Main 20	2-1	5275	0.6	10.30		116	4.15						3000 B
RJV 029 30	144	549	0.7	10:58						-			in and
	23	SHIV	0.7	10.63		120	6.60			1	*- <b></b>		
arain 21	144	5586	0.7	10.91	₹	n na Lina						<u> </u>	
										<u> </u>	<u> </u>		· · · · · · · · · · · · · · · · · · ·
8		· ]		× .						1	8	1	

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	MPAD .	EFFICIENCY LINE® 22-210

		AMPAS' EFFICI	ENCY LINE®	22-210		21.57							
										Ì			
<u>Column Re</u>	MIMIN	stron)		с.)					647	ERTOI-	00 00		
Queflow / tube 1 V	el wa	2 Cum Vole	the fat	$V_{I=50}$	- Calor	1 a loca to	- Fe hart						
LIV030 1 2	23	5609	0.7	10.96	pileyellow		10.0	a	9	10	11	12	13
- R5U031 : 1	144	5753	0.7	11.24	ancient	100	10.0	···•					
	22	5775	0.6	11.28		131	12.4		10 (a <u>-</u> 10				99 <b>5 2</b> 2
	44	5919	0.7	11.56			· · · · ·	~	· · ·	······	pos	en en e	nate
RJV032	23	5942	0.7	11.61		123	10.5						*
	44 23	6086	0.7	11.89	<u> </u>								
	44	6253	0.7	11.93	<u> </u>	123	10.5						
	16	6269	0,5	12:21	rustflows	122-	21.1						
disinso 1	44	6413	0.7	12,53	nuo procs		GT. 1	- 1.1	<u> </u>				
RSV 035 - 2		6437	0.7	12.57	fale vellow	134	12.6						
	44	6581	0.7	12.85	·· <u> </u>	·····			a a <u>anna an</u> na	· • •••	1 - E - E - E - E - E - E - E - E - E -		-
RJV 0360 :	26	6607	0.7	12.90		135	16.5	· · · · ·					** mi <u></u>
	44	6751	0.7	13,89	. <u> </u>							-	
	44	6768	0.5	13.22	rustilacs	146	25.4						
0-1	16	6928	0.5	13,50		144			·				
drain 20 1	44	7072	0.7	15.81		<u></u> _	87.3		······ ,		0 10	38 S	1
	24	7096	0.7	13.86		149	25.4			-			
	44	7240	0.7	14.14		<u> </u>				••••• • ••••	· · · ·		
LJV 0402	23	7263	0.7	14.19		152	25.2			·	10 10 D 10	10 D	
	44 21	7407	0.7	14:47			<i>a</i>						unio a V
	44	7428	0.6	14.51		153	85.2						
RJV 09200 2	23	7595	0.7	14.79		1-11-	20-			-			
diain 20 1	44	7739	0.1	15.12		154	25.2				-		
	24	7763	0.7			155	22.3			<u> </u>			
drain 20 1	44	7907	0.7	15.16			Var						
	24	7931	0.7	1549		149	19.0						
RJV 045	44	8075	0.7	15.11		,					<u> </u>	+	
<u></u>		8090	0.4	15,80	nustplace	140	20.4					•	
					v				1 A				+
Ił		ji ji	J	Т. н. Г. н.		1	ŀ	Ł	a a	l		1	l.
8					e 10. seo	200 V	50 - 50.0						

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Minan '	EFFICIENCY LINE® 22-210	

	4		IÉNCY LINE®	22.210					Œ	)	
Colump	Repurn	etim	late					X	NPERTOL-		
ollefow / hube	Vol (ml)	Eumbellad	melmin	N/1=SI2	1. Colar	Lalmok	r Fe (mg/La		10	11 -	12
disin "	144	8234	0.7	16.08	clear						- <u> </u>
RJ/046 2	17	8251	0.5	16.12		140	16.1				
diain :	- Imile	8395	0.7	16.40							
RIVOY .		8417	0.6	16.44		151	18.9				
Arin : 25/048 :		8561	0.7	1672							
	1 91	8585	0.7	16.77		155	22.3				
diain " RJV 049 .		8754	0.7	17.10	┝ ╢──	1.00	24				1
diain .	144	8898	0.7	17.38		154	28.2				
REV OSO 10		8921	0.7	17.42	1 1	4 240	38.0				
diain "	144	9065	0.7	17.77		- ATV	20.0				v
REV 051 12	21	9086	0.6	17.75		177	40.8		o sea la la seco a		ana -
ajin 13		9230	0.7	18.03		<u> </u>	10.0		197 - 199 - 199 - 199 - 199 - 199 - 199 - 199 - 199 - 199 - 199 - 199 - 199 - 199 - 199 - 199 - 199 - 199 - 199		
LTV OSLIM	22	9252	0.6	18.07	-	178	46.5		······	a <b>nni</b> anana s	
RJV 053 18	144	9396	0.7	18.35							
KJV 053 10	23	9419	0.7	18.40		184	46.5		-0-0.5 (Aller Aller A		
Rov OSY 20	144	9563	0.7	18.68							
arain 10	23 144	9586 9730	0.7	18.72		183	42,8				
RJV OSS 20	25	9755	0.7	19.00							
ALAIN 2	144	9899	0.7	19.05		176	36.6				12 22
RJV 056 22	23	9922	0.7	19.33		175	28.9				
drain 23	144	10000	0.7	19.66		113	20.1	· · · · · · · · · · · · · · · · ·			
RIV 057 20	17	10083	0.5	19.69		172	21.5				
diam 25	144	10227	0.7	19.97					K	<u> </u>	<u>↓</u> ,
RIV 058 20	22	10249	0.6	20.02		173	20.5			<u> </u>	
diain 27		10393	0.7	20.30							
RIV OS9 28		10415	0.6	20.34		175	227				C
drain 20 RSV 0100 20	144	10559	0.7	20.62							1
	24	10583	0.7	20.67	1/	186	32.0		·····		1
drain 32	144	10727	0.7	20.95	V Same						

MAAG .	EFFICIENCY LINE® 22-210	

				<i>R</i>	V 4	· · ···· ·····	5 a a					
	2	a				$\sim$					s=	
		AMAAA' EFFIC	CIENCY LINE®	22-210		20				<u> </u>		
0									t	も		
Column Re	nurnati	á	ρ.	Ŷ					1 10-0-			
allflow / tube	Vol (me)		lace	1077					MPERTO	1-09-11	•	
RJV 061 1	28	Dim Volone		AV (1=512	_	· La high	the (my/L)		10	11	12	13
duin 2	14.4	10755	0.8	21.01	leu	202	46.6			2004 2004 (2008)		
RJV 062 3	25	10924	0.7	21,29	<b>↓ ↓</b>							
Arain +	144	11068	0.7	21.34		202	56.6					
RJV 063 .	24	11092	0.7	21.60		203	69.0					15.15
drain .	144	11236	0.7	21.95		au	61.0					
R5V064,	20	11256	0.6	21.98		204	73.2					
drain .	144	11400	0.7	22.27		1	1110					
RJU 065 .	23	11423	0.7	22,31		205	79.2					
arain 20		11567	0.7	22.59	e .			·				-
RJV 066 11	24	11591	0.7	22.64		204	73.6		·····			
diain 22 RJU 067 23	144	11735	0.7	22.92								
diain"	144	11904	0.7	22.97	·	187	57.4					
ROV 068 10	21	11925	0.7	23.25								
diin "	144	12069	0.7	23.29		184	42.4					1
RJV 069 "	25	12092	0.7	23.57		10-	22					
diain 20	144	12236	0.7	23.90	·	173	33.0				-	
RJV 070 10	21	12257	0.6	23.94		174	24.6					
diam 20	TYY	12401	0.7	24.22		117				·		
RJV071 =	23	12424		2427		171	21.6		ere non ser			
diain 2	73	12497	0.7	24.41				·	D/ 10			
drain =	180	12677	10.0	24.76		1725	25.40	~	410.000	Smin, $\Delta ti$	DEDTA, ION	<b>بد</b>
RJV 072 20	20	12/097	10.0	24.80		172	25.4		2.4	125,3334	A. 08.24	+
dram 20 LSV 073 20	180	12877	10.0	25.15							00.01	
diain 27	19	12896	9.5	25.19		197	29.1			25,607+	008:59	-
RJY 074 28	19	13076	10.0	24,54	n		~ <u>~</u>				-	[
disin "	180	13275	10.0	25.58	highed goo	2000	1710	·····	Clumys	allappt el	etter	
RJV075 30	20	13295	10.0	25.93	1000	1450	200			11.00	1	
train "		13475	10.0	Un	1-	0001100	2520		clump	26.337+	09:09	
	<u> </u>			10.74							- 10 - 10	
								1				

a a seconderate

EFFICIENCY LINE # 22-210

Columni Reministran

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Column	Require	ation	late						MP	ERTOI-0	29.12		
oulflow/pibe	Val (me	) Eun Vol (m	Mare Imin	R (1=51)	-woor	· Ca (myle	te (male)	) a	1.	<u> </u> 10	//////	12	13
RJ1076 1	20	13495	10.0	26.36	Auguel	1290	2310	<u> </u>	elumpw				13
disin 2	180	13675	10.0	26.71	I.				picture and	pr.	× .		27
PSU077 .	20	13695	10.0	26.75		1000	2260		Clumpw	lite ppt			10 HOME
KJ V 078 :	180	13875	10.0	27.10			20000						
P-0 V 0 / 8	19	13894	9.5	27.14	¥	890	2380		clump w	Rite Ppr			
RJU 079;	180	14074	10.0	27.49	<u> </u>	ar							
	180	14273	9.5	27.53	cloudyon	8- 345	1940	<u> </u>	C1059 -	27.667+fr	lime 3/c	acid in	Hubes
par oro:	20	14293	10.0	27.88	rest por	020-			change.	perment	probe cla	nely or my	<b>_</b>
diain 20	180	14473	10.0	27.92		835	2270	<b> </b>	Ļ				
RJV 081 11	1019	14492	9.5	28.27 28.30		645	in	+	Auto	<u> </u>			
drain 12	180	14672	10.0	28.66			1950	<u> </u>	C1139 -	28333			
RJV 0820	19	14691	9.5	28.69		640	1930		Change bac	to RINJO	2 6"left on	drain fil	2. 028.58
arain 24	180	14871	10.0	29.04		<u> </u>	1150		l	·····	and ran v		
RJV 08310	20	14891	10.0	29.08		545	1620						L
diin "	180	15071	10.0	29.44		2.3	1000	<u> </u>			2012 D 2017-000	en ermen	
RJV 08417	19	15090	9.5	29.47		470	1160						28
diam 28	180	15270	10.0	29.82			1.000		e• aas aa		e 100 es 10 as		¥ 0
RJV 085 19	19-	15289	9.5	29.86		446	960			········		· · · · · · · · · · · · · · · ·	
disin 20	180	15469	10.0	30.21		1.1.1				·			8 - 61
RJV 086 21	20	15489	10.0	30.25		306	575		1 20 C				l
drain 22	180	15669	10.0	30.60							1010-010-01-0-0-0-0-0-0-0-0-0-0-0-0-0-0	(	10 M
RJV087 23	19	15688	9.5	30.64	alerny	168	375						
diain 24 RJV088 25	180	15868	10.0	30.99	Pole orange	-							8
	180	15887	9.5	31.03		91	128			/ An			
Acain 20 25 V 089 27	16	16067	10.0	31.38					-			vr	
drain 28	180	16283	8.0	3141		645	Ø						
REV 090 20	19	16282	10.0	31.76			20.0						
dian 20	180	16462		31.80		55.9	35.5						5 3 M
LAV 091 31	M	16481	10.0		1.5	63.5							
		197.1.01	- 7.3	JACT.	clear.	02-2	22.8	r					1
								0					
Ш		1 1	d.	5	I		' I		1	G .	a - 18		
				аг. С		• *** • * * *	2	7 7					

EFFICIENCY LINE 22-210

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Column Re			lite				<u> </u>			M	PERTOI-	09-13		
success/tube		Euro Vollant		#V(1=51)	lo	<u> </u>	. Ca (24/1	re(mg/L)	8		10	11	12	13
diain : ROV 092 :	180	16661	10.0	32,54				~	Reality Plan					
	19	16688	9.5	32.59	clea	$\sim$	73.5	16.9		hstelle	te + fl	diain /35		100
drain : RJV 093 .	144	16824	0.7	32.86				·	filting -	1 Collect	time 205	diain /35	collect v	Hewo.
diain :	23	16847	0.7	32.90			44	27.4	33,000	Visume a	vid and	LL LOVI		melm
RJV 094.	23	17014	0.7	33.19						0.2 ml	Haby in ea	h tube		
arain ;	144	17158	0.7	33.23			29.2	27.8			·			1
RIV 095.	23	17181	0.7	33,51		-	163	750 -	·					I.
drain .	144	17,325	0.7	33,56 33,84		· <u> </u>	29.3	25.9						5
RJV 0960	\$25	17350	0.7	37.89			39.7	2.1						
arain "	144	17494	0.7	34.17				31.6		10 17				
RJV 097=	as	17517	0.7	34.21			46.2	26.6		0 III - V				
diain 23	144	17661	0.7	34.49			53.5	33.3						-
R5V 098	25	17686	0.7	34.54			55,750		n			A		1
diain 15	144	17830	0.7	34.82			<u>vs. 130</u>		rapa is	or, vau	C 0/14 @1	Son M	YL 15 M	My14_
RJJ 099=	19	17849	0.5	34.86	-		49.0	21.0						
drain 27	144	17993	0.117	35.14					<u> </u>					+
RAJ 100	21	18014	0.6	35,18		·	51.0	13.9				a an na 🕠		
diain 10	144	18158	0.08 sm	35.46										<u> </u>
RJV 10120	18	18176	0.5	35.50		_	55.5	12.4				· •••• · · · · ·		
RIV 1020	144	18320	0.91-7	35.78				· <u>- · · · ·</u>	• • • • • • • • • • • • • • • • • • • •			5	226.2.5.2	15.55
	22	18342	0.6	35.82			64.0	7.4						
diain 23	144	18486	0.7	36.11					2			· • • • • • •	50 (Jacober 1997)	
RTV 103.	25	18511	0.7	36.15			66.5	6.5						- · · · · · · · · · · · · · · · · · · ·
aram 33 RJV (0428)	144	18655	0.7	36.44			1							
	26	18681	0.7	36.49			78.0	3.95						
RJV 10520	144 25	18825	0.7	36.17										
dun 20	144	18850	0.7	36.82	-	-	89.0	3.80						
RJV 10600	25	19019	0.7	37.10			A11 -	4.50						
drain 22	144	19163	0.7	37.15		_	94.0	4.20						
7	<u></u> • <del></del>		<u>, U.I.</u>	2,117	¥.									
		1								double				

а <sub>2</sub> на зната на селот

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 EFFICIENCY LINE® 22-210	

Column	Real	6 <del>7</del> .1.1	1							8	. 00 IN	L	
allflaw/fule				ATT -		A tout	<del>f. t. t. r</del>	<u> </u>	۸ 	1164101	1-09-1	r	×
RJV 107 1	15 15	19178	0.4	AV (1=512) 37.46		(a(mg/L)		•	P	10	11	12	13
dian2	82	19260	0.4	37.62	Elear	98.5	4.75			<u> </u>			
RJV 108 :	15.	19275	0.4	37.65	├/	102,0	2 1/		ļ				
diaina	82	1935	0.4	37.81		100,0	3.40				· · · · · · · · · · · · · · · · · · ·		
R5V 109 3	28	19385	0.8	37.86	rust ppt.	127.5	33,5	·					
diain	164	19549	0.8	38.18	rans pp.								
R5V 110 ,	16	19565	0.4	38.21		110.0	445		~		-		
disin .	87	19647	0.4	78.37			ha	· · · ·	1				
RJV 111 .	3	19650	0.09	78.38		110.0	5.93		shut	own -	Colum	1 tuluis	
RJV 112 11		19668	0.09	78.41					plug	ked.	1		1
diains2	3	19671	0.09	38.42					V	0			
P5V 113 13	2-	19689	0.09	38.46									9 5 - 5 5
diama	Ĩz	19691 19703	0.00	78.46			-						
RJV 114 15	10	19704	0.00	78.48 78.48									
diaines	- 10	19710	0.07	38.50									
R5V 115 27		19711	0.07	78:00									
diam 20	6	19717	0.03	38.51									o was
RJV 116 10	1	197,8	0.07		··								
diam 20	φ	18724	0.03	38.52									
RJV 117 21	1	19725	0.03							0 n ev			a xa x
drain 22	6	19731	0.03	38.53				·	ter an <u>na ain</u> a		· · · · · · · · · · · · · · · · · · ·		ien i
RJV 118 22	t,	19732	0.03						energenetisten (n. 1916		··	<u></u>	2.5.5
RJV 119 25	6	19738	0.03	38.54			·					5	× 46.67
	1		0.03										
RIV 12027	<u>()</u>	19745	0.03	38.56									а <sub>с</sub> та
RIV 12027 drain 20			Q.										10 I I I I I I I I I I I I I I I I I I I
RAV 12/ 20	-1-												
areir so													
ROV 1220	~		V.				- <u>-</u>						
	<u> </u>		<u>v.</u>		a try	· · · · · ·	<u>a ag</u>		<u></u>				
				l.	8								
и			a.	1	40.6 and		e de <sup>de</sup> l	·	1 at 1	· 1	. a × 1	1	

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EFFICIENCY LINE 22-210

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Rejuvenation Batch Tests

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							Re	juvena	tion B	atch Te	575		
	<u> </u>	T		<u> </u>				<u>n</u>	TPERT C	01-10-	-01		
511	1	2	1	4	5	<b>6</b> .	7		9	10	11	12	13
4/2/03	OH	19:41	MA	de 500 419 Na	pml og	Nac	Ac B	FFIN.	/ JACK	5011 10	(ADP)	<u> </u>	$\mathbf{T}$
2				41 a Na	OAC	and 1	B.Smc	alor	A Ac	Aur	See 6774	am 1	-
3						New Section 6.	150.0		1.11				
4		20:00	PH of	NaOAL	BUFFE	A = 4.	95 (3	should b	125-0	1030 01	nous4)	f	
5	TESTIN	to see	if Nat	AC BUF	Fer trim	oves cal	tite Pr	on ZU	wh n	moving	Te		
*			COALBUT							SHAKE			FINA
1 (A) (A)		TUBE #	(3)	Frider	BURNE	OPPO	Time	STOP	Time	(HR.)	Ca-	mall	PH
	LJV-BI	1	0	50~9		2016 41	2/03	4/3/03	10:22	~ 14	352.+	1.01	5.0
	23V-82	2	2.0	0		1		4/3/03		~ 14	102	2650	5.10
	RJV-83	_3	2.0	0					16:54	120	92	3270	5.1
11	RJV-B4	4	2.0	0	V.	{	en e	414/03	11:38		76	6020	5.3
- 5, , "	<u> </u>							1.1	1920-000 C		1 7		
13/03	TUBES	# 2,34	Cthose	w/ grav	ZUE)	had on	soured	40 an	1 Deide	id stre	644		
14	Ne nou	$\mu = 1.6$	mar	CANTAA	UNGSN A	1.58 119 1		127 1-1.	L 12000	1. A . A	1 1 1 .1	Arthert	(on)
15	Appear	to be a	. Smal	l amoun at is ca	top Doc	oder in	Tube 1	Kuli dia	wit it a	nanouni	1923	CØ.	NE HI
16		must &	e H2 th	at is ca	wing	P. buil	dup.	<b>,</b>	[/			· · ·	
17				9 P	a the second of the	10 NOTE 15							1
18	PH of	CONC. 6	Acial M	etic Acie	d = 0.25	_ Dow	Not f.	22 yekan	Powles	d calci	6 add	od	1
19	<i>a</i>					$c_{\rm even} = \sqrt{2\pi} c_{\rm even} \sqrt{2T}$		1.000		ji në të të			
20	16:54	Tubes 3.	and 4 1	ressures	1 up an	d leal	ud - A	eleased	aressa	ne		-	-
21		Contri Cu	sed tak	23 20	mon @	3820	Rpm.	Preserv	d lasta	decent	to las	H 1001	014
22							_					<u>1 - 100 -</u>	
23			10 AGAG	- 1				Śc. go	1	00514)	• 3 <sub>2</sub>		
24	1231 1	made E	OTA S	oution	100	MO ED	rA in .	50 mc		ooks 1	140		
28	180 11	ALISSA	UPA L	mmedi	alch	-H	MASI	1 01			aduel	e. cm.	
- *	P	laced or	n stin	bar 17	37 C	outer (	in Curl	Do has	not o	issided	-	and zz.	
5 , 27		<u>, a s</u>			A	n an					<b>2</b>		1
41-103	1138	Tube	44 4	d pre	sourced a	up an	1 .000	Red B.	nain.		·		+
29	Cent	alinged !	TUBe #4	EDTA 4	Call	and	40 Ac + 0	elat	20	03	20 RPH		†
30				~						_		a	-
274-65	EDIA	· Cales	and the second	no unto	solved 5		10.00	ALS MA	4 - 1 - S		and Car	ditto mo	-Fe
RIV-B6	HOAL	+ Calcit	1 4	u	н.	ĸ							
	1.00.02	~~~~ (R	1.000	1 a 1	*			r~~ /	H = 0.28		Cu=	SUmg	KK

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EFFICIENCY LINE\* 22-210

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MPERT 01-10-02

511	H	1	2	1.	4	5	0	7	0	9	10	11	12	13
3/5/0	2 1	0701	Tubes	R, 3, 4	(w/ grad	ZUI)	attu ci	ntri lug	ation	have tu	med re	d		
	-					s skaping ra	a na faran an tar		A	2 2 2			<u> </u>	_
RIV-C	31 - 1	X-N	OAL	Bulle	(50 mL)	had	357	mall (	p	ů,		1	-	
	5			0-10		1.0.0	4.634	<u> 777 -</u>						
	6		0.05	DL V	352n	<b>1</b> 9 - 1			6 <b>5 8 7 7 7 7</b> 7		1	* ····		+
1997.	7	-					7.6 mg	A Same		Nglatiky ta	and the second		A. 100	-
	B			h. n.	× 40mg	Caco.	••••••••••••••••••••••••••••••••••••••			<u> </u>	- 4	1. 1	$+ x^{-}$	
	•			- my -ac	× 110		= यम्,	ng Cull	P3 (		882	<del>1;550 (</del> 0	td)	+
	20				-10102	CA.								1-
	11	· · · · · · · · · · · · · · · · · · ·		See Street and							1.11	- <u>10 10 10</u>		1
RJV		<u>5</u> E	DTA (	Onl)	had 17	5 mg/L	Ca				<b> -</b>			1
	13	7	0.05	<b>A</b> /	175 mg	a series and the series of the	이 가지 않는 것	•	alat al v	in S				
	14	1.1.8964		ve x	1. 1.	= 8.7	5 mg Co	. · · ·		( CONTRACTOR )			1	
	15							1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1			e gestaget	19 N		$\mathbf{t}$
	10		8.15	mgCn	100 -	Callog	- 21	9 mg Cal	c/2. 1	21.9	= 21.	161		1
	17					10 mg Ca			1. A	100		J. int		
	18					10 - 4 - 4	1							
	19		· · · · <u>· · · · · · · · · · · · · · · </u>			8	in na 👘		. <u>.</u>					
El-la-	20				<u> </u>									
1/2/03	21	2645	MAde S	olition	PY EDT	9, 72151	sodium	Salt	Baller	I 693-	7			
a-10.1.	22	- + W	5 416.	R (A)	12 O COC	$H \rightarrow h$	VCH C	LN(CI	4,000	No) · 2	HO	8		
	24	<u> </u>	5 M -	0.43 K	110.2:	104 910	1.19 (1997) 1997 - 1997 - 1997 - 1997 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1	a la serie de l La serie de la s	in a star			6		
	23		0 M =			C I I	and a subsection		ļ					
	28		40 <u>6  </u>	e og	9.10 M	Solut	ton has	yellow	D cast.	pH=10	85			
-	27		O.IM.EDIA	9- A1/2	STALT &	31404.64		a <b>f</b> am Raagaa saaa	1.7.8			he		
	28	2JV B7	50 mL	20	18433	p#		112105	FIAM	Catt	the second start is a start of the second star	(alle)	1	
		EJV B8				10.85	0	1640	11.02	145	84	9		
		UV B9		29	0753	9.05	270	State State	970	242	940		ia.	
1. J. S. S. A. S.	a	s - Salansaya artis	Second .	<b>~~</b> }	0753	6.88	550	H 303,5220-4917332	8.25	142-	1165	4		
n^		- EY8 9 7	anana ang kang kang kang kang kang kang		and all the states							A Standard Street	and and a second	4.25
			m-no 9											

 $\sum_{i=1}^{n}$ 

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EFFICIENCY LINE® 22-210

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## MPERT 01-10-03

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5.1	1	2	3	4	8	*	7		9	10	11	12	13
34/2/0	3 1640		isued R	TA AL	+ 89	from 3	hahn	Centri	Enged ?	on at	3780 R	pm	T
2		no pr	pouring	lie no	Deaha	4, 20 5	welline	appa)		1			1
à					1 <u>- 19</u> 201 87	2 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	2. 1997 - 2. 2017 - 2. 1975 1975 - 2. 1975 1975 - 2. 1975			5	x x x		1
S. A				0003		and a second			1		1		
1/18/03	0725	Prepari	d new	lead	-lesto-		96 - S. A. S.			2 2			$\square$
6				9				1			•		
7	0.00 0003420	a the star in the			i i se azisi			S. S. Garage					1
8		E OTA	MATERIA	1 (1geach	X	Start Time STOTOS	Time	JHARA TIN (N)	DH	Ca. (ugla)	Fe (mg/L)		
9	RIV BID	50 mL	Cally Pr	wder		0142	01516	15	11-11	3820	0.36		
10	RJV BI	4	ZVI -6	+10 (mont)		1	1		11.13	1.67	80		
	RTV BI2		F 6(1), 1	Fisher	a the deliver		State States	See 1 As a	10.76	2.38	1sar	• • • • • • • • • • • • • • • • • • •	1
12	RJV BIS	SUME	macuetta	ALE		V		· L	10.85	15.4	4 88		
13		an a l'Angle Angle							N. 19 1 8 1 1 1				
14	ALLT	ubes 1	ad re	idual	polids	afta 7	reatine	nt.				1000	-
15	15:16	DIC 3	amples	hom	Shake	P.	A to bus	1 27	RAM	22 mins	din harr		
10											<u> </u>	6	
17	10 10		a a a	in the star				E-jaho jang		00	e and a second		-
18	O.IM	NaOAC	F4	= 82.0	3 (AL	Drich	24124	5 8	29/L	ma	AP 14	pH = 7.	3-
19							186. au			1	~ ·-	/-	
5/9/00	Analyze	& Ca an	a Fe :										+
21					a sta	C.F. Slaves	contentes	tion ()	a Shala	The second second	19		1-
5/10/03	0735	made	news (	acteries	LOG E	07A +	a Colice	powdu	+10 3	UE -6+	10 Imax	). End 00	
23		1 1	$\sim 10^{-10} M_{\odot}^{-1}$	2 x 2		Section Notes					North Contraction	p. ene en	F1
24		50 mL	13 Calla	lg ZVI		The	-Simp Timy	SITATISE (HAL)	Fine H	Ca (my/L)	Fe (mg/4)		
25	RJV BI4	O.I MEMA		1	and a straight day	SI/0/03	1.107	28	11.14	9-50	5.20	•	┝
28	RIV85	D.OSM ENT							11.06	1970	4.10		-
27	RIV BIL	0.025A 880	× *			The second second second	13000	State States	10.90	-Qan -		1	
28	RJV617	DING OAC*					1		964	10.4	0.69		fre a
29	14.	17. 	а <sup>н 2</sup>		a a 1969.	N 20 10 72				7	<u></u>	- F	μ_
30	\$ 0H 7.	32 (no 40	(Ac)					e senere to the second second	<u>n n haiwa</u>	1997 - 1997 -	ana di si		1.2
	C. F. Donation	AND CONSIST	al starts	Transformer - Marga	No March Stand Sta	and the second	1	State State Lation	Arien Aren	an a		enter a constitue a	
5/11/05	1215	D16 55	wher. Co	1.52		· @ 37	- 00 DO	er na stan weer war a sta		an alta anay indi			
1.16	4			and a subce	1	resor	SC MAN	8	<i></i>				1

EFFICIENCY LINE® 22-210

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Phase II - Rejuvenation Extractions

MPERT 01-10-04 P.+

		1	2	3	4	5	5	7	Ta		10	n	12	13
	9/30	103	Set u	h Po	a ciet	mailer	DC TA	ad a fin	e cont.		el a Ar			13
	2			ne- gla	na ach	moore	lanke	D. tA	a cont	noued	Snaker	bath.	<u> </u>	
	3	Pa	oduca	NOAH	AED (DO	mene	anora	_ Oaly	will h	pla 40	10 10	flick		<u> </u>
	4		9/18/00	BY DI		NOAH A	En alla	PAGE DO	Lines a	and the	NOAHT A	to wn	S MAO	4
		, wd3	0.2M	Ammo	winn c	Valati	and	$n \rightarrow m$	Oralic	pans.	mixe	solution	en g	
	Ouesot	0,300	togethe	n (see	EST D	and the		DH 7	(400 m	L Am-	Ox +	300 ml	and and	
Art	CONOT		Coll Y	his A	m, Or	Alate	off 3		temper			10 25	E Cdi	1XIL
	* C.W.		H-1)-		not 4	Ual	deroni	200 1	20). E	DTA CAN	Pour in		do 517	p17/12/
a nov	9	Atomic dar	from E	AKen EDT	A Tetra:	sodium :	alt. pt	= 10.71;0	inn(l=10, 4)	TO asica	aron w		ne 5/4/	<u>وي</u>
	10			· · · ·		Dite	and the second		1 1 1 1 1 1 1		mg/L	mg/L	Fft.	SHAKE
κ¥.	Sampl	NO. HOM	Ligu	0 (40 mL)	Jolin	Ra)	2H with	Plt	Cont	Const	Ca	Fe	Color	TIME
	RP-	1	O.IM ES	TA	NOAH A	O Porder	10.714	5.85	18-00	16.130	21.0	434	clear	2 hr
<u>.</u>	13	- Z.	V	a orthogo	Hematit	Pounder	H53	4.83	5,60	15,960	0.40	260	ht BR	1
5	14_	3				the powerka		4.11		15,960	2.12	204	Clear	1
(	15_	Ч				Omesh ZUE		3,75		15,910	0.26	140	Clear	11
-	18-	5	V	·	CALCIT	Powder	V	4.22	V	16 070	170	0.50	Clem	11
2	17,	6 4	D.2m Am	n Oracate	NOAH A	FORDUSA	3	3.18	20 300	20,100	40.1	394	green/yel.	11 -
	18	.7	-pH3	(indark)t	Hemetite	Poinda	1	3.05	1	20,100	0.31	<0.TA.		1
5	29.	-V			magnet	te pousda	· · · · ·	3.13	an a	20,100	0.45		lgt. gren	1
	20_	1				D mere 247		3.12		20, 200	0.18	98	u	11
2		10.			Calut	Poudar	1 V	3.14	V	20,200	0.50	0.48	elecin	
	STAR			0644		<u>*</u> _S	haper bas	n keep	Kem	in the	dark			
	SHAA		stopped.	10/1/03	@ 084	7	Shak	n at l	DO RAM		4	1	4	
	24		ATERIAL											
	-Q	NOAH A	EU Pou		see abo		Sec. Sec.	and <u>shake</u>	an. The second se			$a_{\mu} = a$		
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	<u> </u>	MAGNY	ite Moioo	uc - ACF	A-310	masver	C Conse	WW As	RINAK	XRD i	onfiem	d as n	aquation	e.
N		FISH	40 1054	- ZVI -	Hister	Iron m	tal Fil	ales abo	1+40 mar	16 T4	7-500		•	
	<u>(</u>	CALCIN	powde	- Ald	hich 27	,921-6	Cally	; conf	emed as	caled	e by ye	2:0	× 5	а.
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MPERT 01-10-05 8-2

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3				1.0		25										8	
4		Anal	y-sel .	for C	2a	and F	te b	2	A A		1000400						
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EFFICIENCY LINE® 22-210

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## Reiuvenation Tests

MPERT 01-10-06

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/0/	2/03		<u> </u>			1.19	1977 - 19 199	17.4			100		Т
	081	3 Pry	gened	0.3m	Na-Cit	trate (	AH = 8.4	10): 11	n Ab HI	On-loi	#= 7.95	ड़ों) —	+
,*	<u>n</u>	intur e	\$ 200	0.3m Na Uhen di	to Na-Ci	sate +	a conter a	De No H	10. 12	de Selle	X		+
4	M	tysture of	200 mi	0.3m Na	-Litonte.	125ml	ImNal	1ca + -	1017-1	14 25 447	this la	H= 6.9)	ŧ۲.
¥		F	12203 1	when di	Hiomite i	added	A States	<b></b> _	101m			101-01-0	Ψ
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FLACK	Sample	Lighting		RATIV-	Joli	¥*	alte	OHE	(mg/L)		Time (m)	Traum	┢
1 •	RE-11	O.3M.M	a-citrat	(Sal)	NOAU A	254		3.49	63.0		THE ME (MC)	-35°C	+
2 10	-12		<u></u>			Pounde		8.41	2.08	0.58			
3 11	-13			a <sup>6</sup> a'				8.44	16.4				┢
<u> </u>	-14					meon ZUI		8.57	1.44	68	A CREASE RESIDENCE	<u>₽</u>	· —
5 "	-15	l l		. N., N.	Cal		14 A.	8.68	246.5			<u>├ </u>	+
6 "	-16	54-8 AS	RE-11 - 15	5 Bus	ALAAH A	FO Pousen	1.04	7.44	62.8		Contraction of the second		┢
7 15	-17	-3-04/	19-00-1	Contrational_	Hernatite	Paul	1010	7.19	2.41	1050			_
8 16	- 18				magneti		<u> </u>	7.08				╂-┠	
9 27	- 19	9			The at	Trees Eug	100 C	7.08	13.0	235	and the second		┢
10 10	-20		V .		Calcole			7.13	209		1 - 46 - 22 - 33 (m. 1	find the second	
18					C GICOT	ouran-	<b>.</b>	7.12	207	0.40	<b>*</b>	<u>  + </u>	+
* 6	e orein	aux day	chat	for pro	Hust do	Si to all	<u> </u>			<u> </u>			
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1024	1 Stop	rel that	her Th	a Tier		man in	DO RH	<u>m</u>	<u> </u>				
23				time	mo .	pune p	lastic	rentrig	prose ta	<u>pes. C</u>	full i fing	1 d 20 m	e
24	RE-16	AFO	ANG	ite tarne	d 10	125			<u> </u>	<u> </u>		<u> </u>	
25		not any	and the	here t	- maur	LIE DE	ing real	peed ] ! h	proceeding_	hemati	k KE-	2 000	
26	-		core to	Menue n	en re	ucco.			<u> </u>	ļ	ļ		
27					<b>├──</b>						ļ		
28					┟╍┅╴──┥				<u>                                      </u>			<u></u>	
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30				-			20 <sup>00</sup>		<b> </b>	<b> _</b>	e x o — v —		
31					9985 <sup>10</sup> 11111			· · · · · · · · ·					
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EFFICIENCY LINE 22-210

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MPERT 01-10-07

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	1	Made	0.05 N	LEDTA	TETRA	sodiu	- Solt	No Luch	- (an	81	1	H=10.		13
-	2	made	mixture	01 0.	SM ED	TA SOZ	Gard	D/M	the Diffe	10 714	$f \rightarrow f$	- 6.97		
	3			0						w				
	4	_						C. CALLAND CONTRACTOR			a al la seconda de la composición de la	1000 C		
	5	 			1	29 A			Sec.		A State of the	en.		
		·										- <u></u>		
	7						1000 (C.C. 2000)					All and a second		
	8	-				4				-		Controlle		
FIA	k.	sample		O (HOML)	-010	1	PAC	1997 - 1998 - 1997 - 1998 - 1997 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998	S.72_	FEIL				
	10	RE-21	D.OSMI	OTA (Tema)	NOAH A	to Porda	10.93	10.61	52.5	11.2	2	85 <	<u>.</u>	
<u> </u>	2 *	-22			Hematike			610-29-	1.88	0.66	1	and the second	1 33	
	3 *2	-23			MAGNER			10.82	7.9	1.22		2		
	4 "	-24			Fisher 4	ZUE			1:45	24.0.				-
	<u>5</u> *	-25			CALCINE	Proder	1 V	10.92	288	0.14				1,000
	6 15	-26	100 mL 0.05 + 65 mL 0	.I.M. Ale-Ditt	NOAH A	FO Poister	917	9:30	43	12.5			- <u>8</u>	
	7 10	-27	1		Hematite	Poudu	. 1	9.25	1.76	0.64				<u> </u>
	8 17	-28		-	magnetit	e founder		7.28	5.8	1.45	-			-
	7 20	-29	<u> </u>		Fisher 4			9.37	1.16	1075			-	
10.00	0 <sup>19</sup>	-30	<u> </u>		Calcit	Powden		9.34	224	101		S. S. Carlos	a a construction of the second s	
	TART	0 shaka	5 (60 BB	n) 0709	10/6/	23 SX0	241 09	04 (24	e) a Cont	N. @3	COO ROM	aomi	Dece	70.1
												The second second		mag
<b>n</b>	- 1							2						-
	10/0		39 111	rAtion	of O.IT	EDTA	(Tetr A)	w/ 0.1	m No.	Dittion	ute (3	art w/	DOO mL 9	EDT
Adde		No Ditt	pH											1
	28		the second s		Add.	com	pH		Add_	cam	ott	. 8 %		
<u> </u>	<del>ر</del> ې ۲۷	<u>~ 0</u>	10.74		5	20	10.13		10	90	9.36	-		
<u> </u>		3	10.70		/0	30	9.97		_10	100	9.28	20.94		1
$\frac{\lambda}{2}$	26	1 Y 1 - 1	10 60	5 AL	/0	40	9.84		_10	110	9.20			
	29	5	10.53		10	50	9.43	5 B	20	130	9.02			
<u> </u>		10	10.36		10	60	9.63		20	150	8.83			
5	31	15	10.24	<u>, , , , , , , , , , , , , , , , , , , </u>		70	9.54		20	170	8.59	n n gan in Kanan n		
	ľ				16	80	9.45		20	190	8.24		· · · · · · · · · · · · · · · · · · ·	

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EFFICIENCY LINE 22-210

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m PERT- 01-10-08

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10/0/03	Made	200								10		12	
3		1 AUUAL	0.05	FOTA (	TetrA +A	67 4 6	S	AA NI-	mel		4-017	100000	13
3	This	Solution	75 600	ed on 4	+ titra	Hom Ca	me	27 - 0/ -	0-07	have and	1 = 7.14		
	AOD	nore. ob	49. Th	hour	ht is 4	hat sie	at in the second	A COH W	a3) : 5	allector	AF		
4	sem	ooms (	la but	also ne	mours	erne Fre	· perho	-> b.	andi		Auchen	K.	
5	(No	- Dith	5 +44	support	con of	Ty cont	A-25-6	sauld	he red	irod	auron		
6				A	0					<u></u>			
,	<u> </u>						A Chief	tan National		Tai Marahani			· · · · · ·
6												a 40	
10/7/03.	Made	soluti	ons for		tests:			an a					
10	·i	30/N 10	-7-1	IM Hyl	nexylan	nine Hy	discretor	ide in a	5% AU	treact	1 (see	Landa	1982
11			<u> </u>	PH= 1	148						ан айда ал ан ал ан		-
12		<u>Solv 10-</u>		DOONL	0.3M	Na Citt	ate 2	TIME IN	K, CO.	3.91	7g Na-	Dittio	ele
13	l		H (befe	e Na	Ditt) =		をおけ	and a state			0		
14			pH (Mit	<u>ti Na</u>	Pita) =	9.70		Start S	aker Q	15:35	10/7/03		
		1					Surfred and	Stop 2	hater C	17:35	10/4/03	an e	-
	P PC	Liquid	40 mL)	3011	dt the	2 	4	Ca	-	Stake	controlle		
FLASE "	NO	200	A. P. Tauto		а <sup>33</sup>	a. m pr. 391 2 4.		(my/m)	Fraz.	71	-T ºC	80/5103	
( 18	RE-31	25 m 1.M	A - Difference	NOAH AFO	Powdy	9.70	8.58	36.6	378	21	25		
<u> </u>	1 Tutur	3.717 3 1	A - DIA AND		Powder		<b>19</b> (5)	1.46	69				
<u> </u>	~33	<b> </b>		magnetit			8,63	4.38	75				
	-34			Figher 40		i i i i i i i i i i i i i i i i i i i		0.85	100			G.	
5 22	-35	The disductor	to same	Calibe 8		¥	8.44	23.4	0.75				
<u>6</u> 23	-36	IM Andres	ALLT'L ACIA		O Pousle	1:48	SF.52	46.8	185	9			
7 *	-37	- 2.5 24		10matrice			1.32	0.96	2.51				
8 25		x y [1		magnet		a and straight and	7.33	3.37	13.3		· · · ·		
<u> </u>	-3A			Fishen 40		-	2.20	0.33	2160				
10 27	40	¥		Celit	thurles		2-67	5620	/ 33	~		2 Formed	owed
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30		-							r.				
38						an a							
18	ಾ ರೋದ್ಯಾಣಾ		5 x <sup>4 x</sup> x			the state	Elen Statistican	and a second second	and the states		hand have and	and and the second s	
								4 00 I			10 MM		

EFFICIENCY LINE® 22-210

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o management as a set of the set

10-9-		2	3	4	5	6	7	8	9	10	11	12	13
<b>1</b>	lles	alts f	date	Sugge	t that	EOTA	75 900	dat.	remou	NE Ca	lite b	ut.	
2	not g	ood a	t rem	ums	Fe-OX	de con	Rosim	prod	ucts.	1h-C	itrati.	+ Dittie	mile
3	appea	to to	be go	od at	Almou	ms Fe	orides	High	pH a	spears	40		
4	min	mize -	EUT N	mana	1.								
		There	for 1	pe with	1 try	mintim	Aa-	CitRATE	EDTA	and I	Dithone	<b>k</b> .	
6					-	1							
7	10:03	Start	with	DOOML	EDTA	CORRECT ON A	220 35		Solus	ton Cor	mositic		
8		Addea		Na-I	14h	5H = 9.	13	l	400 -	E074, 41	629	1. 6480	
9		Addec		EDTA			40	1		+ 10-	-2 -2/	6489 5	1
	Į	Addy		EDTA	(0.1m),	SH= 9	58					σ.	
11		Addec	lg E	P+A			- 2		36.94	66,	XXA	6 2 - 10	1.16
12		Added	93 5	PTA		ρH=9.	69		3.2	-			E
		1				- The second second	vir u N		49.0	M _ MA		057M	7:4
14			5 5137 1						41	7 174	19 0		1
15			24.5						,				
16	Sample	Liquia	( (40mm)	50	ice *		.5	Ca.	Fe	SHAKE	Controlld	1	
FLASK "	NO			×	and the second	pH-	লগ <b>ি</b>	ngl	myle	Tine	700		1
i =	RE-41	O.IH EC	TA (TETRA)	NOAH	FO Parode	10.95	10.66	59.5	10.8	Dhe	25	-	1
、 、	-42-			Hemati	K Buda		10.80	2.15	0.53	<u> </u>		10 1	
2 20	-43			MAGNET	the ADLOALLY		10.85	9.0	1.76				†
4 22	-44		-	Erden	o mester		10.97	1.6	26.6				
5 22	-45		and the second second second	PALATS	Produ		10.88	253	0.34				1
6 23	-46	0.16 A E	The Crat. A	NoALT +	FO Pousde	Q 69	9.21	37	167				
7- 24	-47		- <u></u>	Henstit	- Poroder		9.19	2.04	121				
8 23	-48	8 - 6	5 B	manut	H. Buden	4.07 F. 33	9.16	8.7	118				
9 28	-49			Fisher 4	O Mesh ZUE		9.16	1.9	106				· · · · · ·
10 27	-50				Budh		9.20	182	0.53				
28	<b>v</b>					×	10	1.0.5	0.50	¥	¥~		
29	Starte	1 shak	12:4	1 10/9/	5							1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	$\vdash$
30	Slopped	6	14:4	1 10/91	5								
31		lation in Secolity		11	a and a second	lan sett	S also alla 23	tel sa c	are d	25			í
	<u></u>	- 3, 5 m	<u> </u>	1 A 1 4	an an faith			<u>65 8 5</u>	A started	n <sub>en a s</sub> a kar.	<u></u>	and the second	
				x									
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5-13-	.04	Reiw	mation	. Colu	nn Tre	+ (#2	)		MPERA	01 - 12	-01		
	1	2	3	4	5	6	7	0	9	10	112	12	13
1	0700 2	Starting	set up	o for a	10ic	uenat	ton ca	um Y	+st			<u> </u>	
in the second se		Second and According to the	15 111121 (BARRING)			1						1	
·······	1310 C	al: Grat	ion of	electro	des L	0994 Pro	file =	MAY13	04 (F	older = te	juvence	tim Coll	enn
me # "	THOP		ES4	<b>T</b> 4 <b>A</b>		STOS	PH4	pH-7	ertice	ZOOCUI ORP			
13:16"	DHM	MANF Orion	F9107	Isternet 13.9249	<u>5100</u> -3.8460		Check	Ebeck		nV.			r.
10 1 7	att gel	Orion	E9107	12.9397		4,7	<u>3.95</u> 4.08	6.99	10.14	+	+As pa	e Vernie	<u>e</u>
15:36 "			A05990-55					6.47	10.04	194			
ų <b>t</b>			CU5901-04						 	189			
10											5 Car - C	· · ·	r allas
11									2 B 32	<i>N</i> .	9		8
\$ 04 13	P				· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·		<u></u>					
7/04 13	Talk	12 dia	meter a	lumn	wang	uch ZVI/	pavel a	un like	that	undi	w the	UI/gree	ree
15	2 me	Pert 1	vill in	hontic	ello. 1	tisa /	mxoz	2500/05	-4/+20	2VI to	gyd gu	riel	
	necue	agni y	fill =	1531.65					n n		0		
04 17	Aine	TOL R	M3 A	In Thet	2 1171	e usin	- Hur L						
18			a a ta a sea ea	June	ce ware		P	centre	7				a.
19	SOAL	Nattos		220 ml		n n	nto · S	soria	melin	ashit	Sind Sus	-C. A.	
20	1.Sg/L	Casay.2	4,0 10	300 mil		92trale	elly 2420	with 100	ALL Krisch	Result	ton. Sur	unt Ca	yes
21	2005/L	Mg SDy. 7	the 1	54 ml		oreidio	mand 9	Kinp	en p	e 058	for M	etes	
22	14/25/	c taces :	the	5 me	· •				2	1 / 1	<b>y</b>		
23	10g/L 1	2504		34 me 7387 m		a ann an	an an a		a n	· · · ·			
25	Millig 1	w								a a		5	1
, 28	- ×-		· · ·····	20,000 M	in in a second	6 V 1995	a a						
0945 27	start	air to	ia aqua	rumpi	nahtone	Sauch	10.	win tou	VIANIAN	in aton	Paa	IDen 1.	
094S 27 28	initial	pH= 8.4	3. 8	hit m	1 sti	ber		and Jan	Jagaan	muche.	, core	10cc/n	yen
		· · ·			<u> </u>								
000 30	fill in	let tube	ng.					× ×					
1010 2	stut	flow-1	O Colu	mn Q	0.7 ml	Inin	using A	4 16 m	esterfle	K DUMD	hud.	point.	Done

AMAN SEFFICIENCY LINE® 22-210

MPERTO1-12-02 2

1	1	2	3	•	3	6	7		9	10	11	12	13
2125/04	file M	eme =	huy25_	04a.	Callec	£ 12 pi	sints/h	n. Stef	- collec	t time	.C 336	Ro (2we	ks)
3.	pHand	ORPM	sues ch	ecked.	mint	stut.			n antara antara	55555	1 <del>.</del>		
• 		intercept 139249	plage	p#7 <sup>v</sup>	pH 10	soluel				1			
5	pH		-3,7984	7.07 7.06	10.13	v.						2	
7	ORPI	- 389.76	222.6			213					•3		-3
	OP-P2	-389.76	332.6			1 89							
104520	note p	+ checke	din por	ucetan	k=7;	phe ph	1= 8.60	(line 9	). wie	mont	n . att	chould	
11	diopri	rhen C	Or entr	uned	Hino fiel	Stubin	gand	(line 9 reaches	PHIP	obe-	1 P.		10
								nis 1 1					
	•			7.51			100		2 free	4 E			
	↑ Cor	* /1 (			16	-						·	
<b>600</b> 17	hogian	n Dilso	~ 206 f	ration	collect	n <u>#</u> ≤	8618	file #2	. Drai	nxzas	" Cree	ct×3	<u>_"</u>
20	205"0	train 7	ime to	fill ou	THew-	hibin	. (Drai	tert j	rac. ca	in hor	nause	the	
											<del></del>		
1807 22		<b>u</b> 1						r 1					
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28)								7 159.6					
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EFFICIENCY LINE® 22-210

MERIOI-12-03 5/20/04 000 Unive to find live @ Cruncitor to fraction collector Water on Contater. To first ennictor and che ele ochers. The branches (1) cellector Water on Contater. To first 3.26 celector placted not more write in tuling to these Runpless at 6730 interved tuling anall lives 250, 287. Lest wire to tak employed to fire. 1000 Seems to be humany well. And zone come those b sech collection tule 1000 Seems to be humany well. And zone come those b sech collection tule 1100 Seems to be humany well live 300 to work bettor. 1100 Seems to be humany well live 300 in pH 022 1100 Con the one of the humany well live 300 in pH 022 1100 Con the place to be humany well live 300 in pH 022 1101 appears to be humany well live 300 in pH 022 1101 To cellected Remains well live 300 in pH 022 1101 To cellected Remains well live 300 in pH 022 1102 Content of the humany well live 300 in pH 022 1101 To cellected Remains well content the present of the state 1102 Content of the humany well live 300 in pH 022 1102 Content of the humany well live 300 in pH 022 1100 Celleman appears to be humany well content to present long present of the state 1102 Column appears to be numering well - Con flow a take of the state 1102 Column has hum well and state to cent tules to present long present of the state 1102 Column has hum well and state of the numering well - Con flow a long for Case 1102 Column appears to be numering well - Con flow a long for Case 1102 Column has hum well and state of the numering well - Con flow a long for Case 1102 Column has hum well and state of the numering well - Con flow a long for Case 1102 Column appears to be numering well - Con flow a long for Case 1102 Column has hum well and state of the numering well - Con flow a long for Case 1102 Column appears to be numering well - Con flow a long for Case 1103 Column has hum well and state of the numering well - Con flow a long for Case 1103 Column has hum well and state of the flow a long for the flow a long for the flow a long for					MF	68501-	17 - 02		Ë
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<ul> <li>Thoved tubing around lines 25, 287. leak wire to be ad coupling to free.</li> <li>Calleton Replace no leaks equient</li> <li>1000 Seems to be unning well. and zoone cone this to beach callection tube.</li> <li>1000 Seems to be unning well.</li> <li>1000 Congress to be non phin phinon of the second cone this to beach callection tube.</li> <li>1000 Unit to one from phinon phinon phinon to work better.</li> <li>1000 Congress to be non to be non to work better.</li> <li>1000 Congress to be non to be non to work better.</li> <li>1000 Congress to be non to be non to work better.</li> <li>1000 Congress to be non to work better.</li> <li>1000 Congress to be non to be non to work better.</li> <li>1000 Congress to be non to be non to work better.</li> <li>1000 Congress to be non to be non to work better.</li> <li>1000 Congress to be non to be non to work better.</li> <li>1000 Congress to be non to be non to work better.</li> <li>1000 Congress to be non to be non to work better.</li> <li>1000 Congress to be non to be non to work better.</li> <li>1000 Congress to be non to be non to work better.</li> <li>1000 Congress to be non to be non to work better.</li> <li>1000 Congress to be non to be not to be non to be not to be non to b</li></ul>	- 100 00 000 000	we to gend le	ale connecti	to grace	in collector	Water	on count	ter Trafit	ten
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1100: Seems to be running well and 200 we come UNOs to each collection tube 1100: Seems to be running well and 200 we come UNOs to each collection tube 125 v Co, years to lowe finin pt - 709 line 322. Changel Co, diffuse (with the air diffuser C 1020. Pert diffuser areas to work better 165 all appears to be furning well three 365 in ptt Oep 185 all appears to be furning well three 365 in ptt Oep 185 all appears to be furning well three 365 in ptt Oep 185 all appears to be furning well three 365 in ptt of 153,45 185 all appears to be furning well three 365 in ptt of 153,45 185 all appears to be furning well for few for fore for the sto 186 all appears to be furning well for few for the sto 186 all appears to be furning well for few for the sto 186 all appears to be non well all day. Struptes to cent these to prevent longpreters for Cast 26,04 or sto Column appears to be running well Conflow for lowel and and for Cast 186 all appears to be running well Conflow for lowel and apple for Cast 26,04 or sto Column appears to be running well Conflow for lowel and apple for Cast line 824 primeter of be running well Conflow for lowel and apple for Cast							· · · ·		
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1252 V Cor low to low finin pH-7.09 line 322. Chenned Cor dispuser (was the all dispuser C ~1020. Les taipuner seens to work wetter. 1653 all appears to be twinning well line 362 in pH ORP 1654 153,49 427,52 -148,47 16,67 153,49 10 - Daismeters pH ORP 10 - Jaismeters in 6.67 163.48 10 - Jaismeters pH ORP 10 - Jaismeters in 6.67 163.48 10 - Jaismeters philos to cent tules to prevent longpiction. 20 - Column has un well all day. Snuples 1- 10 - source analyzed for Case 5/28/04 0755 Column appears to be running well Corflow & lowelain	<u> </u>		· //					an a la A an a	
1665 all appears to be running well three 363 in pH ORP 10 0750. Calumn appears to be running well. Con flow Come/min. Que 510 10 0750. Calumn appears to be running well. Con flow Come/min. Que 510 10 0750. Calumn appears to be running well. Con flow Come/min. Que 510 10 0750. Calumn Appears to be running well. Con flow Come/min. Que 510 10 0950. Column Appears to be running well. Con flow Come/min. Que 510 10 0950. Column Appears to be running well. Con flow Come/min. Que 510 10 0950. Column appears to be running well. Con flow Come/min. Come for Content of the running well. Conflow Content of the running well. Conflow Come/min. Content of the running well. Conflow Come/min. Content of the running well. Conflow Come/min. Content of the running well. Conflow Conflo			-	- a - C	one UND3 TO	tach C	ollectro	stube	
1615 : all appears to be running well the 363 in pH ORP 17.52 -148.47 18.67 153.43 917/07 0700. Catumn appears to be running Well. Con flow c Ome/min. Que 510 paremeters in 6.67 163.48 out 7.32 -212.59 21 22 21 22 21 22 21 22 21 22 21 22 21 22 21 21	" ain d	plans to lowe 1	nin pH=7.09	Une BZ	2. Change	d Cord	liffusa	(with the	
42/04 0750 Calumn appears to be running well Conflow Come/min 20 Column has pun wellall day. Shuples 1-10 + source analyzed for Cafe Column has pun wellall day. Shuples 1-10 + source analyzed for Cafe Column has pun wellall day. Shuples 1-10 + source analyzed for Cafe	12 A 10 -		o. pra aggi	1	o while wetter	V.	51 N		
Artor 0700. Calumn appears to be running Well. Cor flaws cone/min. Que 570 paremeters in 6.67 163.48 out 7.32 -212.57 Ransper callected Pamples to cent tiles to prevent longpration. Column has run wellall day. Somples (-10 + source analyzed for Cate checker of the running well Corflows come/min eine 835 primeters of the running well Corflows come/min	1613 13 Ull a	preas to be /	unning wel	f three				8 <b>-</b>	n e e enti
Spriot 0900. Calumn appears to be running Well. Cor flow come/min. Que 510 paremeters in 6.67 163.48 out 7.32 -212.57 22 Pransper callected samples to cent tiles to prevent longpration. Column thas un wellall day. Supples 1-10 + source analyzed for Caste chedred 0755 Column appears to be running well Corflow clowed and line 850 primeters of be running well Corflow clowed and	10					6.69	153,43	en -	
20 21 22 22 22 22 22 22 22 22 22	Shatat man Cal	Im al Amagel A	to lie nemina	111000 0		200003 00	a contra presidente a	e 1000 en 11	
22 Pransper callected samples to cent tiles to prevent longpration. 23 Column has run wellall day. Suples 1-10 + source analyzed for Cate 5/18/04 0755 Column appreaso to be running well Corflow e lowe anin	10 par	emeters		weee. C	a frome	Ome/min	. kan	e 579	
22 Pransper callected samples to cent tiles to prevent longpration. 23 Column has run wellall day. Suples 1-10 + source analyzed for Caste 5/28/04 0755 Column appreass to be running well Conflow c 10me/anin 21 line 835 princedos of the running well Conflow c 10me/anin	10 V 20	in	The second secon			е	10101 - 1 10 - 1	- 580. - 21	
5/2/04 0755 Column has run wellall day. Suples 1-10 + source analyzed for Cate	21		·····		• • •		16 (1 <b>4</b> (14)		
Spelot 0755 Column has run wellall day. Suples 1-10 + source analyzed for Cate	22 84	usper collect	d pauples to	Cent Rel	es to preven	t lungo	atin.		
Spelot 0755 Column appears to be running well Conflow Comelain	24 Colum	has pun we	eall day. Sr	uples 1-	10 + source	anilie	at to (	n E	
22 line 839 parameters pt OUP	Shelow orse Calus	··· · · · · · · · · · ·	the all	100 00					58
	2) line	e 83 minude	10 off	ORP 02	flower	nun	e un se se		
	28		VI WIII	ISPAT					
20 rust colored staining C bottom of column	30 Must	colored stamin	a C bottom a	-328.08					
" Outreavis pale orang	Outres	wispace nan	¥						a da
	v	5							

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EFFICIENCY LINE 22-210

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itoy pa	1/2100	2 Juch	3	+n	5	6	ng wel Aulis	8,		10	11	12	<u> </u>
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3	Clean	NIOM	grom	harde	000.00	trace	Junis	quent	telle	are fi	cled a	monu	tel.
	A-			fine	and the	Juay	•	0					17
·	line	1864	parame	ters	pH	ORP		155,250	Rea			<i>a</i> .	
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8	······································			out	7.22	-389.76	÷					<i>*</i> *	
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104 13										2		1	
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15	Column Collect last in for new to pero	what t	Find	Colum	w. um	filled	TO over	flow	ith Ce	lection	# 37, a	rival	
	for new	tocall	ition i	Aum	sed co	reet b	lot T	1. 39	Julies U	un	ptied	tube	
17	to peco	daug	conta	nnient	July	40 lac	Kont	ules S	100 ALM	in	poster	y lost	
19	line	1990	Jarame	n						cco) ru	Jugune	Frany	†
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21	5 00 C 0000			out	723	192.83 -38176_							
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27			and yea	mape									
28	se. ru	mm	well	line					OFP				
29	[	¥					m	6.38	19092				
30	De co	Tend					out	7.34	38176			a a z	
	$\sim \sim \psi$	the											80 <b>-</b> 0 4 4
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EFFICIENCY LINE® 22-210

	-	MRE	RT01-12-05	- 5	
	5 8 7	a /	¢ 10	11 . 12	23
1/2/2004 - 0715 column punning wed	e php pource	etank has	" since DICO	) Cor place	6/1/04
2 Will restart Cor flow @ (	Ome/man		·	, , , , , , , , , , , , , , , , , , ,	
· line 1275 parameters e	189.500 his	PH ORP		a l	
	m	7.03 178.42	tette en	а а	
• · · · · · · · · · · · · · · · · · · ·	out	7.32 -389.76			
0930 Cor running well lin	10 2002 000	144 0 181 22	<b>1</b>		
1 - Car human where whe	ac con parame	11.55	in \$2.09	ORP (75,16	
10			out 7.32	-389.74	
1018 00 10 100 0 10	A	- 11			
1018 stop frac callector = 69 m	un left g 205	"dean	= 95 mb out do	ing 136" of	diain
13 Olog punip	· · · · · · · · · · · · · · · · · · ·				
1029 Restart pumpe 10me	mm & O.M	EDTA (dus	dium 2777	49/2	
nestant grac callecto o tude 147 will be first,	18" drein 2m	uncellect	9,00	7.5/-	
" Fulle 047 will be first,	split out af	the start	3 EDTA		
1340. Two & Disodium EDTA		8	0		
20 Julies 47-55 Collected de	in a this tran	. Lo kept on	18" drain C	ycle	
21 0 1					
22 time 2348 parameters C 195	.583 hrs (	pH- ORP			
223 V V V V V V V V V V V V V V V V V V	m 9.16			12 205	
25	outs	5.17 -232,44	а.	203	
134720 Reprogram grac Collector	205" drein 35	-" callect			
" restart pump = RIM3 CO.	The min		5 - C		
20 Jack Al mun to the human			a internet	111	10.
20 Mok AI minutes to pump 2 mstad of Calc rate from to	WOME EDIA SON	tur, place =	0.4/ml/min	Willuse	this
ary any anto 2 gas generated	n calima hining	NGENTA MIM	nigeour toal	an	
	- conserver and and		=		
	1			1	

EFFICIENCY LINE® 22-210

MRERTOI-12-06 6	
6/2/2004 1 347 cont. Cyptaes formed in listlom of test tables in tules 50->55, white augular	
1715 · Rive 22990 parameters pH ORP time 199,083 Start of tube 56	x
" plevate outer and of prove holders to allow EDTA to completely fluch	
1805 Col summing week, white pH is trive low will make any chonges on An	1
6/3/04 05/30 Coe running well pt has gradually 9 on influent	
" " " " " " " " " " " " " "	
10 NOLIN Deurce tank, CD2 e 10ml/min	
" "rusted" area ( ustom of column ( opposite infet) has lightened significantly Bringhe tubes are Cargued in color. When transferred to Cent. takes, lagerin	1
6/4/04 000 Col running well pH grad & on upluent	**
20 line 2856 priameters C 237.917 pH OLP 30 000 6.47 171.09 31 000 7.19 -322.01	a
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EFFICIENCY LINE® 22-210

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MPERTO1-12-07 7

MH and	nc.	1		- /	5	6	'	" A	9	10	11	12	13
191/04 1	De	Cow To	Colun	2- 10	en es	e check	, lata	lough	- conti	ues to	Nen.		1
	Ken	ove pro	us an	a pla	celu ci	el pola	s	00			5.0		
0949	O Dine.	2878	tring 22	5.76	·		000		1.1.1	+			
· · · · · · · · · · · · · · · · · · ·	Can	0010	anc 03	1 50	m	pH	0RP 1717.36	· /	ina of	tube 66	callea	<b>f.</b>	e e
				1 var_e		7.21	-370.74		<i>0</i>	· · · · · · · ·	. w		
7	DCH	owise	end 5	tule	ant	ut.	<u></u>			a u			22
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	Justa	at m	all 4	2 Vine	2880	8239.	117 time			0			
	/	SHL7	Std 4			Soluel							
13	pH-1	7.01.	4.07		ORPI	197.72							
	<u>p</u> #2	7.02	4.08		ORP2	183.04							
18	1+ n/L	10.00	mal	- Air	001		13 <b>0003400</b>	es a )	e				
	switch					,		a conservation					[
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بوا ا		0.000	<u> </u>		1 manof	n		v - w ju	arian	r voc a	unais	gy	
11 2				10-					25. 25			~ /	
2/7/04 05	15 Col	umn	tunna	nguel	e Co.	C. ~10	milmin	J					
22 				9				<sup>2</sup> а эно но					
080	2 clin	e-3726	time 3	10.41T		pH	ORP	4) (1)	- 100 		10		
24					m	р <del>н</del> 6.93	143.37		94 42		¥ 0		
20					out	7.27	-389.76				6 X 66 - O		
20	T T	to to			X-		. A				2		
	<u>ا ا</u>	IK fl	W TO G	olum	$-, -\mathcal{D}_{1}$	cau	a log	fu					
28	0	37000	0 311	0				· 0					
	une	3744	<u>e sn.</u>		ptt	OPR		-0 - 22	90 V	8	x x		
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				out_	7.26	-284.16							
						Í				1.00			

EFFICIENCY LINE® 22-210

MRERT01-12-08 8 12 13 6/14/2004 Discovered error in RIM3 policin preparation resulting in low Ca in Queenect amounts of 12.72g/2 Caces 2420 and 100g/2 K2SCY were used 1.7 mL/L (instead of 0.25 mL/L) of 100 g /L K250+ used resulting in 76.3 mg/L (instead of 11.22 mg/L) K 93.7 mg/L (instead of 13.78 mg/L SO4 680 To of descred & concentration 10 0.25 mL/L (Instead of 1.7 mL/L) of 92.72 g/L Cick 2. 24 a used peraltingin 13 14 6. 3162 mg/L (instead of 42 95 mg/L) Ca 11. 1898 mg/L (instead of 76. 09 mg/L) CC 14. 11% of desired concentration from Ocicle 2440 29 30 31

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A	В	0	D	E	F	G	н		<u> </u>	Тк	7
1 R1-M3, Samples 1/14/2003; for Rejuvent	tation Column S	tudy initialed	4/26/03				<u> </u>	- <u>-</u>		<u> </u>	
2	mL per	1			-		-		1		-
3	Lof	Ne	к	Çe	Mg	804	ci	6	u	v	4
4	Saln	mg/L	mg/L,	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meA	-
5 Liquid Components				1		1				- Complete	4
6 V205, V+998mg/L, 2%HN03	0.00									0.00	-1
7 V205, V=1000mg/L, 5%HNQ3	0.00			1						0.00	-
8 V206, V=1000mg/L, 1.4%HNO3	0.00	1.000								0.00	-
9 V205, V=1000mg4, 216HNO3	0.00			1000		1			-	0.00	1
10 Ne2MoO4.2H2O, Mo=926mg/L	0.00	0.00	1.		-		1				1
11 Na2MoO4.2H2O, Mo=1000 mg/L.	0.00	0,00					1	2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 -			1
12 (NH4)2MoO4, 1008 mg/L Mo	0,00							201			1
13 USO6, U=10000mg/L, 3.5%HNOS	0.00								0.00		
14 U306, U=10000mg/L, 5.2%HNO3	0.00			1					0.00		-
15 U Std, U=1000mg/L, 2% HNO3	0,00								0.00		1
16 Re Std, Re-68.7pCi/mL, 2% HNO3	0.00						- C			1	-
17 As Std, As=999mg/L, 5%HNO3	0.00					100			1	1	1
18 As Std, As=1000mg4., 1.4%HNO3	0.00										1
19 Se =### mg/L 5% HNC3	0.00						1			1 Contraction of the second se	
20 C6 3td - 1000mg/L, ~2% HNO3	0.00	1			10.00					0.00	-
22 100g/L K2CO3		9									1
	0.00		0.00					0.00			1
23 50p/L Net+CO3 24 100p/L Net+CO3	11.00	150.60	-					78.57	100		1
24 1090/L No.2504.10H20 25 1000/L No.2504.(0.80 H20)	0.00	0.00		1000		0.00			Conception and Conception		1
28 800g/L (NH4)2504	0.00	0.00	<u> </u>		_	0.00				· ·	
27 1.5g/L Ca804.2H20	0.00		<u> </u>	-		0.00			10		7
28 1.2 pl. CaSO4	515.00			179.83		430,99	_				7
29 2000/L MoSO4.7H2O	2.70	2		0.00		D,00				1.000	1
30 100g/L K2SC4	0.25		1. m		53.28	210,48				( X	
31 conc H25O4(38N)	0.25		11.22		-	13.78	-				
32 927.2 p/L C=C(2,2H2O	0.00					0.00					
33 82.72 g/L CeCi2.2H2O	1.70			0.00 42.95	-	+	0.00				
34 300g/L NeCl	0.00	0.00		42.95	<u> </u>		78.09				
35 100g/L MgC/Z.6H2C	0.00	0.00					0.00		-		
36 100gA_NH4CI	0.00				0.00		0.00	4		1	1
37 100g/L NaNO3	0.00	0.00	· ·			-	0.00		1		1
38 2% HNO3	0.00	.w						-			
39 mL 1N NeOH needed to neutralize	0.00	0.00				·					
40 66.67 g/L NaN2	0.00	0.00	-			1	-		-		1
41				100		-		4	L	1	
42		+ ····		99.0	+		- L		1	10.000	
43		<u> </u>			- k-	-				_	4
44 Totals (mg/L)	530.65	150.60	11.22	222.88	60.00				1		
45 ACTUAL (mg/L)	400.00		11,22	213.00	53.28 52.80	655.21	76.09	78.67	0.00	0.00	1
46 Toles (mol/L)			2.67E-04	213.00 5.56E-03	52.00 2.19E-03		76.60	76,00	0.57	0.35	4
47.			LAND THE	0.306-43	2.182.145	0.635-03	2.15E-03	6.55E-03	0.00E+00	0.00E+00	4
48 ACTUAL PH	6.85	-		<u> </u>							-
49 Measured pH(no acid or base)	7		1		+		-	-			4
50 Measured pH ( added)	17 B		_	-	<u> </u>	+		· · · ·	2.00		-
51 ACTUAL Alk (mg/L CaCO3)	317.00									100	4
52 Messure Alk (no sold or base)	2	1		+	-						1

n Na Na Na Na Na Na Na

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EFFICIENCY LINE\* 22-210

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MPERTO1-12-09

illens/tube 1 Vol	(ma) Bern Val	Rate	·PV 1=391	lolon	. Ca (4/2)	7 Fe (mg/L) +		•	10		11	12	13
5 outrent 24	24	0.7	0.06	orance	55.5	7,68	SIS	S measure	A Ca	More	retank	= 153mg	K
		<b></b>	-	<u>↓                                    </u>				ulcul	uh.		xetank =	223mg	L
	A. A. 4							measur	de	Pou	xetank =	Omgli	
	+ Harry March	<u> </u>			<u> </u>				L ,				
<u>duin 0</u>			-					* fille	ngt	dun	y. Smill	leak (49	pml.
C2-4 1 12	36		0.09	A0	16.0	- #4			<u> </u>		J 	<b>`</b> .	
diain . 144	180		0.46	clear	16.0	04							
C2-5 · 24	204		0.52		14:0.	0.20		1005				·····	
arain 20 144			0.89		74.0	0.39							
C2-6 - 24	372		0.95		73.0	0.40							
	F 516		1 20	<u>, , , , , , , , , , , , , , , , , , , </u>	15.0	0.40				-			
Orain 22 144 C2-7 23 24	540		1.32		72.0	0.50						<u></u>	
diam " 144	684		1.75		14.0	0.50							
diain 14 144 C2-8 15 24	708		1.81	·	15.0	0.0							
arain 10 140			2.18		15.0	0.56							
arain 20 140 C2-9 27 24			2.24	1977 at 1	80.0	0.98							
drain : 140	f 1020		2.61		<u>80.0</u>	0.70							
drain 10 140 C2-10 20 24			2.67		88.0.	2.16							
drain 20 141	1044 F 1188		3.04		00.0.	2.10					· · · · · · · · · · · · · · · · · · ·		
drain 20 140 CZ-11 21 24	THV	-	3.10.		102.0	3.63		-					
22 144	1		3,47	,	100.0	5,65							5 N
C2-12 23 ZI	4 1380		3.53		106:5	5,13							
24 140	6 1524		3.90		10013								
c2-13 20 24	1548		3.96		106.5	6.60.							
26 144	1692		433	•	100~	0.00				-			ļ
L2-14 27 24	1716		4.39		106.0	7.42							
28 44	1860		4.76		10010	<u></u>							
-c2-15= 24	1884		4.82		108.0	8.96							
	+ 2028		5.19		,	<u> </u>							<u> </u>
20 144 22-16 22 24	2052		5.25:		111.5	9.00		· · · · · ·	-	-+			
		· · ·				,							

EFFICIENCY LINE® 22-210

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<del></del>  (	-		<b>A</b>		MPERTOI- 12-10							
allfons/ture ve				m) N1=391 = Colo	amak	te (mg/c)			10	11	12	13
	44	2196	0.7	5.62								
RC2-17 2	2964	2220		6.68	121.0	13,45			* tubel	7+37		+
liz-18 .	44	2364		6.05				• • • •		<u></u>		<u> </u>
RC2-18 .	24	2388		6.11	116.0	9.45					·	
	44	2532-		6.48					· · · ·		7 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1	
R12-19 .	ty-	2556		6.54	114.0	9.65		·				<u> </u>
7 /	44	2700		6.91								· ·
RC2-20 .	4	2724		6.97	112.0	9.90	-		<u>vice (1969)</u>		·	
	44	2868		7.34								
	ų į	2892		7.40	111.0	10.30		·····				
<u> </u>	44	3036		7.76								
	Ψ	3060		7.83	111.5	10.70					• • • • • • • • • • • • • • • • • • •	
13 / 0	44	3204		8.19							·	
	W _	3228		8.26	116.0	12.10		•				
15 /	44	3372		8.62								·
	24	3396		8.69	115.5	13.30					the second s	
	44	3540		9.05								
RCZ-25 18 2	까 _	3564		9.12	117.5.	13.95			antes e	200 J. 66 B		
	44	3708		9.48				e seconei				nen x a
	24	3732		9.54	117.5	14.90				• ••••		
21 /	44	3876		9.91				20002402-02	· • • • • • • •			
	24	3900		9.97	117.0	16.70						
23 / (	44	4044		10.34							os os 1960	la e
	24	4068		10.40	119.5	18.00					7.75 A. A	
25	44	4212		10.77								
PC2-29 20 7	4	4236		0.83	121.0	18.90					20 <u>12 - 2012 - 2</u> 013	2 2010-00-000,0000
	44	4380		11.20		<u>_</u>						
RC 2-30 20 20	4	4404		11.26	119.5	20.7						
	<i>µ</i>	4548		11.63								<u>.</u>
	4	4572		11.69	1185	21.1			[·			
<u> </u>	ΨĻ	4710	./	12.00							·	
			-									
									[		ж. 1	
		'		· I	, ,		1	1	1	<i>h</i>	1 I	

MPERTOI- 12-10

EFFICIENCY LINE 22-210

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MPERTO1-12-11

1		. 1	ა			MPERTO 1- 12 11								
	Vol (nl)	6um Vole	Rate fore me	AVI=391 -C	do balon	1) fe (mg/L			10	11	12	13		
Rez-32 1	25	1740	0.7	12.12	119.5	21.8	/ <u>-</u>							
3	144	4884		12.49										
le2-33 "	1 <u> </u>	4909			122.	0 24.4.								
4	144	5053		12.55										
RC2-34 .	24	5077		12.98	125.	5 26.1.			·····					
0	144	5221		13,35					6					
RC2-35 ,	25	5246		13,42	125.	25.7.	10203040							
102.01	144	5390	<u> </u>	13.79							Notes			
RC2-36 .	14	5417	0.8	13.85	184.	5 27.1								
LC2-37 "	A. +GN	5561. 5585.	0.7	14.22										
	144	5729		14.28		<u> </u>								
LC2-38 13		5753		14.65				<b></b>						
14	144	5897		14:71										
RC2-39 10	coster	5921		IS.14					· · · · · · · · · · · · · · · · · · ·			·		
15	144	6065		15.51										
RC2-40 17	24	6089		15.57	/32.5	39.4.								
18	144	6233	-↓	15.94			<u> </u>							
RC2-41 10		6257		16.00	137.	5 42.0								
20	144	6401		16.37		«	1				· · · · · · · · · · · · · · · · · · ·			
RC2-42 21		6427		16.44	134.	5 39.8			• 000 00			n e e		
22	144	6571	-	16.81										
Rez-43 20		6596		16.87	132.0	36.4								
f-c 2-4428	144	6740		17.24										
F-C- 2-4423	25 144	6765		17.30	132.0	) 3SN.								
RC2-45 27	25	6909 6934		17.67				100 - 100 - 100 - 100						
K-L-43 "	144	7078		17.73	/32, 5	. 34.6								
RC2-46 20	25-	7103-		18.10	134.5	20.0			ļ					
30	25- 95+18 75	7386	$r_{i}$	18.89	1543	34.8		1			1			
RC2-47"	R	7411	10	19:43 18:	95 153.0	7 42.8	owner	DEDIA	10 10ml	min	18" drain/	e collect		
			10		12 123.0	44.0	elin		<b></b>		_			
									ĺ			1		
,	u . P			-x 1	μ.	1	1	1	I.	1	L.	I		

## EFFICIENCY LINE 22-210

	MPERTOI-12-	12
Acher	du d	12

offices/here	vol (ml)	Eumbel	Rate (me/num V1=391)=	La (mgli)	re mali	N. Com	lents	10	11	12	13
diain 1	188	7599	19.43		1. 1.1.2	<u></u>					
RC2-48 :	27	7626	19.50	345	945	velou					
ť	188	7814	19.98		_ <u></u>	/ Marin		v :			
RC2-49.	26 188		20.05	1270	4300	MORDINS	green	· · · · · · · · · · · · · · · · · · ·	-	· · · · · · · · · · · · · · · · · · ·	
5	188	8028	20,53		4410	10 mm	fourit				
RC2-50.	20 188	8048	20.58	1085	4300	IN PPOUL	trace 101	tonin	highten	time -	
7	188	8236	21.00		4220	white	Ener li	t el	phone	Fun_,	guo-
RC2-51 "	18	8254	21.11	1130	3765	izelow	anoomi -	5	· · · · · · ·		
•	188	8442	21.59			12001	p	1/	+	<u>na manten a</u>	1
Re2-52 10	16	8458	21.63	1030	4410	wellow	Igneen	1			
11	188	8646	22.11	100	3820	0	1-0	Aun	leand a	to + land	-
RC2-53 12	28	8674	22.18	920	4000	ellow	green	1 APT	tube) u	it cove	u dation
13	188	8862	22.66				1 V	11 0	frame)_u	<u>uce cu</u>	prus
RC2-54 11	21	8883	22.72	810	3560	vellow	Freen	<u>                                     </u>			
10	188	9071	23,20				× .	<u>+-</u> ∖		· · · · · · · · · · · · · · · · · · ·	
RC2-55 10	28,	9099	- 23.27	740	3080	villou	Green	オンーー			
17	99/144		23,89			arthow	- 011" EOT	Heen 2	RIM	swett	1-10
RC2-56 10	10	9352	23.92	662	4730	6	205" drai	n/35" c	10115		7.00
10	144	9496	24.29		12 m		eow/green	= CAIN	[4/g)	1.27	
RC2-57 20	25	9521	24.35	454	3010 3	Educa	ung (ST	1000	100)		· · · ·
1-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0	144	9665	24.72								
RC2-58 22	25	9690	24.78	291	22604	Luned	yellow/hu	art linge	RAIVATAL	a renta	deres
23	144	9834	25.15			r	10		rug v care	pe mora	
RC2-59 24	25	9859	25.21	224	1400	и	a	<u>((</u> )(	21 M	otisdae	4 . (7
25	144	10003	25.58					··· ·	·····		T/
RC2-60 20	25	10028	26.65	175.5	-865-	Perfect .	xellow / lt	blacht	Plou	alon lit	an
1 27	144	10172	210.02				P			pro-wing	1
RC2-61 20	$\mathcal{X}$	10197	20.08	754	494	larged	yelow	to arane	h	• ••••••••••••••	
29	144	10341	26.45		20402		v		5		
RC2-62 30	26	10367	26.51	144.5	302	luned	vellori	r			
31	144	10511	210.88			0	0		·		1
				~							
					i		1		(		ľ

EFFICIENCY LINE 22-210

l	1.7.5		)			Δ.	M	EFT01-	- 12 -	-13			
sulflow/neve	Vol (me)	6um Volt	Este (melnur	AV1=391	,	Ca huti	fam 1)	tonne	to to	10	11	12	13
RC2-43 .	25	10536	07	26.95		146.5	188	yellow	<u> </u>	10		12	13
2	144	10680	1	27.31		110.0	780	Junio	·	<u> </u>		·	
AC2-64.	25	10705		27.38		149.5	135.5	pile of	llout			<u> </u>	
A	254	10849		27.75	·		100.00	1 0					
Rerus:	25	10874		27.81		156.5	99	Very pal	e vellou	<b>F</b>		·····	
100 44	144	11018		28.18					- N				
RC2-66 "	26	11044				156	82.5	Very pe	le yella	no make			
Pc2-61 .	119 25	11163		o	·			D/c plum	×35" fo	a probe	check		
10	144	11188				747	63	clear bo	am	ple yell	wtop		
RC2-68 "	25	11357	<u> </u>					Clear			N		
12	144	11501	<u></u>					uea			en e		en 26 en
RC2-69 13	20	11501	0							u		· · · ·	
14	144	11665					·			• • • • • • • • • • • • • • • • • • •			
RC2701	24	11689									ee		
	144	11833 11858											
RC271 "	25	11858	·····										
RC2-7219	144	12002											
F-L L- 1 L-18	21 144	12023			a								
RC2-73 =	24	12107	···			· ···		naran na n	ie an nan naoa				<b></b>
22	144	12 335	<u> </u>										
RC2-74 23	26	12361			- 5 T		····-						
24	144	12505											
AC275 25	25	12530										nter tar ha	
26	144	12674										5	
RC2-76 27	. 17	12691		- 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10					···			3 0 <b></b> -	
28	144	12835							5		\		
RC2-77 20	24	12859 13003											
AC2-78 31	144	12005							40 41 41 41 41 41 41 41 41 41 41 41 41 41				
<u> </u>	10	13026				0.2			-				
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MREETO1-12-13

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EFFICIENCY LINE® 22-210

MRERTO1-12-14

Julflows/tube	river (ml.)	Vac (my)	state my	A AV 1=351	5	· Ca mal	Afelmile	) a	9	10	11	12	13
diain '	144	13170					*** <b>`</b>	-					
RC2-79 2	26	13196											
diain :	144	13340									••• ••••		
diain : Rc2-80 .	26	13366								-		c	
drain "	144	13510	· ·······										
RC2-81 .	25	13535					17 - 18 <u>87</u> - 34				+		
drain "	144	13679			a		- 7	1					1
Rc 2-82 "	23	13702		0 <del>(31 - 32 - 52</del>						-		-	
Arain "	144	13846											
Brain " RC2-83 10	25	13846 13871					×	·····		ana ana an		2	4.
Arain "	144	14015			· · · · · · · · · · · · · · · · · · ·					• •••• •••••	a manager a		e
drain " RC2-84 12	24	14039	`			-			2.0440.440.0			D.	
13	7	14046		<del></del>									
14		1 10410										1 mar	1
10				04 1 <u>0000-01_0_0_0</u> 0		<u> </u>		· · .					
18			· · · · · · · · · · · · · · · ·							100100-0			
										- es <b>-</b> es			
18								a who					
		• 2 - 555			ar an sa s <del>a</del> s					-			
		a 2000000 000											
20	i		a.								(C) (C)		
22							See. e						
23								2 504 5				1	
24									1. (0.05 A.45)			5 a	1
25												9.9	
28										A 49 A 8			1
27										e 50	10000000	5 6 - 6	2
28		• • • • • • • •						6.9450		ск к. 1		-	- 9
29								-	· · · ·		······	500 300 E	
30								t		a annana ana			
31				·		· · · · · · · · · · · · · · · · · · ·			t		·····		j

. Tests 3:4 EPA			MPER	2T01- 13	- 01		
	4 5	\$ , 7	8	10	J.L.	12	13
2004 thepau 2 col	umns per feite	ing using 15,	non functic c	olumns.	Each H	lin -	<u>-</u>
2 fret Cinlet an	a mone cou	the					
*							
<u>Cal 3 = 41. =</u>	339 net wort.	Mont PE- 11-5	- grade Banyples	to fill call	unny.		
······································				,	1		
, Col 4 = 47.2	3. 0. 4	No + A USE		1 1-1			
8	.35 network	MORE 11-5	give priniples	to fill Co	lignor		
· Pump set 1017	mie 13 head a	·	A				
· Kimp petup w7	in strang a	ia junna	Julflow to grad	uncule	can.		
" trepare 0.25L	O.IMEDTA,	direduin sel	+ Arbindinto				
				te te estimate	10.00		
13 Prepare IL RI	M3 simthetic	water using a	prestiles too be 10	A Atank	n A a	en en	
		2001 C			and the second s	e age	
" repair 2L PII	13 prothetic	water smiked	with Imale U	L. 100	ongli	N.SHI	Vinous
10 Used for Spin	Re. as alware,	pest standard	sused.			72~	( may
20 Measure paramete	son all 3,	Dolutions					5 <b>5 6 6 6 6</b> 6
20 0.1 MEDTA	1000						1.00
	RIM3	RIM3=1419/		LU (2) RIM32		RIMESIA	ullu(4)
21 pH 5.07 22 ORP My 168,2	7.86			24) 8.04		7.97	4-
23 Condina 11390	- 1831	1896	127	/33	- Mani	129	
24 alkingher 380	230	230	1885		- 1884	1905	
25 Cr (m/4) 0.35	189.5	187.5	181.0	189.0		230	
20 UL UNL) <0,1	<0.1	941.7	993.5	967.		1	
27					<u>-</u>	1031.4	
28						-	
28							
. 31						r jeza i	
						-	+
		, j	T I			1	ŀ

MPERTO1- 13-02

	1			1.		1					-		
15/2004	- <u>SL</u>	- 1000		111000	3 0 A A	-	7	8 2 0	9	10	11	12	13
<u>IIJ WUT</u>	mait	- france		MEDI	acrodu	more	toci	<u>1. 2 C</u>	pmc/m.	W. CI	elect 12	BRA 100	L.
	_officer	1071	4 420	ML EDTA	+ throw	for col	um.	S					
4	0759	tast 1	lacin D	3ml/min			<u> </u>						
5			Flow-	11.540	2 and In	w) =	01-13	-				· ·	
5				stan 1	DALL JA	v = -	r v - 73	.Smc_		<u> </u>			
		30		stop f	6								
B	0848	start.	low-0	RIM	3-10-04	010	12 m/1						
•	0900	1st on	thew	(12"×	1.2 40/	nin) a	PV = 10	L. d. u. l					892
10		top p	mo			<u></u>	<u> </u>	<u> </u>				o o <del>n</del> os	
11							1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.	3 Sec				· · · · ·	×
12	Remon	am f	ac cu	lector	the	RIMB	Have	to bot	6 Celin	uno	ou TOme	a. 10.	4
13	0 0						1	-	<u>, co co</u> ,		nu rom	alle	<i>с</i> .,
. 14	0902	star	- flou	- J. R.I	M3 to	bothe	olumi	00 1.2	mLnum	uto C	ellect 9	. 10 m	2 -
16	Apli	to por;	totals	1 Som	L outfl	low of	RIM3				nuc -	22 10 40	<u> </u>
16		-		r 1		V V						8	
17	0946	and	flow	TRIA	73 to 1	both co	lums	2 1.2 ml	min .	Pese	t prec	allecto	שר
18	a	nciea	e pun	p spe	ed to	2.4m4	nin						× .,
								L			· · · · · · ·		
20 11	<u>////</u>	gail	- jew	-07 K-11	nswi	mg/L U	- @ 2.4	m min	n. star	t grac	collect	000	
		0.241	unute	alled	C C 2.4	mlpris	for :	20mL p	plet.	+rel	collect	1	
	350	Ann	1.2				/	<u> </u>				· · ·	
	<u></u>	·nare	- <u>TO D</u> ,	6 ml /m	m, co	elect th	me 5.	<u> 6 = 2</u>	Om AT	lit -	tubes 3	2 -> 37	
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6/16/04 0715 Send	ramples. Co 20 pale yeld	e 3 printup	yrles es, pH c	3-66,67 k = 4.	74 and	83 requ	reed to	ul addi	tional c	one KNO	 غـــْـــ
· Column · culetan	4 outflow Couter of c	was decu	erred. Low a	Chuck e	olumn	and the	bing.	Quesent 1	heedle	uto	10 A.
11 300 Will	restert cal	unn t	ouze 1	+ head	0 Q 61	el /min	. Repa	u new	-betch		Ingk U
13/700 Sine 14 plum	ally restart	Column	10 E SC 2 16 R	g Bhe	edse 3	6 hel /r	nin. a	vatile +	o make	- tight	<i>2</i> . 4
18 Det g	haction co	lector	to call	ect ev	ery H	H Pany	rle. M	ow se			
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6/17/04 20 0700 Cille 20 800 Sels 20 Will Nest	Dilson re fi m - diaero ait colian	n collect	tr. lemu	Idiain	. frac	collec	tres rue	nung	well n	ow	
28	ut 14° du				·	n. fic	et hille	HJ = 8	>	· · · · · · · · ·	

Montrièles EPA Columno 3i4	MPERTOI-13-04
1 2 3 4 5 8 7	
6/17/04. 1005 Switch to RIMS later 3 (44) 0	presce tank. Columna presi to la
rienning well	
and the state of t	
- muchal man rulling welwew coli	imons to theck plason for outplace
- Quitched wild tution between coli from Col 4 . pumphead ( (44) Maw 2 ( Eight )	- Aupplying Cally
,,,	- <u>- (00)</u>
· In addition proved both top and both	om of Col 4 with 21 an needle
" In addition proved both top and both through these and butter will well u	Pately for chance in outflow (at end)
" DIC AN 2 AUTIENT I WIPP DOL	tules7)
" \$15 Col 3 outflow I. will prove with h	lealle. (arain prule 90)
230 Cal 3 outlent good to take 95 1.9	25, 96. Prote again with needle. flow #
1330 Lee 3 short flow on tube 99, proc	Let needle low ?
"Soo Cal > plust flaw tulies 106, 10	7, 108, prove = needle during
"Soo Cal 3 phate flow tulies 106, 10 diain apra 108. flow n.	
1700 Reset fraccallector to start. St	ut RIM3 Batin 4 An augurt
22 Nun	- inter y for originate
	The second se
6/18/04 20728 Both columns had plugged aveinight	. D/cpump
20 Col 3 had essentially Offour (0.3 me 20 02mples 121 → 152 hot retained. >	(Train) fince tabe 122 (~2200)
a Cal 4 had essenticly zero plow (0.3)	7mm) since tube 143 (0530)
una severen reduced scoro 10.61	2min) since tube 127 (2400)
30 samples 127 -> 10 met retained.	

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6/18/04 1	ma	ke pun	p par	lew-	With	Reads	= 3.6 M	1. / min	2	1.			
3		ne one	Louis	a our	ees 0	unca	coccu	nno.	appear	plaw	reitou	æ.	
	hot	4:4	Colun	ns ha	d been	runni	ug we	R. 133	Dowl	would	have	been	
5	Use	a pro	n pou	cetan	R. On	ly ISa	philu	ed.		1000 - 10000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1			e
09	30 <u>Re</u>	start	flou	to as	lunus	@ tub	elsi a	liain	listx1	7" then	7 min	. Calle d	<u> </u>
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MPERTOI-13-06

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MPRAT01-13-07

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MPERTO-13-08

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MRERT01-13-09

Col 3 RIM3 Mont EPA

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MRERT01-13-10

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MARTO1-13-11

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MPERTO1-13-12 6

Monticello EPA Col 3 RIMBEU

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22-210 MARTOI-13-13 7

Monticello EPA Col 3, RIMBEU

	Vol (ne)	(the fue)	Pare min	Callent	Source	1/1735	1,	La pright	. Il luch	h	lu .	12	Y
<u>diain 1</u> 3-136 2	0.6		36	14	RIMBEL	)	1	na (mg/m	-u-fug/c	·		12	13
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	0.6			14	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~			· · · · · · · · · · · · · · · · · · ·					
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139 .				14									0.00
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11	0.6			· · · · · · · · · · · · · · · · · · ·		• • <u>•••</u> •••••••••	· · · · · · · · · · · ·						-
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19	0.6			14		and to conserve		1000 C		u an		2 X	
145 20	0.3			7		1999 A. 18						ч. — — — — — — — — — — — — — — — — — — —	12.2
21	0.6			<u>  </u>    					taan ta		••• •• ••	а. 1	
146 22	0.3			7						2.2 2 2	-	с х н не	12
23	0.6			14									
147 24	0.3	·		7							F		
148 20	0.6										••		
	0.3			7,-							——————————————————————————————————————	· ······	5000 - 10
- 149 27	0.6		_ <b>_</b>	<u></u>									
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Monticello EPA Column 3 RIMBEU

	Vol me	(HEC (ml)	Pare Timin	Time(min)	Source	AVII=135	7	La hur	· ll (ugte)	10 Promi	14.75	12	13
3-151 1	<b>2</b> 2		3.6	7	RIMB				4.48	- Willing	ener es		
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153 .	22 44			7			<u></u>						
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155 .	44												e e e e e e e e e e e e e e e e e e e
10	44			17	•••••• (20) (20 <u>) - 2003</u>			<u> </u>				s co	i s a
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18	44			$1\dot{\mathbf{u}}$							110 X		
160 10	22		e acconca c	7							3 M.	10 10	
20	44			īΨ	<u> </u>				11.45		9		а ж
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22	44			14			·				0 0.000		
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30	off .								11.50				
31	00				·		à						
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1 22-210

Mont EPA Column 4 RIM3

MPERTO1-13-15

	1 Vol (ml)	EumVollar	Pate (mefore			41 (1=14:	+]7	lea (mg/L)	U (ug/L)	"Comme	osts	12	13
f= <u> </u> _1	_9		1.2	8.34	RIMB			1540		clear V	rypale	hown	
2 2 3	9		1.2	8.34	1			715	]	Clear			
	9		1.2	8.34				479					· · · · · · · · · · · · · · · · · · ·
<u> </u>	9		1.2	8.34				406		ц			
<u> </u>	9		1.2	8.34 8.34				376		¥			
6.	17.5		2.4	8.34	RIMBELL					Clear	pele ul	low	
7 7	17.5		2.4	8.34 8.34 8.34 8.34 8.34				1	1	CROAL	10110 0000	yellow	-
8:	17.5		2.4	8.34						A Daw	man para	1 dans	26 - 2600 -
9 •	17.5		2.4	8.34			•						
10 10	17.5		2.4	8.34				-		¥ 9	54 554m		т. Т
//	17.5		2.4	8.34	Г · · -				contractor of			0 <b>2</b> 0	1000
12 12	17.5		2.4 2.4 2.4 2.4	8.34					(0.0)	-	20		ananan a
13 13	17.5		2.4	8.34 8.34						а с	×	n v enn	
14 11	. 17.5		2.4	8.34	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1					92	- 5 X	6 B B	17 V
12 12 13 13 14 14 15 15	17.5		2.4	8.34		an 10 10 10		100 A 100 C			· · ·		п
16 18	17.5	A. 12	2.4	8.34	• • • • • • •	<sup>9</sup> e a <del>na</del>		1 0 D	- 6	8			
17 17	17.5		2.4	8.34	in and so					6 (C	20 m	an ann a	
18 18	17.5		24	8:34 8:34 8:34 8:34 8:34	25		2020 0	de la como	с. 9				
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22 22	17.5	· · ··		8.21									
23 23	17.5		2.4	8.34 8.34				· · · · · ·					
24 24	17.5		2.4	8.34			-				an anna		о в в
25 23	17.5		2.4	8.34					<u>.</u>			. <u> </u>	<u> </u>
25 23 26 28	17.5		2.4	8.34					<0.01				
27 27	-125		2.4	8:24		···							
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29 20	-172-1		2.4	8 34									
30 30	17.5		2.4	824				L					
31 21	17.5		2.4	8.34 8.34 8.34	<u></u>			<u> </u>	2.05			]	
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MART01-13-16

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Mont EPA Column 4 RIM3

	Vo	l(ml)	Bur Volland)	Pare (	mefme	Fimefru	Mank	AV (1=144	7	Ci (mg/2)	alf ug/2)	forme	into	12	13
4-32- 33 34 35 36	1	17.5		3.6		5.56	RIMBEN				12-1-2	2010011-00			
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	5	17.5													
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39	в	21	-										5 <b></b>		
40		21			x				-		7.24				
4/	10	21									6 N			2	
··· 42	11	21					x - co ra e							с юк с	
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	13	21	a Maran ana a								0.000				10 A1075
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40	15	11					ск (ц						20		e x
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MRERT-01-13-17

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4-63 1	21		3,6	6.95	RIMBEN	1 9 1 1 7 7 7 7		and (r. 9/2)	m (m / m)	- Conin	anis	12	13
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MRERTO1-13-18 Ð

V = 20

Col 4 R/M 3-CU Lum Volmel + lase / number time (mus) EDUrce 3.6 7 RIM3ZC Mont. EPA Ca (my 12) allegh) Compacts Va (nue 22 44 N(1=14,4), 1,2 13 4-89: RIMBEU 14 90 : 22 44 8.65 14 91 . 92, 93 • 94 • . . . . . . . . . -----..... 95<sup>13</sup> 96<sup>14</sup> 96<sup>15</sup> 97<sup>15</sup> . . . . . . . . . . .......... .....  $\sim 10^{-1}$ .... -------2.15 18 98 19 99 21 22 100 23 24 ..... \_\_\_\_\_ .. ..... 12.42 22 44 22 44 101 25 . . . . . . . . . . . 10V 27 . .... -----24 103 29 -----28 44 104 31

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MAERTOI-13-19 -

	·Vol (me)	Eunvola	85 Mm	-IM3 E	Menue	AV (1=14.4	,	Ce (my/2)	di fuali	10		1	1
lain 1	44		3.6	14	RIMBEU	1-1-1-1-4	ſ	(	action,	10	11	12	13
4-105-	22 44			7	04101020							1.000.00 a	
а	44	·		14						·			
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17	22 44								9	·	2 2 A	e e	
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Monticello EPA Colt RIMBEU MARTOI-13-20

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MREPTO1-13-21

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Montuello EPA Col 4 RIMBEU Vol(me) Con me State man Callert Conne & lisin: 1.2 14 RIMBEU Source RV (1=14.+) Lafongh) ellfughe) 20 12 13 17 diain 1 4-1362 0.6 7 1.2 14 137. 0.6 . 7 1.2 138 . 1.2-139 0.6 1.2 ..... 0.6 14010 14/ 12 - ----- ---13 142-14 13 143 16 ..... 1 00000000000 ..... 14428 19 14520 21 14622 5.5.502 ----0.3 0.0.0.0.0.0.00 \_\_\_\_ 23 147 24 148 25 148 26 27 149 28 28 150 30 31 0.3 0.6

MAERTO1-13-22-8

	Vol (ml)	BunVolfne	"Tata ("/m	A time nu	Source	of (1=14:4	}	La Aug/2	/Lunte	10 Course	au to	12	13
4-151 1	Hol (ml) 23 46		3.6	7	RIMBEU	1 (			2.35		and	100	+
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Procedure for Column Tests 3 and 4 for EPA Region VIII PRB Rejuvenation Project Revision 1

## Column tests to be conducted week of June 14, 2004

Sarah, Following is a brief outline of the tests. Please contact me if you have any questions or if you need help (Brandon should be available this week). The purpose of these tests is to determine if EDTA treatment improves U-uptake rates. From the previous column (Column 2) we determined that disodium EDTA was capable of removing calcite from ZVI.

Use OMNI 22 mL columns. Collect in fraction collector.

Use sample(s) PE 11-5, 11-6 and/or 11-7 (if you use more than one sample, be sure to blend them) for the tests. This is ZVI sampled from the August 2003 coring of the Monticello PRB. It was selected because it has some of the highest Ca concentrations (i.e. it should contain the most calcite). It has no rad component and because it is from the ZVI zone, it will not require magnetic separation.

M Fill 2 columns (Columns 3 and 4) with the ZVI. Determine mass of ZVI in each. Make a solution (at least 120 mL) of 0.1 mZ disodium EDTA (pH should be about 5). Flow this solution through column 3 at 3 mL/min. It will take about 40 min to complete. Collect samples every 10 mL (total of 12 samples). Preserve in acid (about 1-2% HNO3) and analyze these for Ca. Analyze source tank for pH, ORP, conductivity, alkalinity, U and Ca.

Make up a solution (about 1 liter should be sufficient) of synthetic R1M3 (no U). Run 50 mL of this solution through each column at 1.2 mL/min (residence time about 10 min). This should take about 42 min. Collect samples every 10 mL, preserve, and analyze for Ca and U. Analyze source tank for pH, ORP, conductivity, alkalinity, U and Ca.

Spike R1M3 with 1 mg/L U. Run 400 mL (about 33 pore volumes) of this solution through each column at 2.4 mL/min (residence time about 5 min). This should take about 3 hr. Collect samples every 20 mL (total of 20 samples), preserve, and analyze for U. Analyze source tank for pH, ORP, conductivity, alkalinity, U and Ca.

Continue to run 400 mL (about 33 pore volumes) of the U-spiked solution through each column at 1.2 mL/min (residence time about 10 min) or another specified rate dependent on the results. This should take about 6 hr. Collect samples every 20 mL (total of 20 samples), preserve, and analyze for U. Analyze source tank for pH, ORP, conductivity, alkalinity, U and Ca.

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_	Α	8	C	D.	E	F F	G	н	1 1	JJ	T K
1	R1-M3, Samples 1/14/2003; for Rejuvery	tation Column \$	Study initiated	4/28/03	-1	1	- <u> </u>				N N
2		mL per			1		-			+ -	-
\$		Lof	Na	ĸ	Ca	Mg	504	- CI	c	<u>h</u> —	-
4		Sein	mg/L	mg/L	mg/L	man	mg/L	mg/L	mpt	mg/L	ma/L
	Liquid Components								- Contraction	ingr.	mger.
	V205, V=998mg/L, 2%HNO3	0.00				1				-	0.000
7	V205, V=1000mg/L, 5%HNO3	0.00				-			-	1	0.00
	V206, V=1000mgA_, 1.4%HNQ3	0.00						+	4	+	0.00
8	V205, V=1000mg4_, 2%HINQ3	0.00						-			0.00
	Na2MoO4.2H2O, Mo=925mg/L	0.00	0.00	1							0.00
11	Na2MoO4.2H2O, Mo=1000 mg/_	0.00	0.00			-				<u></u>	
	(NH4)2MoO4, 1986 mg/L Mo	0.00		· ·		1	-	-		· ·	
	U308, U=10000mg/L, 3.5%HNO3	0.00	-	220							
14	USO8, U=10000mg/L, 5.2%HNO3	0.00	-		-	-				0.00	
	U Sid, U=1000mg/L, 2% NNC3	0.00	-			-				0.00	
	Ra Std. Ra-68.7pCl/mL, 2% HNOS	0.00		_		2		1	2	0.00	
17							-				
	As Std, As=1000mg/L, 1.4%HNO3	0.00							1000	22	
	Se #999 mg/L \$% HINO3	0.00	1	25	_					( new	
		0.00	_								_
21	Cd Std = 1000mg/L, -2% HNO3	0.00		-		1.122		-		100	
					1.0			-			
22		0.00		0,00					0.00		
	50g4, NeHCO3	11.00	150.60					1001000	78.67	-	+
	100g4_NL2504.10H20	0.00	0.00				0.00		100		
	100g/L Na2SO4.(0.89 H2O)	0.00	0.00		1000		0.00	1			
26	500g/L (NH4)2504	0.00	41) 				0.00		-		
	1.5gA. CaSO4.2H2O	515.00	1.000		179,93	-	430.96	1	1		
	1-2 pl. Ca904	0.00	- NOT		0.00	3	0.00	1	105		
	200g/L MgSO4.7H2O	2.70			-	53,28	210.48				-
	100g/L K2SO4	0.25		11.22	-		13.78	_		+	
	conc H2SO4(36N)	0.00					0.00			+	
32	927.2 g/L CaCI2.2H2O	0.00			0.00		0.00	0.00	-		
33	62.72 g/L CaCI2.2H2O	1.70		1 2 2	42,95		-	76,09	-		-
34	300g/L'NeCl	0.00	0.00					0.00			
35	100g/L MgC(2.6H2C)	0.00		+ -	100	0.00	+	0.00			
36	100g/L NH4CI	0.00		-		0.00	100100			- k	
37	100g/L NaNOS	0.00	0.00		_	-		0.00	_	.j	_
	2% HN03	0.00	0.00			···	_		-		
	mL IN NaOH needed to neutralize	0.00	0.00								
	66.87 g/L NaN3	0.00	0.00			-				a trans	
41			0.00					-		10	
42	· · · · · · · · · · · · · · · · · · ·		-								
43			-		-		1000				-
	THE 2 11				_					1	
	Totals (mg/L)	530,65	150.60	11,22	222.88	53.28	655.21	76.09	78.57	0.00	0.00
	ACTUAL (mp/L)		111.00	11,30	213.00	52.60	677.00	76.60	76.00	0.57	0,35
46	Totais (mol/L)		6.59E-03	2.87E-04	5.56E-03	2.19E-03	6.63E-03	2,15E-03	6.55E-03	0.00E+00	0.00E+
47					1	1.0	1		1		ALL ALL A
	ACTUAL PH	6.85						1	1	-	
	Measured pH(no acid or base)	?	-			1	1			1	1
	Measured pH (added)						1	-			
	ACTUAL Alk (mg/L CaCO3)	317.00					1		1	-	+ -
63	Measure Alk (no aoki or base)	7			× *		1	1 -		1	-

## WORK SUBMITTAL TO ENVIRONMENTAL SCIENCES LABORATORY

Submitted By Star	14/2004 Date Required 6/18/2004
	14/2004 Date Required 6/18/2004 ~ Marcison Signature Fran marcison ley som
Formal ESL Report ?	? Yes <u>V</u> No
Data Report Only?	
Electronic Data Deliv	
Project: EPA- PRB	Phase II Charge No. 113401105
Analysis Type (check	cone): Kd Leaching
Expedited Site	e Characterization Other (Specify)
Colum	m
·····	
Sample Numbers	PE11-5, Columno 314
Analytes Cr. Fe	U. pH, ORP, Cond, alkalinity
·	
6	
Solution Composition	· • • •
See attac	B RIMB Prikedz Ing/LU
2 RIMB	3 RIMB Anchedz Inigh U
Tommer and a ford at	cedure if needed)
omments (attach pro	
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Procedure for Column Tests 3 and 4 for EPA Region VIII PRB Rejuvenation Project Revision 1

Column tests to be conducted week of June 14, 2004

Sarah, Following is a brief outline of the tests. Please contact me if you have any questions or if you need help (Brandon should be available this week). The purpose of these tests is to determine if EDTA treatment improves U-uptake rates. From the previous column (Column 2) we determined that disodium EDTA was capable of removing calcite from ZVI.

Use OMNI 22 mL columns. Collect in fraction collector.

Use sample(s) PE 11-5, 11-6 and/or 11-7 (if you use more than one sample, be sure to blend them) for the tests. This is ZVI sampled from the August 2003 coring of the Monticello PRB. It was selected because it has some of the highest Ca concentrations (i.e. it should contain the most calcite). It has no rad component and because it is from the ZVI zone, it will not require magnetic separation.

M Fill 2 columns (Columns 3 and 4) with the ZVI. Determine mass of ZVI in each. Make a solution (at least 120 mL) of 0.1 pat disodium EDTA (pH should be about 5). Flow this solution through column 3 at 3 mL/min. It will take about 40 min to complete. Collect samples every 10 mL (total of 12 samples). Preserve in acid (about 1-2% HNO3) and analyze these for Ca. Analyze source tank for pH, ORP, conductivity, alkalinity, U and Ca.

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	A	1 8	C	0	3	F	G	Н	1	<b>T</b> .	
1	R1-M3. Samples 1/14/2003; for Rejuvery	tition Column	Study initiated		~		- · · ·	1 7		1	K
2		mL per	100	1	1			-	-	1.00	-
3		Lof	Na	к	Ca	Mg	\$04	a	c	10	v
4		Soln	mgA.	mg/L	mg/L	rog/L	mg/L	mg/L	maft.	mort.	mg/L
	Liquid Components			1 5723	3 3				- mgaz	HING .	meye.
6	V205, V-998mp/L, 2%HINO3	0.00		۲ <u>ــــــــــــــــــــــــــــــــــــ</u>							0.00
7	V2O5, V-1000mg/L, 5%HINQS	0.00							1	1	0.00
8	V206, V=1000mg/L, 1.4%/INO3	0.00							+		0.00
	V205, V=1000mp/L, 2%HNO3	0.00		S	-				1	-	0.00
10	Na2MoO4.2H2O, Mo=825mgA	0.00	0,00						-		10.00
11	Na2MoQ4.2H2O, Mo-1000 mg/L,	0.00	0.00		1	-			-	-	
	(NH4)2MoO4, 1006 mg/L Mo	0.00		1.1	1					-	
13	U3O6, U+10000mg/L, 3.5%HNO3	0.00			8 S		-				
14	U306, U=10000mg/L, 5.2%HNO3	0.00								0.00	-
15	U Std, U=1000mg/L, 2% HNO3	0.00				· ·	-		· · ·	0.00	
	Ra Std, Ra=56,7pCVmL, 2% HNO3	0,00					-			0.00	
	As Std, A#999mgA_, 5%HNQ3	0.00					-	10 10	-		
	As Std, As=1000mg/L, 1.4%HNO3	0.00		-	-			_			_
	Se =### mg/L, 5% HNO3	0.00	-		4				-		
	Cd Std = 1000mg/L, -2% HNO3	0.00	-			_		_	-		
21					1				_		
	100g/L K2CO3	0.00	1	0.00			-		2		
	50g/L NaHCO3	11.00	150,60	0.00		-			0.00		
	100g/L H123Q4.10H2O	0.00	0.00		-	-			78.57		100 August
	100g/L Na2\$C4.(0.69 H2C)	0.00	0.00			4	0.00			_	
	500g/L (NH4)2504	0.00				-	0.00				10
	1.5gf. Ca304.2H20	515.00	0.00		11770.000	-	0.00	~			
	1.2 pl. CaSO4	0.00			179.93		430.96				
	200g/L MgSC4.7H2C	2.70		-	0.00		0.00	_			
	100g/L K2SO4	0.25		11.22		53.28	210.48				
	conc H2SO4(36N)	0.00	-	11.22	-		18.78		-		
	827.2 g/L CaCt2.2H2O	0.00	-	-	-		0.00	-	-	1	
	92.72 g/L CeCt2.2H2O	1.70	-		0.00			0.00	_	1	
	300g/L NaCl	0.00	0.00		42.95		100	76,09			
	100g/L MgCi2,6H2O	0.00	0.00			-		0.00			
	100g/L NH4CI	0.00				0.00		0.00			1
	100g/L NinNO3				-			0.00	1		
	2% HNO3	0.00	0.00	6 - C							
		0.00								-	
	mL 1N NeOH needed to neutralize	0.00	0.00						200		
	66.67 g/L NeN3	0.00	0.00		19. J. C. C.	1					
41			1								1
42		100				2		1.			1
43			10°	5				1	1	1	1 -
	Totals (mg/L)	530,65	150.60	11,22	222,88	53.28	655.21	76.09	78.57	0.00	0.00
	ACTUAL (mg/L)		111.00	11.30	213.00	52.60	677.00	76.60	76.00	0.57	0.35
	Totals (mol/L)		6.555-03	2.87E-04	5.58E-03	2.19E-03	6.83E-03	2.15E-03	6.656-03	0.00E+00	0.00E
47					1	1		1		1	D.DWE-
	ACTUAL pH	6.65				1		-	1	+ -	
	Messured pH(no acid or base)	?			1.000			1	1.00	-	
501	Measured pH ( added)		1		20 C	1				+	4
51	ACTUAL Alk (mgA, CeCC3) Measure Alk (no acid or base)	317.00						+		-	

## WORK SUBMITTAL TO ENVIRONMENTAL SCIENCES LABORATORY

Electronic Data Deliverable? Yes No Project: EPA ARB - PHASE II Charge No. 113401105	ley on
Formal ESL Report ? Yes <u>No</u> Data Report Only? Yes <u>No</u> Electronic Data Deliverable? Yes <u>No</u> Project: EPA ARB - PHASE TI Charge No. 113401105	un son
Data Report Only? Yes No No Electronic Data Deliverable? Yes No Project: EPA AB - PHASE TI Charge No. 113401105	-
Electronic Data Deliverable? Yes No Project: EPA ARB - PHASE II Charge No. 113401105	
Project: EPA ARB - PHASE II Charge No. 113401105	
Analysis Type (check one): Kd Leaching	
Expedited Site Characterization Other (Specify)	
Requirection Column test (Col #2)	
Sample Numbers 26 Aucl mix	
Analytes G. Fe	
analytes <u>Q</u> , <u>R</u>	
omments (attach procedure if needed)	
Use Qubit Numier data lossen	
Act. grac collector to 35 minute callects	
205 minute diaina	,
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	A	B	1 0	<u> </u>			-				
-	R1-M3, Samples 1/14/2003; for Rejuvent		<u> </u>	0	E	F	G	Н		1	K
2	renting, camping (/14/2003; for Repuyers	mL per	indy initiated.	4/28/03	-		<u> </u>		1		
3		Lof	Na			1					
4		Soin		<u>ж</u>	C-1	Mg	804	a	C	U	NV NV
	Liquid Components	aon	mgil.	mg/L	mg/L	img/L	mg/L	mg/L	mg/L	mg/L	mp/L
6	V205, V+996mp/L, 2%HNO3	0.00	1								
7	V205, V=1000mg/L, 5%HNO3	0.00	1		-			-	1.1		0.00
8	V208, V=1000mg/L, 1.4%HNO3	0.00				-		_			0.00
	V205, V=1000mg/L, 2%HNO3	0.00	- · ·	<u> </u>			10				0.00
10	NezMoO4.2H2O, Mo=925mg/L	0.00	0.00	<u> </u>			<u> </u>	-			0.00
11	Na2MoO4.2H2O, Mo=1000 mp4.	0.00	0.00	<u>+</u>			5	1	1		
12	(NH4)2MoO4, 1996 mg/L Mo	0.00	0.00	+	-	<u> </u>	-	100			
13	U308, U=10000mg/L, 3.5%HNO3	0.00			-			<i>.</i>			
14	U306, U=10000mg/L, 5.2%HNO3	0.00			-	-				0,00	
	U Std, U=1000mg/L, 2% HNO3	0.00	<u> </u>							0.00	
16	Ra Std, Ra=66.7pCl/mL, 2% HNO3		-	1						0.00	1 -
17	As Std. As=989mg/L, 5%HINO3	0.00	-	<u> </u>							1
	As Std, As=1000mg/L, 1.4%HNO3	0.00		-			1.1			-	+ -
	As 585, AS=1000mg/L, 1.4%(NO3 Se =859 mg/L \$% HNO3	0,00		-							1-
20	Cd Std = 1000mg/L, -2% HNO3	0,00	-						1		+
21	The store incompress = 2% HNO3	0.00			_	1.			10		
	100g/L K2CC3		_							-	
	SOM NaHCOS	0.00	-	0.00			10		0.00		+ -
	100g/L Na2504.10H2Q	11.00	150,60	-					78.57	_	
25	100g/L Na2SO4.(0.89 H2O)	0.00	0.00	<u> </u>			0.00		· · · · · ·		1 -
26	500gA, (NH4)25C4	0.00	0.00	÷		200	0.00	1.11.11.11.11		-	1 -
	1.6g/L C4504.2H2O	515.00			-	12	0.00			<u> </u>	1-
	1.2 pl. CaSO4	0.00			179.03	-	430.95		Ľ.	100	1
	20004. MgSO4.7H2O	2.70			0.00	<u> </u>	0.00		1		1
	100g/L K2SO4	0.25		10.00	_	53.28	210.48	1			- · · ·
	conc H2SO4(36N)	0.00	-	11.22		4	13.78				
	927.2 g/L C=Cl2.2H2Q	0.00			-	-	0.00				-
	92.72 pl. CaCt2.2H2O	1.70	+		0.00	-	- · · · ·	0.00		1,01	-
	300pt NaCl	0.00	0.00	1	42.95			76,09			10.
	100g/L MgC12.6H2()	0.00	0.00			-	-	0.00			-
	100pA, NH4CI	0.00	-			0.00		0,00			
	100g/L NaNO3	0.00						0.00			-
	2% HNO3		0.00	-	-				1		1
	mL IN NaOH needed to neutralize	0.00	-		_				1	1	+
40	66.67 g/L NeN3	0.00	0,00		- 860 						
41	DOLOT DE MINO	0,00	0.00	<u> </u>					· ·	<u> </u>	
42								1		1	1
43			-						-		100
	Totals (mg/L)	_	-						<b>†</b> –	<b>†</b>	1 ar
	( otalis (mg/L)	530.65	150.60	11,22	222.88	53,28	855,21	76.09	78.57	0.00	0,00
	ACTUAL (mpl.)	-	111.00	11,30	213.00	52.60	677.00	78,60	76.00	0.57	0.35
46	Totals (moVL)		6.56E-03	2.87E-04	5.505-03	2,192-03	8.836-03	2.15E-03	6.55E-03	0.00E+00	0.00E+0
		-	-	1	1		-			0.0000100	PT-00E+00
48	ACTUAL pH	6.65				1					
48 49	Menewood phi(no acid or base)	7	<u> </u>				-				
48 49 50			<u> </u>	<u> </u>						-	

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