Technical Memorandum

Uranium and PCE Treatment - Phase 1 Evaluation of Treatment Technologies

Prepared for

City of Las Cruces

Utilities Division
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Las Cruces, NM 88004

June 2006

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Submitted to

City of Las Cruces

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Purpose

The purpose of this technical memorandum (TM) is to evaluate various treatment alternatives to remove uranium (from natural sources) and tetrachloroethylene (PCE) from selected groundwater wells used for drinking water. The evaluation includes recommendations to select one or more treatment alternatives for pilot testing for uranium and PCE removal.

Uranium Treatment

The U.S. Environmental Protection Agency (EPA) promulgated the Radionuclides Rule on December 7, 2000. The purpose of the rule is to limit exposure to radionuclides in drinking water in order to reduce the risk of cancer and improve public health protection. The rule retains the existing Maximum Contaminant Levels (MCLs) for combined radium-226 and radium-228, gross alpha particle radioactivity, and beta particle and photon activity. The rule establishes initial regulations for uranium. See TABLE 1 for a list of contaminants regulated by the Radionuclides Rule, including the corresponding MCL and MCL Goal (MCLG).

Additionally, the rule requires community water systems (CWSs) to begin initial monitoring for radionuclides under a plan specified by the state by December 8, 2003, unless the state permits the use of grandfathered data. Initial monitoring must be completed by December 31, 2007.

Uranium is a naturally occurring and radioactive element. It is a normal part of rocks, soil, air, water, plants, and animals. Uranium is considered to be weakly radioactive and contributes to low levels of natural background radiation in the environment. Natural uranium has three different isotopes; U-238, U-235, and U-234. See TABLE 2 for a summary of characteristics of natural uranium isotopes.

TABLE 1
Radionuclides Rule – Regulated Contaminants

Regulated Radionuclide	MCL	MCLG
Beta/photon emitters[1]	4 mrem/yr	0
Gross alpha particle	15 pCi/L	0
Combined radium 226/228	5 pCi/L	0
Uranium	30 μg/L	0

(1) A total of 168 individual beta particle and photon emitters may be used to calculate compliance with the MCL.

TABLE 2
Uranium Isotopes[1]

	U-238	U-235	U-234
Natural Abundance (%)	99.27%	0.72%	0.0055%
Half-life (years)	4,47 billion	700 million	246,000
Specific Activity (pCi/μg)	0.333	2.144	6,189.0

(1) Source: Clifford, Dennis. University of Houston. Presentation from U.S. EPA website: "Fundamentals of Radium and Uranium Removal from Drinking Water Supplies".

The City of Las Cruces operates several groundwater wells as part of its potable water system that exceed the MCL for uranium established by the Radionuclides Rule. The uranium in these wells is likely from natural sources. Therefore, it is considered a Naturally Occurring Radioactive Material (NORM). See TABLE 3 for a summary of uranium water quality data for selected wells containing uranium. This data summary does not include all wells operated by the City that contain uranium. The summary includes only those wells selected as candidates for pilot treatment. For complete water quality information of uranium affected wells, see APPENDIX A.

Wells No. 10, 20, and 44, were considered for well head treatment, because these wells are not located near other wells affected by uranium. Wells No. 19, 21, and 27, were considered for centralized treatment at the Upper Griggs Reservoir (UGR) because of their proximity to this area and high uranium concentrations. Wells No. 21 and 27 already have piping going to UGR and Well No. 19 is located in close proximity. Therefore, the expense of pipe installation from wells farther away is minimized. The data for Well No. 27 does not indicate particularly high levels of uranium above the MCL, but this well has not been sampled for some time because it has been out of service. This well could be used in conjunction with Wells No. 19 and 21 for blending to produce compliant water.

TABLE 3
Summary of Uranium Water Quality Data – Selected Wells(2)

Well No. >	10(3)	19(1, 4)	20(1, 3)	21(4)	27(1, 4)	44(3)
Flow (gpm) >	500	750	1,050	1,000	650	780
	U (μg/L)	U (μg/L)	U (μg/L)	U (μg/L)	U (μg/L)	U (μg/L)
Maximum	123.0	57.0	92.2	51.8	15.0	91.0
Minimum	32.0	51.0	52.3	28.0	15.0	3.2
Average	45.7	54.0	65.3	33.9	15.0	49.7

(1) Well currently out of service.

(2) Selected well data does not include all wells operated by the City of Las Cruces that contain uranium. The wells listed are considered candidates for pilot treatment. Source of well data from NMED and City of Las Cruces.

(3) Wells considered for well head treatment.

(4) Wells considered for centralized treatment.

Treatment Process Alternatives

The following treatment process alternatives were evaluated for uranium removal:

- Enhanced Coagulation/Filtration
- Ion Exchange
- Reverse Osmosis
- Lime Softening
- Granular Ferric Hydroxide
- Alternative Media - Brimac 022060

Enhanced Coagulation/Filtration

Enhanced coagulation/filtration (E-C/F) is a treatment process that can effectively remove uranium from a drinking water supply. The process is listed as a Best Available Technology (BAT) for uranium removal by the U.S. EPA.

The E-C/F process alters the physical or chemical properties of dissolved colloidal or suspended matter in order to enhance agglomeration. The coagulant changes the surface charge properties of solids to allow attraction and/or enmeshment of particles into a flocculated precipitate. The resulting agglomerated particles, or floc, are more readily removed by sedimentation or filtration. A sedimentation step prior to filtration would likely be necessary in this application since the estimated dosage of a metal hydroxide coagulant is above 20 mg/L. Sedimentation would minimize the potential of blinding the filter with coagulated floc particles. See *FIGURE 1* for a process flow diagram of an E-C/F system for this application.

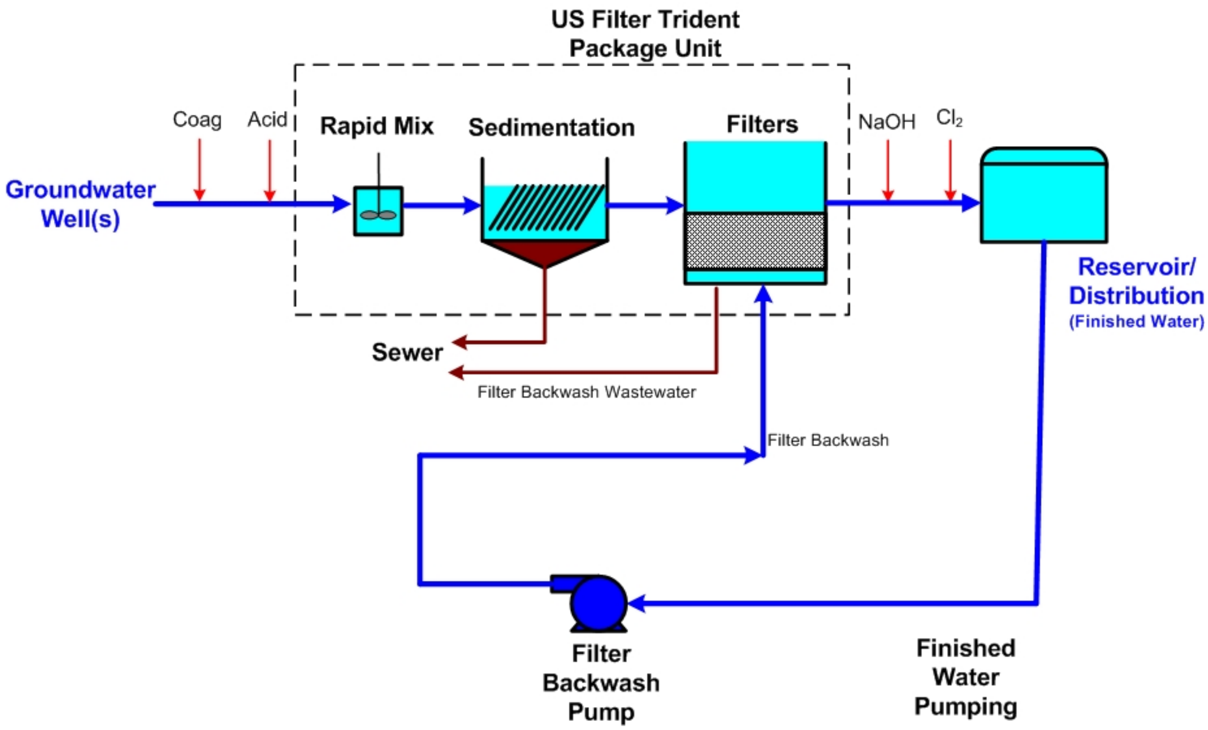

FIGURE 1. Coagulation/Filtration Treatment

The coagulation/filtration (C/F) process has traditionally been used to remove solids from drinking water supplies. However, the process is not restricted to the removal of particles. Coagulants render some dissolved species [e.g., natural organic matter (NOM), inorganics such as uranium, and hydrophobic synthetic organic compounds (SOCs)] insoluble. The metal hydroxide particles produced by the addition of metal salt coagulants, such as aluminum sulfate, ferric sulfate, or ferrous sulfate, can adsorb dissolved species such as uranium. A major portion of these particles, or flocs, are removed in the next treatment step by sedimentation.

The C/F process is "enhanced" (E-C/F) for increased uranium removal by adjusting the pH of the raw water prior to rapid mixing and flocculation. It has been shown that removal of uranium by coagulation is more effective at a pH of 6 or 10.

At a pH of 6, the charges of the dominant uranium complexes and metal hydroxide coagulants are neutral.[1] The neutral charges of these molecules allow them to agglomerate. The agglomerated particles form flocs that are physically removed by sedimentation and filtration. Uranium removal rates have been shown to exceed 85 percent when using alum or ferric sulfate as a coagulant at a pH of 6. The use of ferrous sulfate as the coagulant has not been as effective, with removal rates just above 40 percent.[2]

In contrast, at a pH of 10, the charge of the dominant uranium complex is positive, while the metal hydroxides are negative.[1] The opposite charges of these molecules allow them to

[1] Lee, Suk Y. and Bondietti, Ernest A. "Removing Uranium from Drinking Water by Metal Hydroxides and Anion-Exchange Resin". Journal of American Water Works Association (JAWWA), October 1983.

[2] Clifford, Dennis. University of Houston. Presentation from U.S. EPA website: "Fundamentals of Radium and Uranium Removal from Drinking Water Supplies".

agglomerate. The agglomerated particles form flocs that are physically removed by sedimentation and filtration. Uranium removal rates have been shown to exceed 85 percent when using alum, ferric sulfate, or ferrous sulfate as a coagulant at a pH of 10. Other pH ranges are not as effective, with removal rates less than 50 percent.

In an application where the source water is groundwater with appreciable hardness, it is recommended to enhance the coagulation process by lowering the pH to 6, instead of raising the pH to 10. If the process is operated at a pH of 10, dissolved salts, such as calcium and magnesium, would precipitate out of solution and cause scaling. After the coagulation and filtration steps of the process, the pH would be neutralized to match other water supplies in the distribution system. The adjustment of pH would be accomplished by adding sulfuric acid (H_2SO_4) to lower the pH ahead of coagulation and sodium hydroxide or caustic soda (NaOH) to raise the pH after filtration.

The major components of an E-C/F facility include:

- Chemical feed systems (e.g. coagulants, sulfuric acid, sodium hydroxide, chlorine)
- Mixing equipment (e.g. rapid mixers, flocculators)
- Rapid mix structure
- Flocculation basins (may be eliminated if solids contact process is used)
- Sedimentation basins
- Filter media (e.g. GAC, anthracite, sand)
- Filter backwash facilities (e.g. storage, pumps)

The waste products from an E-C/F facility include both liquid and solid wastes. The liquid waste stream is comprised of sedimentation waste and backwash wastewater. The solid waste portion consists of the filter media. Possible disposal options for the liquid waste include discharge to the sanitary sewer or solids drying beds. The filter media typically lasts many years before replacement is required. After this time, the media may contain elevated levels of uranium. Therefore, when the time comes to replace the filter media, the uranium content of the media would have to be assessed to determine if it requires disposal in a solid waste facility authorized to accept radioactive wastes.

The E-C/F process is a potentially viable method for removing uranium from the groundwater supply and it is listed as a BAT by the U.S. EPA. For these reasons, E-C/F was considered for additional evaluation and compared with other viable treatment processes with respect to cost.

Ion Exchange

Ion Exchange (IX) is a treatment process that can effectively remove dissolved uranium from a drinking water supply. The process is listed as a BAT for uranium removal by the U.S. EPA.

IX is a physical/chemical process by which an ion in the media is exchanged for a uranium ion in the feed water. In this case of uranium removal from groundwater, the uranium ion is a negative ion, or anion, since the pH of the water is above 6.5. This further defines the IX process as an Anion Exchange (AX) process. The media used in an IX system consists of a synthetic resin which has been designed to preferentially adsorb uranium. The IX process operates by continually passing feed water through a bed of ion exchange resin in an upflow mode until the media is exhausted with uranium. Exhaustion occurs when most sites, or ions, on the resin beads have been filled, or exchanged, by uranium ions. The exchanged ions that have been replaced by uranium become part of the treated water solution. These ions are considered harmless in a potable water system.

There are important considerations when assessing the applicability of the IX process for uranium removal. Water quality parameters such as pH, competing ions such as sulfates, media type, alkalinity, and influent uranium concentration, each must be considered when evaluating the efficacy of an IX system for uranium removal. Other factors to consider include the affinity of the media for uranium, secondary water quality effects, and design operating parameters.

In a typical IX system, once a media bed is exhausted, the media is regenerated by backwashing the IX column with a regenerant. The regenerant is a concentrated solution of ions initially exchanged from the resin. However, it is not recommended to design a regenerating IX facility for uranium removal. Regenerating an IX system after the bed has been exhausted by uranium would produce a liquid waste stream containing a concentration of uranium and a corresponding level of radioactivity that would not be suitable for disposal in a sanitary sewer system. There exists the alternative of backwashing the IX system more frequently to meet the uranium disposal requirements of the sanitary sewer system. However, this alternative requires a significant volume of regenerant to accommodate the frequent backwashing necessary to achieve uranium concentrations acceptable for sanitary sewer disposal. Additionally, there is a limit to how many times the media can be regenerated. After some time, the media will have to be replaced and disposed of in an acceptable facility. These considerations make non-regenerative IX a more viable operation method than a regenerative IX system.

A non-regenerative IX process is significantly simpler to operate and maintain than a regenerating IX process. There are no backwash pumps, backwash tanks, or chemical additions required. This makes the process a simple single pass system, and from a mechanical standpoint it requires significantly less operator skill and attention. See *FIGURE 2* for a process flow diagram of a non-regenerating IX system for this application.[3]

The only waste product from a non-regenerative IX facility is the exhausted media. There is no liquid waste stream since the IX resin is not regenerated with a brine solution. Typically, non-regenerative IX media used for uranium removal would last up to a year or more before replacement and disposal is required. Possible disposal options for the spent media include transporting to an authorized solid waste facility or to a uranium reprocessing facility.

[3] Flow diagram is based on non-regenerating IX system design by Water Remediation Technology (WRT).

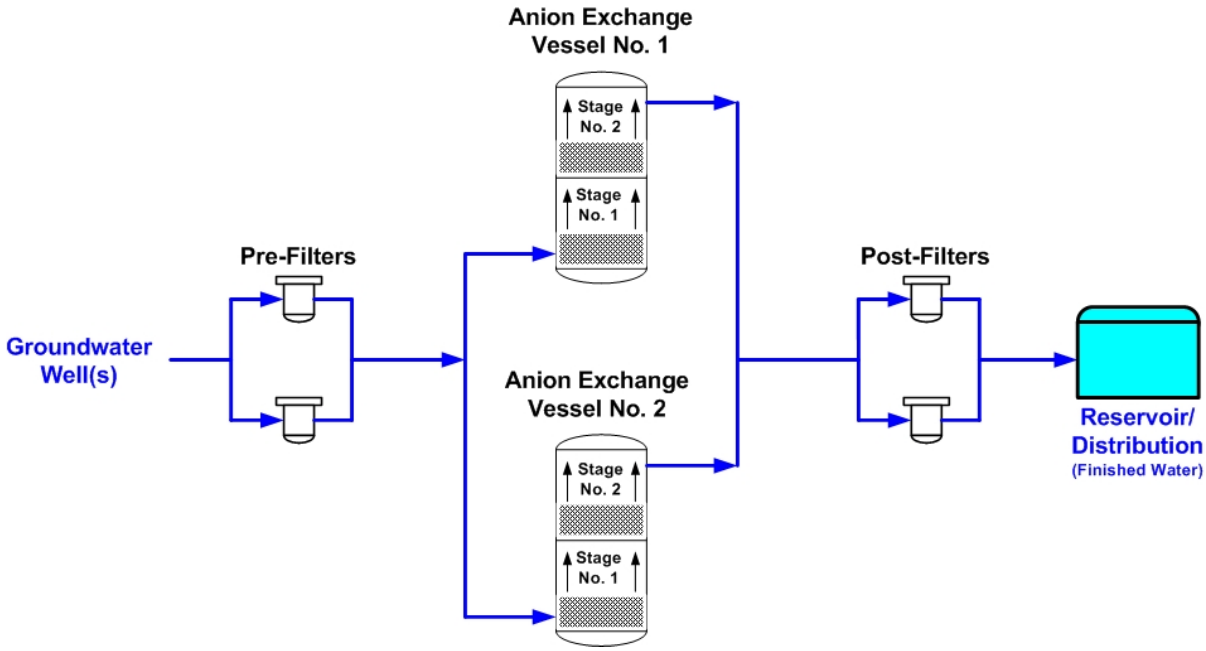

FIGURE 2. WRT Anion Exchange Treatment

The IX suppliers for uranium removal offer operations, maintenance, and disposal support for radionuclide removal systems. The suppliers establish long term contracts (i.e. 10 year, 15 year, 20 year, etc.) with municipalities that require the supplier to monitor the water quality results flowing into and out of the IX system and replace the media at a predetermined exhaustion threshold. The supplier is responsible for removing, packaging, transporting, and disposing of the spent media. The supplier is also responsible for retaining staff that is trained in handling radioactive wastes of this nature. Certain suppliers have intimate knowledge of the abundant regulations surrounding the handling, transportation, and disposal of wastes containing radionuclides. Under such a contract, it is the responsibility of the supplier to meet all of these regulations, including those of the radionuclides rule.

The IX process is a potentially viable method for removing uranium from the groundwater supply and it is listed as a BAT by the U.S. EPA. IX suppliers can provide long term operation and maintenance contracts at a reasonable cost. IX has been shown to be successful at pilot plants and full-scale facilities for uranium removal. For these reasons, a non-regenerating IX system will be considered for additional evaluation and compared with other viable treatment processes with respect to cost.

Reverse Osmosis

Reverse Osmosis (RO) is a treatment process that can effectively remove dissolved uranium from a drinking water supply. The process is listed as a BAT for uranium removal by the U.S. EPA.

RO treats water by maintaining a pressure gradient across the membrane greater than the osmotic pressure of the feed water. The osmotic pressure increases as dissolved solids (salts) build up on the membrane. The majority of the feed water passes through the membrane;

however, the remainder is discharged along with the rejected contaminants as a concentrated waste stream. Depending on the raw water quality and the properties of the membrane used, the volume of the discharge concentrate can be substantial, between 10 and 30 percent of the total influent flow.

RO performance can be adversely affected by the presence of turbidity, iron, manganese, silica, scale-producing compounds, and other constituents. Therefore, RO often requires extensive pretreatment for particle removal, and occasionally for dissolved constituents. Pretreatment requirements can add to the cost of an RO process. For this evaluation, media filtration may be sufficient for pretreatment. However, if RO is selected as the preferred treatment alternative, additional evaluation is necessary.

The RO process requires a significant amount of operator skill and attention due to the pretreatment systems and the sensitive nature of RO membranes. The high quality treated water from an RO process can be blended with the raw water supply to reduce costs and produce a finished water of acceptable quality. See *FIGURE 3* for a process flow diagram of an RO system for this application.

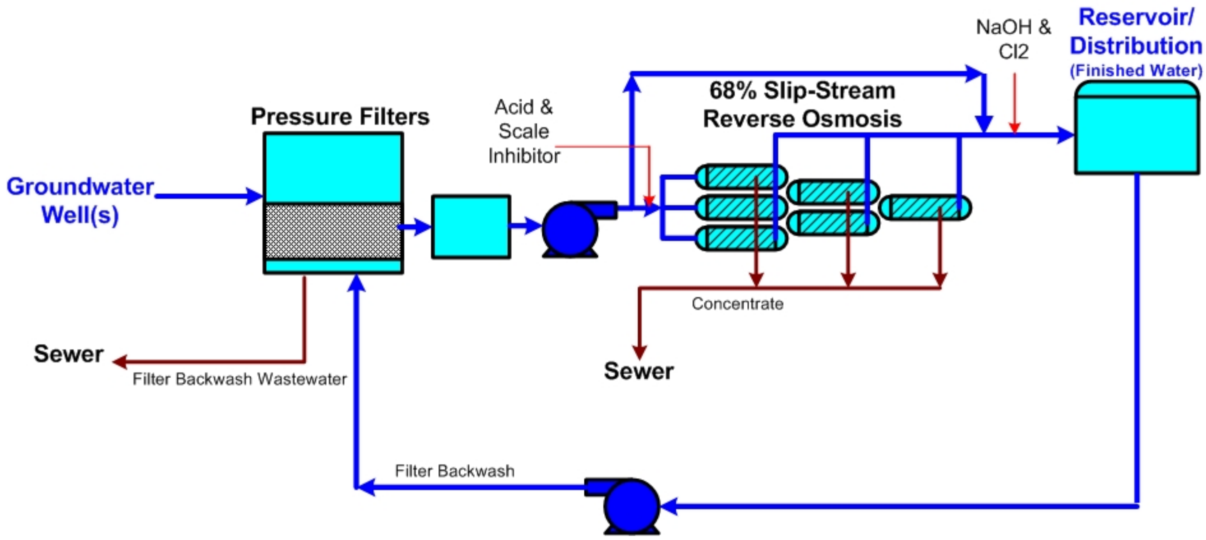

FIGURE 3. Reverse Osmosis Treatment

The waste products from an RO facility include both liquid and solid wastes. The liquid waste streams are comprised of backwash waste from the pretreatment membranes and concentrate from the RO membranes. The solid waste consists of used membranes. Possible disposal options for the liquid waste include discharge to the sanitary sewer or solids drying beds. The membranes typically last three to four years before replacement is required. When the time comes to replace the membranes, they would be disposed of in a solid waste facility.

The RO process is a potentially viable method for removing uranium from the groundwater supply and it is listed as a BAT by the U.S. EPA. For these reasons, RO will be considered for additional evaluation and compared with other viable treatment processes with respect to cost.

Lime Softening

Lime Softening (LS) is a treatment process that can effectively remove uranium from a drinking water supply. The process is listed as a BAT for uranium removal by the U.S. EPA.

LS has been widely used for reducing hardness (typically calcium and magnesium) in large volume water treatment systems. The hardness is removed by creating a shift in the carbonate equilibrium. The addition of lime to water raises the pH. Bicarbonate is converted to carbonate as the pH increases, and as a result, calcium is precipitated as calcium carbonate. Softening for calcium removal is typically accomplished at a pH range of 9 to 9.5. For magnesium removal, lime is added beyond the point of calcium carbonate precipitation to form magnesium hydroxide precipitates. This occurs at pH levels greater than 10.5. At these pH levels, uranium removal rates exceed 80 percent.[4] If the pH of the softened water is excessively high, neutralization is required for potable use. Common methods of pH adjustment include recarbonation with carbon dioxide (CO_2) or adding sulfuric acid. Removal of uranium by LS is pH dependent. As lime is added and pH rises, the removal rate of uranium increases. Removal rates of 85 percent or more can be achieved if pH is maintained above 10.5.

Sedimentation basins are required after the addition of lime to remove the chemical solids created. In addition, filtration would also be required to remove solids and turbidity that carry-over from the sedimentation process.

Considerable amounts of sludge are produced in a LS system and disposal can be expensive. A LS system is extremely operator intensive. Addition of the various chemicals used for LS requires a significant amount of operator attention. For these reasons, and because LS is an additional and costly step to C/F, LS was not considered for additional evaluation.

Granular Ferric Hydroxide

Granular Ferric Hydroxide (GFH) has not been tested for uranium removal and the process is not listed as a BAT with the U.S. EPA. The manufacturers of this product are doubtful of its capability to remove uranium from water. For these reasons, GFH was not considered for additional evaluation.

Alternative Media - Brimac 022060

Brimac 022060, manufactured by Brimac Carbon Services in Scotland, is an alternative media that could potentially be used for uranium removal. It is a granular activated material with an active surface, similar to GAC. The active surface for Brimac 022060 media is a combination of carbon and hydroxyapatite, a calcium phosphate. The media is made from processed animal bones. It has been designed to adsorb a variety of organic and inorganic substances. It has been used in Europe to treat a variety of drinking water issues, such as removing heavy metals, color, disinfection byproducts, and taste and odor compounds.

There are no full scale operating facilities in the world that uses Brimac 022060 media for uranium removal. Currently, there is a pilot study in Sweden that is testing the efficacy of

[4] Clifford, Dennis. University of Houston. Presentation from U.S. EPA website: "Fundamentals of Radium and Uranium Removal from Drinking Water Supplies".

Brimac 022060 media for uranium removal. However, results from this pilot study are not yet available.

As described in the preceding sections, there are several other treatment technologies that have proven pilot and full-scale history than the Brimac 02260 media. For these reasons, Brimac 02260 media was not considered for additional evaluation.

Residuals Management

Managing residuals containing uranium from a water treatment process is a key consideration for this evaluation. The nature and composition of the waste residual determine its potential disposal options. Characterizing the waste often depends on many site-specific factors, including:

- Uranium concentration in the source water.
- Removal efficiency of the treatment process.
- Volume of residual waste generated.
- Form of residual waste (e.g. liquid or solid).

Treatment of water containing naturally occurring radionuclides results in residual waste streams classified as “technologically enhanced naturally occurring radioactive materials”, or TENORM. Typically, TENORM is defined as naturally occurring materials such as rocks, minerals, soils, and water whose radionuclide concentrations or potential for exposure to humans or the environment is enhanced as a result of human activities, such as water treatment.

There are numerous federal, state, and local regulations governing waste containing radionuclides. The interaction between these regulations is complex. It is important to understand these regulations to properly classify and dispose of radioactive wastes in order to minimize danger to public health and safety.

The treatment alternatives evaluated produce either a liquid waste stream or solid waste, both containing TENORM. The disposal methods for the liquid waste stream are by either sanitary sewer discharge or solids drying beds. The disposal methods for the solid waste are by either transporting to an authorized solid waste facility or to a uranium reprocessing facility.

In addition to evaluating disposal options, regulations governing exposure to radionuclides were evaluated. It is important to understand these regulations to minimize danger to operations staff of the uranium treatment facilities.

Regulations governing the following topics were evaluated to determine viable disposal alternatives:

- Radioactive Waste Classification, Regulating Authority, and Required License
- Liquid Waste Disposal
- Solid Waste Disposal

- Exposure to Radionuclides

Radioactive Waste Classification, Regulating Authority, and Required License

When handling and disposing of radioactive wastes, it is important to understand the following:

- How will the waste be classified?
- What agency will regulate disposal?
- What licenses will be required for disposal?

Following is a brief discussion on the waste classification for uranium, the regulating authority, and the required licenses to handle and dispose of the radioactive waste. See APPENDIX B for a detailed presentation of the regulations governing these topics.

The waste residuals from uranium treatment in this application would likely be classified as a Low-Level Radioactive Waste (LLRW) as defined in Chapter 42 of the U.S. Code (USC), Section 2021b(9) [42 USC 2021b(9)]. In addition, the natural uranium in the LLRW produced in this application would likely be classified as "*source material*" as defined in 42 USC 2014(z) and in New Mexico Administrative Code (NMAC) [20.3.1.7(CZ) NMAC].

New Mexico is an "*agreement state*" and consequently has authority from the Nuclear Regulatory Commission (NRC) to regulate disposal of LLRW generated by this application. New Mexico requires either a *general license* or *specific license* for the possession and disposal of radioactive material. These licenses are regulated under 20.3.3 NMAC and in Title 10, Part 40, of the Code of Federal Regulations (10 CFR 40).

According to this regulation, under a *general license* no more than 15 pounds of uranium can be held by the City of Las Cruces, including all treatment facilities, at any one time. Also, the City may not dispose of more than 150 pounds of uranium in a calendar year.

It is unlikely that E-C/F or RO facilities would contain more than 15 pounds of uranium at any one time in this application. However, at a yearly utilization rate of 50 percent for each well and no bypass/blending operations, the total amount of uranium disposed of by all E-C/F or RO processes may exceed the *general license* limitation of 150 pounds per year (see APPENDIX B).

The non-regenerating IX treatment alternative would most likely require a *specific license* since the media is only exchanged every year or more causing the total uranium held by the City to exceed 15 pounds. In addition, at a yearly utilization rate of 50 percent for each well and no bypass/blending operations, the total amount of uranium disposed of by all non-regenerating IX processes may exceed the *general license* limitation of 150 pounds per year (see APPENDIX B).

It appears likely that the City would be required to obtain a *specific license* from NMED to operate uranium treatment facilities and dispose of the uranium wastes for the selected wells. However, it will not be certain which type of license would be required until a treatment alternative is selected and the variable parameters are defined.

Provisions for filing an application to NMED for a *specific license* can be found under 20.3.3.307 NMAC. Key elements of this provision include:

- License must be acquired before construction of any facilities.
- An environmental impact report would be required that specifically addresses the short-term and long-term environmental, radiological, and public health and safety aspects of the uranium treatment facilities.

General requirements for obtaining a *specific license* from NMED are outlined in 20.3.3.308 NMAC. A couple of these requirements include:

- Applicant shall have proper experience and training to use the radioactive materials in such a manner as to minimize danger to public health and safety.
- The equipment, facilities, and procedures of the applicant are adequate to minimize danger to public health and safety.

These regulations would allow NMED to assess the ability of the City to operate uranium treatment facilities prior to issuing a *specific license*. As part of this license, NMED may require the City to retain staff that are certified and trained to operate, maintain, transport, and otherwise handle radioactive residuals. Such requirements would incur additional operational costs to those normally observed in more conventional water treatment facilities.

Liquid Waste Disposal

The liquid backwash waste from an E-C/F facility or concentrate from an RO process treating for uranium will contain elevated levels of uranium, or TENORM. Disposal options for such waste include the sanitary sewer system or solids drying beds.

Disposal of liquid wastes to solids drying beds requires surface impoundments adequately designed to prevent leakage of concentrated uranium wastes into the groundwater supply. The size of the beds can significantly affect the capital cost of this disposal option, particularly if land acquisition is required. After the liquid waste dries, the solids deposited have to be removed and disposed of as a radioactive solid waste. For additional information regarding the disposal of dried solids, see the Solid Waste Disposal section of this report.

The following discussion evaluates the federal, state, and local requirements surrounding sanitary sewer discharge of liquid residuals containing TENORM.

Federal and State Sewer Discharge Requirements

The Nuclear Regulatory Commission (NRC) addresses discharge of radioactive wastes to the sanitary sewer system in 10 CFR 20.2003. NMED addresses such discharges in 20.3.4.435(A) NMAC. Sanitary sewer disposal is allowed if specified requirements on solubility, maximum radionuclide concentrations, and total radionuclide discharge quantities are met. Although it would need to be confirmed through pilot testing, it appears that the E-C/F and RO treatment processes would meet the requirements for liquid disposal to the sanitary sewer (see APPENDIX C for a detailed presentation of these regulations).

If disposed to the sanitary sewer, the uranium would either be removed in the sludge of the wastewater treatment plant or pass through to the treated effluent. The concentration of uranium in the receiving water body of the wastewater treated effluent is regulated by 20.6.4.900 NMAC. This regulation requires that the dissolved uranium concentration in the receiving water body shall not exceed 5,000 μg/L. Therefore, the uranium that passes through the wastewater treatment plant can not cause the concentration to exceed this limit. It is estimated that the sanitary sewer discharges will increase the uranium concentration in the WWTP effluent. These calculations conservatively assume that no uranium will be removed at the WWTP.

If sewer disposal is selected for this application, the wastewater treatment plant will likely receive more than 150 pounds of uranium in a year from the uranium treatment facilities (see APPENDIX B for uranium disposal estimates). Therefore, if the plant receives more than 150 pounds of uranium in a year, it is likely that the plant will dispose of more that 150 pounds in a year, either in the form of sludge or treated effluent. If uranium accumulates in the sludge, the plant may exceed the 15 pounds possession limit of a *general license*. Exceeding either of these limits would require that the City obtain a *specific license* from NMED to operate uranium treatment facilities.

Local Sewer Discharge Requirements

The City of Las Cruces addresses waste discharge requirements to the sanitary sewer system in municipal code Chapter 28, UTILITIES. The most specific reference to governing the disposal of radionuclides in the sanitary sewer system occurs in Section 28-189, General discharge prohibitions. This section states:

> *(a) No person shall discharge or cause to be discharged the following described substances, materials, waters or wastes into the sewer system if it appears likely, in the opinion of the control authority, that such wastes can cause interference with or harm the POTW; can have an adverse effect on the receiving stream; or can otherwise endanger life, limb, public property, or constitute a nuisance. In forming an opinion as to the acceptability of these wastes, the control authority will give consideration to such factors as the quantities of subject wastes in relation to flows and velocities in the sewers, materials of construction of the sewers, nature and capacity of the POTW, degree of treatability of wastes in the POTW and other pertinent factors. The substances which must be considered include but are not limited to the following:*
>
> > *(13) Any wastewater containing any radioactive wastes or isotopes of such half-life or concentration as may exceed limits established by the control authority in compliance with applicable state or federal regulations.*

The regulation indicates that once state and federal disposal requirements are met, the *control authority* determines whether or not the waste will be accepted for disposal in the sanitary sewer system. The term "*control authority*" is defined in the regulations as "*…the city manager or his designated representative.*"

In order to dispose of liquid wastes containing radionuclides from an E-C/F or RO facility in the sanitary sewer system of the City of Las Cruces, the waste must comply with the following:

- Meet all state regulations governing disposal of liquid wastes containing radionuclides in a sanitary sewer system.

- Meet all federal regulations governing disposal of liquid wastes containing radionuclides in a sanitary sewer system.
- Obtain a *specific license* from NMED.
- Adhere to the requirements of the *control authority* by obtaining permitted authorization for disposal of liquid wastes containing radionuclides in the sanitary sewer system.
- Ensure that the liquid waste shall not interfere with the ability of the wastewater treatment plant to meet its NPDES permit.
- Ensure that the liquid waste shall not cause the uranium concentration of the receiving water body of the wastewater treated effluent to exceed 5,000 μg/L.

Regulations governing disposal of drinking water residuals from uranium treatment processes are not well developed. If regulations are developed in New Mexico to control the disposal of radionuclide wastes to the sanitary sewer, it may be difficult, if not impossible, to continue such discharge operations.[5] However, there is no timeline for these regulations at present; therefore, sewer discharge is a potential disposal option.

Solid Waste Disposal

The exhausted media waste from a non-regenerating IX system or dried solids from the liquid wastes of E-C/F or RO processes treating for uranium will contain elevated levels of uranium, or TENORM. Disposal options for such waste include an authorized solid waste facility or a uranium reprocessor. The following discussion evaluates the federal, state, and local requirements surrounding disposal of a solid waste containing natural uranium to a solid waste facility. In addition, the alternative of disposing to a uranium reprocessor is also discussed.

Federal and State Requirements for Solid Waste Disposal

NMED is responsible for regulating the disposal of radioactive wastes since New Mexico is an *agreement state*. NMED establishes waste classification criteria for radionuclide wastes under 20.3.13.1324 NMAC. The NRC regulates waste classification criteria for radionuclide wastes under 10 CFR 61.55. According to this regulation, the exhausted media from an IX system in this application would be *Class A* waste. Wastes with radionuclides are considered *Class A*, according to 20.3.13.1324 (F) NMAC, if the waste does not contain any of the nuclides listed in either table 1324.1 or table 1324.2 of 20.3.13.1324 (C and D). Uranium is not listed in either of these tables. *Class A* waste has certain packaging requirements as regulated under 20.3.13.1325.

The commercial solid waste disposal facilities in New Mexico are regulated under 20.9.1 NMAC. Section 107 (I) [20.9.1.107(I)] of this regulation lists a prohibited act regarding radioactive waste disposal as follows:

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[5] According to Water Remediation Technology (WRT), an IX system supplier for uranium removal, the California Department of Health Services (DHS) is expected to eliminate the alternative of disposing of backwash wastewater containing radionuclides in the sanitary sewer.

20.9.1.107 PROHIBITED ACTS: No person shall:

> *I. process, recycle, transfer, transform, or dispose of radioactive waste including low level radioactive waste in a solid waste facility; however, nothing in this section shall prohibit the storage or disposal of radioactive materials or radioactive waste from a uranium mine or mill pursuant to a license or other authorization from the United States nuclear regulatory commission or the state;*

Discussions with NMED staff concluded that there are no commercial facilities in New Mexico that are permitted to accept radioactive wastes. NMED understands the problem this poses to disposing of drinking water residuals containing TENORM. However, regulations have not yet been developed to cover such wastes.

There are a few solid waste facilities within the Unites States that accept radioactive wastes, including LLRW, that meet certain disposal criteria. Some of these facilities include:

- Envirocare of Utah,LLC, in Salt Lake City, UT (http://www.envirocareutah.com/)
- Waste Control Specialists in Andrews, TX (http://www.wcstexas.com/)
- U.S. Ecology, 3 locations (http://www.americanecology.com/)
    - Richland, WA
    - Grand View, ID
    - Robstown, TX

It is likely that many of these solid waste facilities will only accept large volumes of waste from consolidated sources. These facilities don't often contract with clients disposing of the small waste quantities as expected in this application. If a treatment alternative is selected for pilot testing, which requires the City to manage disposal of waste at a solid waste facility, additional analysis is required to determine costs, benefits, and ability to dispose of the solid waste at these facilities in this application.

Transporting radioactive wastes is regulated by several federal and state agencies in order to minimize danger to public health and safety. There are regulations from the U.S. Department of Transportation (DOT) that govern the shipping, labeling, and transport of radioactive waste. These regulations are covered under 49 CFR 171 to 180. NMED regulates transport of such wastes under 20.3.4 NMAC. The NRC governs the packaging and transport of radioactive wastes under 10 CFR 71. If a treatment alternative is selected for pilot testing, which requires the City to manage transport of radioactive wastes, these regulations must be carefully evaluated to ensure compliance and minimize the potential for causing harm to the public.

Local Requirements for Solid Waste Disposal

The City of Las Cruces does not specifically addresses radionuclide waste disposal requirements to a solid waste facility in municipal code Chapter 25, SOLID WASTE. Therefore, it is assumed that the City defers regulation to the federal and state levels.

Disposal by Uranium Reprocessing

Disposal of IX media to a uranium reprocessor is a potential solid waste disposal option. However, disposal of dried solids from solids drying beds may not be acceptable to reprocessing facilities; therefore, additional evaluation is required to determine the viability of this disposal option.

Some advantages of disposing of IX media to a uranium reprocessing facility include:

- Likely to be less expensive than disposing of waste in an authorized solid waste facility.
- The City would relinquish responsibility for the waste once it is received by the uranium reprocessor.
- Permitting requirements for disposal in an authorized solid waste facility would be eliminated.
- Likely the most environmentally conscious alternative since the uranium is extracted and used by an authorized facility instead of being stored in a solid waste facility where leakage containment is of concern.

Disposing of radioactive wastes to a uranium reprocessor still requires an entity to abide by all applicable federal, state, and local regulations governing the operation, handling, and transport of these wastes. These regulations may include the following:

- Develop a radiation control program to safely manage the radioactive materials in the operation.
- Acquire a *specific license* to handle and dispose of radioactive wastes.
- Maintain staff adequately trained in handling, transporting, and disposing of radioactive wastes.

In addition to these regulations, a contract would have to be developed with a uranium reprocessor to establish disposal guidelines and acceptance criteria.

There are some IX system suppliers that are in the process of developing these contracts with uranium reprocessors. A service that these suppliers offer is a long-term operation, maintenance, and disposal contract that requires them to handle, transport, and dispose of the exhausted media to a uranium reprocessing facility. Some advantages of this service include:

- The IX system supplier, not the City, is responsible for meeting all federal and state regulations governing radioactive waste handling, disposal, and transportation.
- The IX system supplier, not the City, develops and maintains the contract with the uranium reprocessor.
- The IX system supplier, not the City, handles and transports the radioactive wastes.
- The IX system supplier, not the City, is responsible for developing a radiation control program.

- The IX system supplier, not the City, is responsible for acquiring a *specific license*.
- The IX system supplier, not the City, maintains staff trained in disposal of radioactive wastes.
- The IX system supplier guarantees the system will meet effluent water quality standards.

These advantages make this service attractive. However, a long-term contract with an IX system supplier would be required.

Exposure to Radionuclides

The intent of the Radionuclides Rule is to reduce exposure to radionuclides in drinking water in order to reduce the risk of cancer and improve public health protection. Therefore, it is important to understand the regulations pertaining to radionuclide exposure.

The NRC and NMED have regulations that limit exposure to radionuclides for occupational staff and the public. Since New Mexico is an *agreement state*, NMED is responsible for enforcement of NRC regulations.

The NRC dose limits for occupational staff are regulated under 10 CFR 20.1201, while NMED regulates by 20.3.4.405 NMAC. These regulations limit the total annual effective dose for an individual adult occupational worker to 5 rem (5,000 mrem). The estimated exposure to an operator of a non-regenerating IX system would be less than 4 mrem per year.[6] This assumes the operator is within the effective vicinity of the IX vessels 90 hours per year. This amount of exposure is well within the regulated limits.

The NRC dose limits for members of the public are regulated under 10 CFR 20.1301, while NMED regulates by 20.3.4.413 NMAC. These regulations limit the total annual effective dose for an individual member of the public 0.1 rem (100 mrem). Since the estimated exposure to an operator of a non-regenerating IX system would be less than 4 mrem per year, it is expected that public exposure will not be an issue.

Even though the estimated cumulative radiation dose is low, strategies may need to be implemented to monitor operator exposure. In addition, written guidelines will be required for operational procedures which could result in the operator handling exposed spent ion exchange resin.

Any treatment alternative for uranium removal must include a radiological monitoring program. These programs typically include time logs, dosimetric badges, and regular emissions testing. A detailed evaluation of the federal, state, and local requirements for public and worker protection from radiation should be conducted prior to implementation of this project.

PCE Treatment

The City of Las Cruces operates several groundwater wells used for drinking water that contain tetrachloroethylene (PCE), a volatile organic carbon (VOC). Tetrachloroethylene is a

[6] As determined by Water Remediation Technology (WRT), an IX system supplier for uranium removal.

manufactured chemical that is widely used for dry cleaning of fabrics and for degreasing of metals. It is also used to make other chemicals and in the manufacture of some consumer products. Other names for PCE include perchloroethylene and tetrachloroethene.

The U.S. EPA has designated the City and Doña Ana County as the potentially responsible parties (PRPs) for the Griggs-Walnut PCE Contaminant Plume and is requiring that the City institute a program to remediate the PCE in the groundwater supply. The City and County, in collaboration with the U.S. EPA, are conducting a Remedial Investigation/Feasibility Study (RI/FS). In addition, the U.S. EPA has established a drinking water MCL for PCE of 5 μg/L, and a MCLG of zero. The purpose of the MCL is to reduce exposure to PCE in drinking water in order to reduce the risk of cancer and protect public health.

The City operates four groundwater wells that contain PCE. See TABLE 4 for a summary of PCE water quality data for affected wells. This data summary includes all wells operated by the City that are known to contain PCE, except for Well No. 24. However, this well was not considered in the evaluation because it is expected to be abandoned in the future. For complete water quality information of these wells, see APPENDIX A.

TABLE 4
Summary of PCE Water Quality Data – Affected Wells(2)

Well No. >	18(1, 3)	19(1, 4)	21(4)	27(4)
Flow (gpm) >	500	750	1,000	650
	PCE (μg/L)	PCE (μg/L)	PCE (μg/L)	PCE (μg/L)
Maximum	50.2	5.1	6.0	7.8
Minimum	14.0	2.0	1.6	3.8
Average	32.2	3.4	3.8	5.2

(1) Well currently out of service.

(2) Well data includes all wells operated by the City of Las Cruces that are known to contain PCE. Source of well data from City of Las Cruces.

(3) Well No. 18 is considered for well head treatment for the purposes of this analysis. However, during implementation, this well could be centralized with other wells near the UGR.

(4) Wells considered for centralized treatment.

Wells No. 19, 21, and 27, are considered for centralized treatment at the Upper Griggs Reservoir (UGR) because of their proximity to this area. Wells No. 21 and 27 already have piping going to UGR and Well No. 19 is located nearby. Well No. 18 is considered for well head treatment for comparison purposes only. It is possible to install the transmission piping to use Well No. 18 at a centralized facility such as UGR.

Treatment Process Alternatives

In order to comply with the remediation mandate by the U.S. EPA, the City is evaluating treatment alternatives that can remove PCE from affected wells. The evaluation intends to recommend one or two treatment alternatives for pilot testing. The following treatment process alternatives were evaluated for PCE removal:

- Air Stripping
- Liquid-Phase Granular Activated Carbon (GAC) Adsorption
- Advanced Oxidation Process (AOP)

Air Stripping

Air stripping has been used successfully in many applications to remove a volatile organic carbon (VOC), such as PCE, from a water source. The process operates by partitioning the VOC from the water source by greatly increasing the surface area of the source water exposed to air. Henry's Law constant is used to determine whether air stripping will be effective. Henry’s Law constant is a measure of the extent to which a chemical separates between water and air. The higher the Henry’s Law constant, the more likely substances will volatize rather than remain in water. Compounds with low volatility at ambient temperature may require preheating of the groundwater. Generally, organic compounds with constants greater than 0.01 atmospheres – m^3/mol are considered amenable to stripping. The Henry’s constant for PCE at a temperature of 18 degrees Celsius (assumed groundwater temperature) is 0.0124 atmospheres – m^3/mol (U.S. EPA website). This makes PCE a good candidate for air stripping. However, the site specific Henry’s constant should be verified by bench-scale testing.

A concern with most air stripping methods is fouling. Fouling can decrease the performance and efficiency of the air stripping process. Fouling can occur when metals are oxidized or scale is produced from hardness. When metals (e.g. iron and manganese) are oxidized, particulates can form that plug the process. This typically becomes a concern when the iron and manganese concentrations exceed 30 mg/L. There is water quality data available for two of the four wells being considered for PCE treatment. Each of these wells has an iron and manganese concentration less than 0.10 mg/L. Therefore, fouling of the process from metals oxidation is not expected.

When hardness elements (e.g. calcium, magnesium, and other salts) precipitate out of solution, the scale products can obstruct the passage of air through the process. If this type of fouling occurs, pretreatment methods can be used to minimize scale build-up. Available pretreatment methods include:

- Precipitate hardness elements out of solution and remove prior to air stripping.
- Add an acid to suppress the pH prior to air stripping to prevent hardness elements from precipitating out of solution.
- Add sequestering agents prior to air stripping to prevent hardness elements from precipitating out of solution.

An alternative to using pretreatment methods to minimize scale build-up is to periodically clean the air stripper. However, some air stripping processes are more easily cleaned than others.

There are several types of aeration methods used to strip VOCs from water. The following air stripping alternatives were evaluated for PCE removal in this application:

- Packed Tower Aeration (PTA)
- Diffused Aeration
- Tray Aeration
- GDT™ (Gas Degas Technology) Process by Mazzei®

If post-treatment of the PCE gas is required after air stripping, a Vapor-phase Granular Activated Carbon (GAC) Adsorption system can be implemented. This system would mitigate the potential for releasing PCE gas into the atmosphere.

Packed Tower Aeration (PTA)

Packed Tower Aeration (PTA) is a treatment process that can be used to remove PCE from a drinking water supply. The process is listed as a BAT for PCE removal by the U.S. EPA.

PTA operates by spraying source water through a spray nozzle located at the top of a tower which contains a specially designed packing material. As the water descends through the packing, air is forced up through the column, stripping off the volatile compounds. The packing within the tower increases the surface area of the source water that is exposed to air. The additional surface area allows for volatilization of the VOC. A sump at the bottom of the tower collects the treated water. See *FIGURE 4* for a process flow diagram of the PTA process.

The packing material of a PTA system can be difficult to clean if fouling occurs from oxidized metals or scale build-up from hardness. The packing is cleaned by pumping an acid solution through the tower to wash the media. The spent acid solution must be handled and disposed of as a hazardous waste. If excessive fouling occurs, the packing may need to be removed manually and cleaned or replaced with new material.

The towers of a PTA process make this alternative more visible than other air stripping methods, such as diffused aeration and tray aeration. The towers range in diameter from 6 feet to 13 feet. The height of the towers is directly related to the desired removal efficiency. A removal efficiency of 95 percent requires a tower height of approximately 40 feet. The excessive height could limit the viability of this treatment alternative if negative public feedback is received.

PTA is more expensive than other air stripping methods, such as tray aeration, and is not frequently implemented because of advancements in other air stripping methods. However, PTA is listed as a BAT by the U.S. EPA and it has been used successfully in the past to remove PCE from groundwater sources. For these reasons, PTA will be considered for additional evaluation and compared with other viable treatment processes with respect to cost.

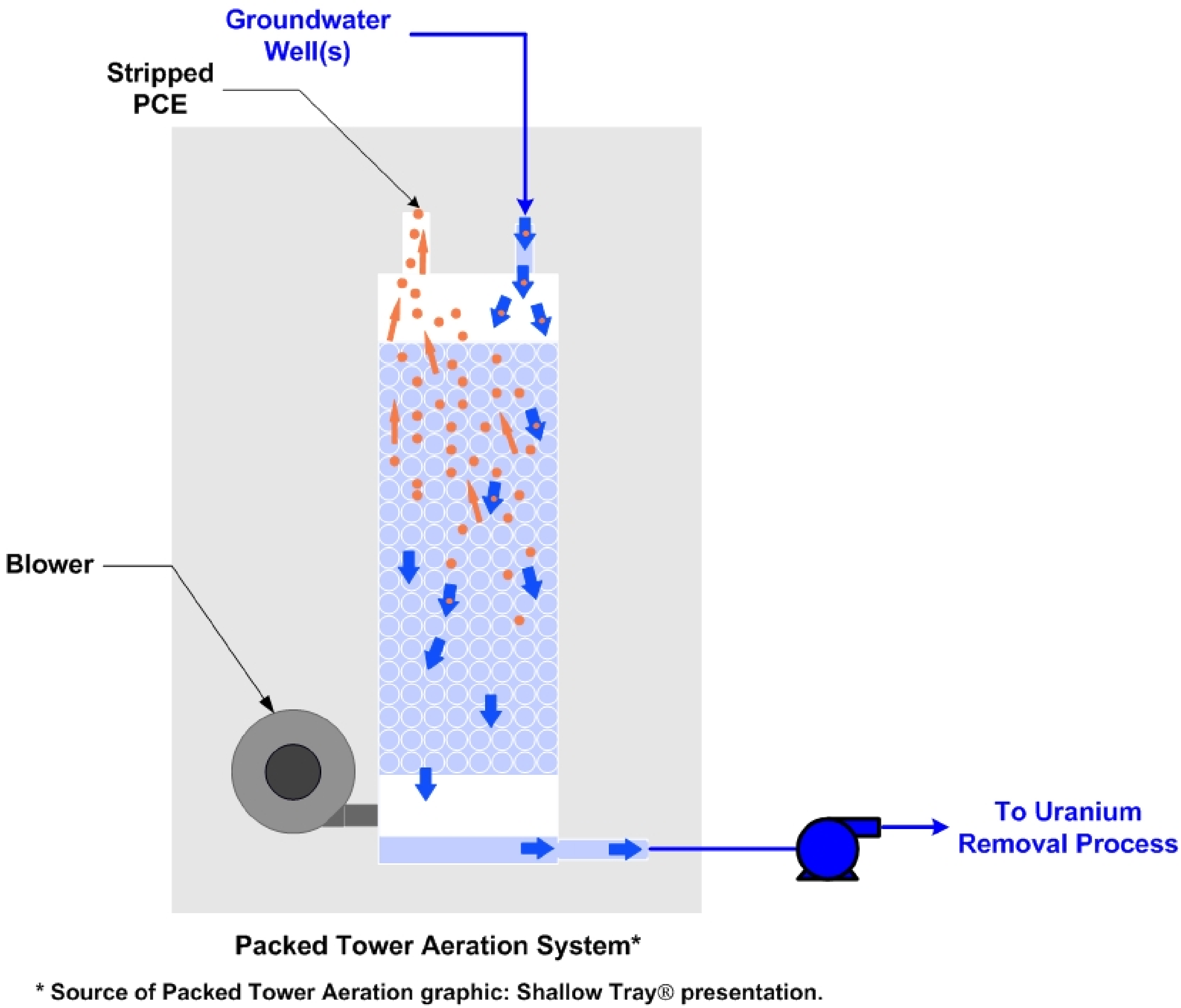

FIGURE 4. Packed Tower Aeration (PTA) Treatment

Diffused Aeration

Diffused aeration is a treatment process that can be used to remove VOCs from a drinking water supply. Diffused aeration operates by diffusing air into the source water in order to increases the surface area of the water that is exposed to air. The additional surface area allows for volatilization of the VOC. A diffused aeration system consists of segmented basins and high pressure blowers. The source water enters each stage of the basin while air is pumped into the basin from the bottom through small tubes. Typically a basin depth of 10 to 12 feet is necessary to provide the adequate contact time for effective volatilization of the VOC.

The tubes used in a diffused aeration system can be difficult to clean if fouling occurs from oxidized metals or scale build-up from hardness. In order to clean the tubes, the process has to be shut down and the basins have to be emptied.

The blowers used in a diffused aeration system are both larger and have a higher horsepower than blowers used on other air stripping methods. These large and powerful blowers are more expensive and emit more noise than the smaller, lower pressure blowers used in a tray aeration system. For these reasons, diffused aeration was not considered for additional evaluation.

Tray Aeration

Tray aeration is a treatment process that can effectively remove PCE from a drinking water supply. Tray aeration operates by forcing counter-current air through horizontally extended trays to strip VOCs, such as PCE, from water. See *FIGURE 5* for a process flow diagram of the tray aeration process.

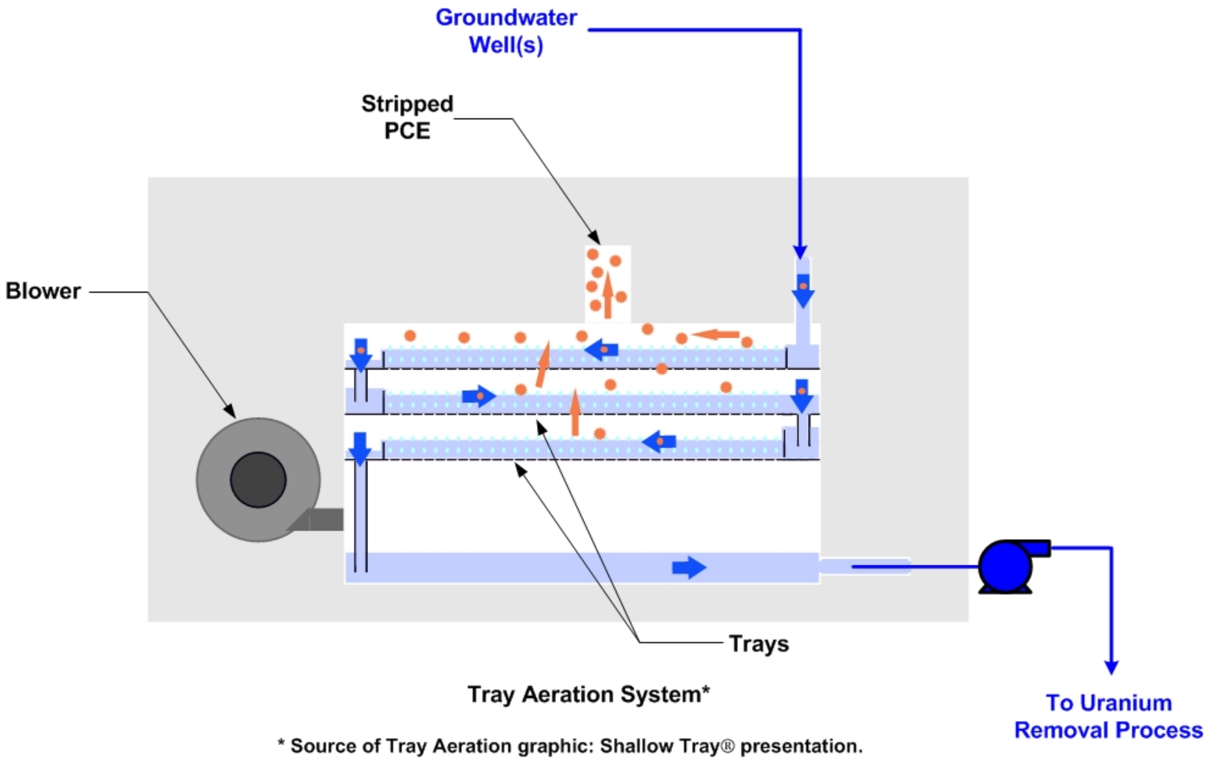

FIGURE 5. Tray Aeration Treatment

The groundwater is sprayed into an inlet chamber through a coarse mist spray nozzle. The water flows over a distribution weir and along the tray. Clean air is blown up through holes in the tray. The air and water forms a froth of bubbles which provides the surface area to allow mass transfer, or volatilization of the PCE. A certain contact or residence time is required to volatilize the PCE. The time varies according to model size, number of trays, and flow rate. The stripped gas flows up with the air and out the top of the unit for discharge to the atmosphere or collection and additional treatment. The water flows down through the holes in the trays where it is collected and pumped to the distribution system. This process can achieve removal rates in excess of 95 percent.

The trays of a tray aeration system are easily cleaned if fouling occurs from oxidized metals or scale build-up from hardness. The trays can be cleaned through access ports using a washing wand, pressure washer, or by an automated acid-wash system. Trays can also be completely removed for a more thorough inspection and cleaning. Another alternative is to have spare trays that can be exchanged for used trays that require cleaning. The fouled trays can be cleaned by operations staff as time permits without extended shut down times.

The tray aeration process has some advantages over other types of air strippers, such as PTA and diffused aeration. Some of these advantages include:

- Lower profile than PTA.
- A simple process which requires less maintenance.
- Packing is not required as in PTA.
- Noisy high pressure blowers are not required as in a diffused aeration process.
- Fouling can be managed by maintaining and cleaning trays.

For these reasons, tray aeration will be considered for additional evaluation and compared with other viable treatment processes with respect to cost.

GDT™ (Gas Degas Technology) Process by Mazzei®

The GDT™ (Gas Degas Technology) Process by Mazzei® is a system that can be used to remove VOCs from a drinking water supply. The GDT™ air stripping process operates by drawing air into the pressurized treatment stream via venturi-type injectors. Mixing occurs at the injector which transfers air (oxygen and nitrogen) into the treatment stream. The entrained air provides the surface area to allow mass transfer, or volatilization of the PCE. The stripped PCE gas is removed by the GDT™ degas separator before the gas can return to the treatment stream. The GDT™ degas separator operates as a centrifugal vortex unit that separates entrained gases (PCE, air, and nitrogen) from the water based on the density difference between the gases and the liquid. The water and gas mixture enters the top of the separator tangentially, forming a vortex. The water spins and flows down through the separator where it is discharged through an outlet at the bottom. The entrained gasses collect at the vortex where they pass through a collector and flow out the top of the separator. The separated gasses exit the top of the separator through a relief valve. The gases can either be discharged to the atmosphere or collected for additional treatment. See *FIGURE 6* for a process flow diagram of the GDT™ process.

The supplier of the GDT™ air stripping process indicated that two GDT™ systems in series are required to achieve 70% PCE removal in this application. A booster pump is required between each system because air is drawn into the process to reduce pressure to atmospheric in order to volatilize the PCE. The booster pump adds the pressure required to force the process water through the second series. After the second series, additional pumps would be required to transport water to additional treatment processes or the distribution system.

The GDT™ process requires multiple units in series to achieve PCE removal rates that are significantly less than more traditional air stripping methods, such as tray aeration. Operating multiple units in series requires additional pumping requirements. PTA and tray aeration appear to be a more efficient air stripping processes than GDT™. For these reasons, the GDT™ air stripping process was not considered for additional evaluation.

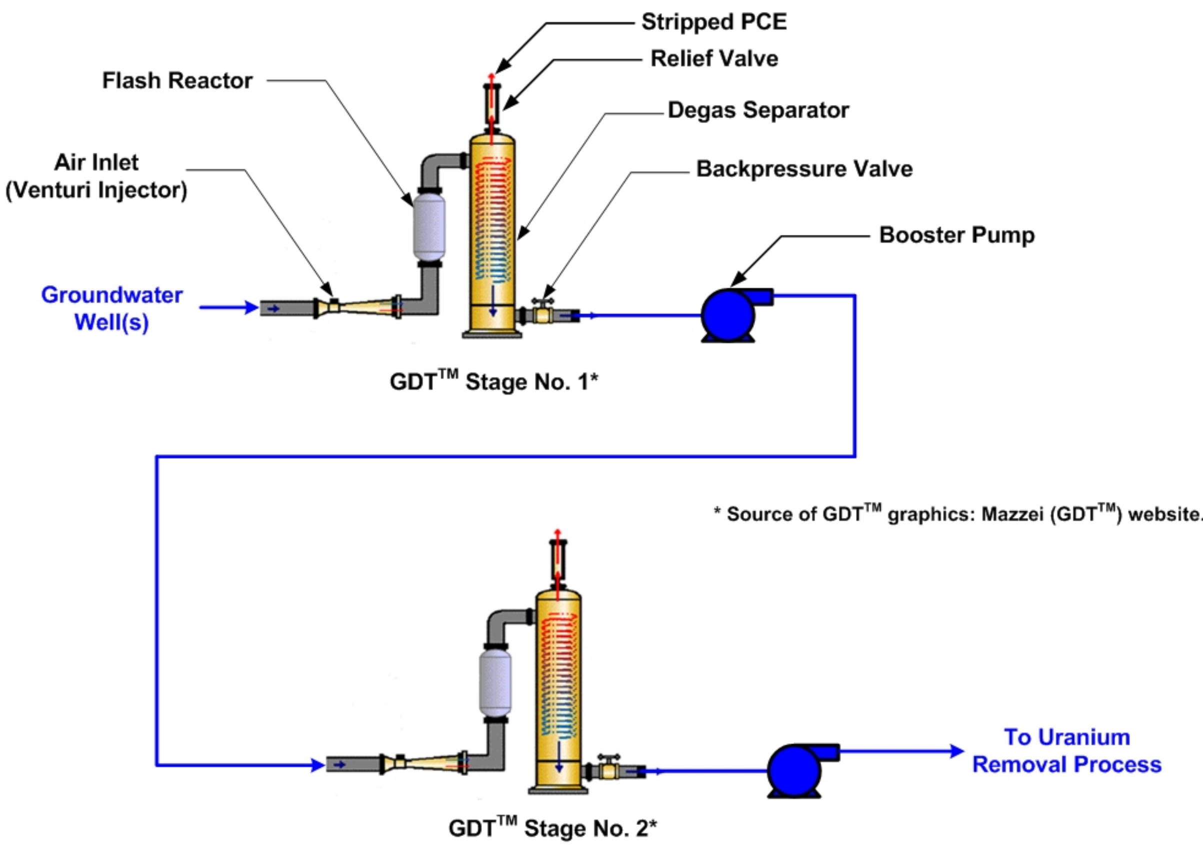

FIGURE 6. GDT™ Treatment

Liquid-Phase Granular Activated Carbon (GAC) Adsorption

Liquid-phase Granular Activated Carbon (GAC) Adsorption is a treatment process that can effectively remove PCE from a drinking water supply. The process is listed as a BAT for PCE removal by the U.S. EPA.

Liquid-phase GAC adsorption operates by pumping groundwater through one or more vessels containing GAC media. The activated carbon attracts and adsorbs organic molecules, such as PCE, as well as certain metal and inorganic molecules. The dissolved PCE molecules adsorb onto the surfaces of the activated carbon due to its porosity and large internal surface area. Water is passed through the vessels relatively quickly. When the concentration of PCE in the water exiting the vessels exceeds a certain level, the carbon must be replaced. Spent carbon can be regenerated in place, removed and regenerated at an off-site facility, or removed and disposed.

The liquid-phase GAC adsorption process is a potentially viable method for removing PCE from the groundwater supply and it is listed as a BAT by the U.S. EPA. For these reasons, liquid-phase GAC adsorption will be considered for additional evaluation and compared with other viable treatment processes with respect to cost.

Advanced Oxidation Process (AOP)

An Advanced Oxidation Process (AOP) that uses ozone and hydrogen peroxide is a treatment process that can effectively remove a variety of contaminants from a drinking water supply, including PCE. However, the process is more suited to treat contaminated water sources with recalcitrant contaminants that are difficult to remove.

The AOP operates by mixing ozone and hydrogen peroxide together in a reaction chamber to form hydroxyl radicals. The hydroxyl radical is a strong and short lived oxidizing agent. The oxidizer is injected into the source water stream at numerous locations and PCE is oxidized. In this application, the most likely byproducts of PCE oxidation include: chloride, carbon dioxide gas, and water. Ozone is typically generated on site using ozone generators. See *FIGURE 7* for a schematic of an AOP system.[7]

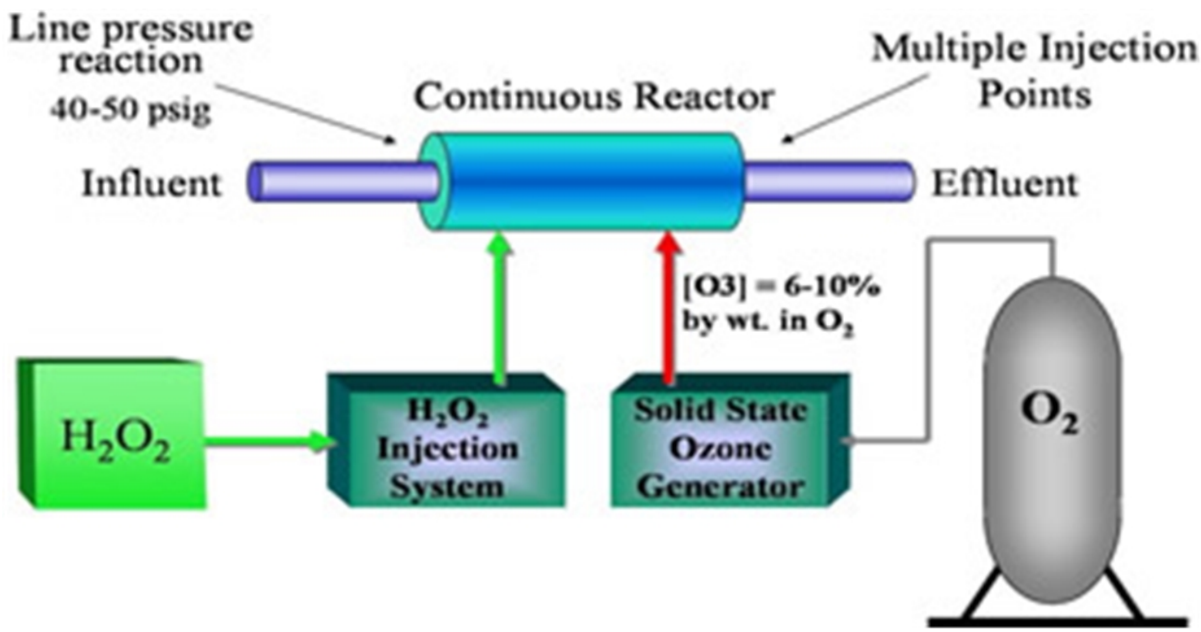

FIGURE 7. Advanced Oxidation Process (AOP) Schematic

The AOP is a potentially viable method for removing PCE from the groundwater supply. For this reason, AOP will be considered for additional evaluation and compared with other viable treatment processes with respect to cost.

PCE Residuals Management

There are numerous federal and state regulations governing the disposal of wastes containing PCE. It is important to understand these regulations to properly classify and dispose of PCE wastes in order to minimize danger to public health and safety.

The PCE wastes generated from this application are likely to be one of the following:

- Contaminated air from an air stripping process, such as PTA and tray aeration.
- Contaminated GAC from a liquid-phase GAC adsorption process.
- Contaminated GAC from a vapor-phase GAC adsorption process.

[7] Figure from Applied Process Technology, Inc., website (http://www.aptwater.com/). APT supplies the HiPOx™ system as an AOP for removal of VOCs.

An air waste contaminated with PCE must meet various federal and state regulations governing air emissions. A solid waste containing PCE must meet federal and state solid waste disposal standards.

Air Emissions Disposal

Air stripping processes, such as PTA and tray aeration, remove dissolved PCE from water by volatilization. The PCE volatilizes from the water into the air. Air contaminated with PCE can be discharged to the atmosphere if it meets the criteria of certain federal and state regulations. If the contaminated air does not meet these regulations, additional treatment, such as vapor-phase GAC adsorption, may be required.

Federal and State Requirements for Air Emissions

The Air Quality Board (ACB) of NMED is responsible for authorizing and permitting the emission of regulated air pollutants from a source that is either newly constructed or modified. NMED regulates who must obtain air quality permits for constructed or modified sources under 20.2.72.200(A) NMAC. The PCE emissions from this application do not appear to require a permit from the Air Quality Board of NMED. However, in order to receive a "No Permit Required" (NPR) designation from NMED, a letter must be written to the Air Quality Board providing details of the application and estimated pollutant production. NMED will make an official determination on whether or not a permit is required. If NMED does not require this application to have an air quality permit, it is recommended to release the stripped PCE into the atmosphere, unless the City requests additional treatment at their discretion. Refer to APPENDIX D for a detailed presentation of air permit regulations.

Vapor-Phase Granular Activated Carbon (GAC) Adsorption

Vapor-phase Granular Activated Carbon (GAC) Adsorption is a treatment process that can effectively remove PCE from air after a stripping process. The process is listed as a BAT for PCE removal by the U.S. EPA. This process may be required for post-treatment of the PCE once it is removed from the source water.

Vapor-phase GAC adsorption operates by passing contaminated air through one or more vessels containing GAC media. The thermal processing of carbon creates small porous particles with a large internal surface area. This attribute makes the granular carbon activated. Organic molecules, such as PCE, adsorb onto the surfaces of the activated carbon. When the concentration of PCE in the vapor exiting the vessels exceeds a certain level, the carbon must be replaced. Spent carbon can be regenerated in place, removed and regenerated at an off-site facility, or removed and disposed.

Vapor-phase GAC adsorption does not require additional evaluation since it is the industry's preferred method for removing PCE from air. In addition, the requirement of this technology would likely be at the request of the City, and not by air quality regulations.

Solid Waste Disposal

GAC treatment processes remove PCE from air or water by adsorption. The PCE is adsorbed by the large internal surface area of the carbon particles. GAC contaminated with PCE can be disposed of in a solid waste or hazardous waste disposal facility if it meets the criteria of certain federal and state regulations.

Federal and State Requirements for Solid Waste Disposal

It is important to determine whether or not the solid waste produced in this application would be classified as "*hazardous waste*". NMED establishes regulations for hazardous waste management under 20.4.1 NMAC. This regulation adopts the U.S. EPA regulations of 40 CFR 260 through 263. PCE is listed as a *hazardous waste* in 40 CFR 261. However, the solid waste produced in this application is a mixed waste containing both *solid waste* and *hazardous waste*. Therefore, it is likely that the Toxicity Characteristic Leaching Procedure (TCLP) test, developed by the U.S. EPA, would have to be used on a waste sample to determine the *toxicity characteristic* of the solid waste as defined in 40 CFR 261.24. The waste is toxic, and is classified as a *hazardous waste*, if this testing procedure indicates that the solid waste has more than 0.7 mg/L of PCE. The solid waste classification could be evaluated using solid waste residuals from pilot studies.

Once the waste classification is determined, the GAC contaminated with PCE can be disposed of at an authorized solid waste or hazardous waste facility. However, federal and state regulations involving disposal and transportation of such waste must be identified and followed.

The City may decide to be responsible for removing and disposing of spent GAC. However, the GAC suppliers offer removal, disposal, and replacement of spent media as a service. The supplier is responsible for removing and disposing of the spent GAC according to all applicable federal and state regulations. The supplier tests the media prior to disposal to determine if it is a *hazardous waste*, and also to determine if the GAC can be reactivated for other uses. The GAC suppliers do not reactivate media for drinking water treatment. The reactivated media can contain trace amounts of contaminants. The suppliers recommend replacing spent media with new GAC. This service minimizes efforts by the City to determine waste classification and meet the waste disposal and transport regulations.

Recommended Treatment Alternatives and Cost Comparison

Various treatment alternatives were evaluated to determine the viability of each technology for removing either uranium or PCE from selected groundwater wells. The evaluation was based on both non-monetary and monetary criteria, which is presented in the following sections.

Non-Monetary Review of Recommended Uranium Treatment Alternatives

The recommended treatment alternatives for uranium removal include the following:

- Enhanced Coagulation/Filtration (E-C/F)
- Non-Regenerating Ion Exchange (IX)
- Reverse Osmosis (RO)

These treatment technologies are all listed as Best Available Technologies (BATs) by the U.S. EPA. Each technology can effectively remove uranium from a drinking water supply; however, IX is the only technology that appears to have full-scale operating plants specifically designed for uranium removal.

A decision analysis was completed to evaluate and compare the treatment alternatives using non-monetary criteria and cost. The non-monetary criteria used in this evaluation included the following:

- Sustainability of Disposal Method.
- Uranium Removal Efficiency
- Ease of Operation
- Ease of Implementation
- Public Acceptance

The "sustainability of the disposal method" was considered the most important non-monetary criteria used in the evaluation of these technologies. The E-C/F and RO processes produce a liquid waste stream and non-regenerating IX system produces a solid waste. Disposal methods for the liquid waste generated by E-C/F and RO processes include the sanitary sewer or solids drying beds. Disposal methods for the solid waste generated by a non-regenerating IX process include an authorized solid waste facility or a uranium reprocessor.

Disposal of liquid wastes to solids drying beds requires large amounts of land area. The City would have to either use land they already own or purchase new property to accommodate this disposal option. In addition, the dried solids from the beds have to be removed periodically and disposed of in a solid waste facility authorized to accept radioactive wastes. For these reasons, disposal of liquid wastes to solids drying beds was not considered a viable disposal option.

The liquid waste would likely meet current regulations governing disposal to the sanitary sewer. However, other issues that could limit the viability of sewer disposal include:

- Future regulations may limit the disposal of wastes containing radionuclides in the sanitary sewer system
- Wastewater facility may have issues disposing of sludge if uranium concentrations exceed regulated limits.
- Sewer disposal transfers uranium "downstream"; does not isolate the contaminant.
- City must obtain a *specific license* from NMED that not only covers the uranium disposed of from the drinking water facility, but also the uranium treated and released by the wastewater facility.

Disposing of the solid waste to a uranium reprocessor would likely be more viable than disposing to an authorized solid waste facility. There are few facilities in the United States authorized to accept low-level radioactive waste (LLRW). These facilities typically contract with waste consolidators who dispose of a significant amount of waste per year. The infrequent disposal of a small volume of spent IX media in this application would likely limit the viability of this disposal method.

Disposal of a solid waste containing uranium to a reprocessor instead of a solid waste facility has significant advantages. Some of these advantages include:

- Likely to be less expensive than disposing of waste in a solid waste facility.
- The City would relinquish responsibility for the waste once it is received by the uranium reprocessor.
- Eliminate permitting requirements for disposal in a solid waste facility.

The City would likely be required to develop a contract with a reprocessor for disposal. However, a few of the leading IX suppliers are in the process of developing contracts with uranium reprocessors, and these suppliers are offering operation, maintenance, and disposal contracts to municipal clients. These contracts have the potential to minimize efforts from the City to manage the disposal of radioactive wastes. A few of these suppliers have intimate knowledge of the federal and state regulations that govern radioactive waste disposal. Some advantages of contracting with an IX supplier for waste disposal include:

- The IX system supplier, not the City, is responsible for meeting all federal and state regulations governing radioactive waste handling, disposal, and transportation.
- The IX system supplier, not the City, develops and maintains the contract with the uranium reprocessor.
- The IX system supplier, not the City, handles the radioactive wastes.
- The IX system supplier, not the City, is responsible for developing a radiation control program.
- The IX system supplier, not the City, is responsible for acquiring a *specific license*.
- The IX system supplier, not the City, maintains staff trained in disposal of radioactive wastes.
- The IX system supplier guarantees the system will meet effluent water quality standards.

Another important non-monetary criteria used to evaluate these technologies is the "ease of operation". An E-C/F and RO facility each require advanced levels of operator skill and attention. These processes require chemical addition and advanced skills in water chemistry. These processes also have a significant amount of mechanical equipment to operate and maintain (e.g. pumps, pre-filters, and membranes). These are advanced treatment technologies that require a significant amount of time, attention, and skill from an operator.

In contrast, a non-regenerating IX system is significantly easier to operate and maintain. This type of IX system has some of the following advantages:

- IX requires no chemical addition.
- IX does not have any complicated backwash or cleaning schemes.
- IX is much simpler from a mechanical standpoint.

- IX requires minimal operator attention and skill.
- IX can potentially minimize the need for City staff to come in contact with radioactive materials if the City enters into a long-term contract with a supplier.

Non-Monetary Review of Recommended PCE Treatment Alternatives

The recommended treatment alternatives for PCE removal include the following:

- Packed Tower Aeration (PTA) Air Stripping
- Tray Aeration Air Stripping
- Liquid-Phase GAC Adsorption
- Advanced Oxidation Process (AOP)

Each of these technologies can effectively remove PCE from a drinking water supply.

A decision analysis was completed to evaluate and compare the treatment alternatives using non-monetary criteria and cost. The non-monetary criteria used in this evaluation included the following:

- Sustainability of Disposal Method.
- PCE Removal Efficiency
- Ease of Operation
- Ease of Implementation
- Public Acceptance

The "ease of operation" was considered the most important non-monetary criteria used in the evaluation of these technologies. A PTA system is fairly simple to operate. However, the process requires an acid-wash system to clean packing material after fouling occurs. The spent acid solution must be handled and disposed of as a hazardous waste. Additionally, if the packing material can not be adequately cleaned using the acid-wash system, the packing must be removed and either cleaned manually or replaced.

An AOP system is complicated by ozone generation facilities and mixing requirements. This is an advanced technology that requires a significant degree of operator attention and skill.

A liquid-phase GAC adsorption system is simpler to operate and maintain than an AOP system. However, this process still requires a backwashing scheme that involves backwash supply tanks and backwash pumps. This adds a level of complexity to the operation and maintenance of this technology.

Tray aeration requires the least amount of operator skill and attention compared to the other treatment alternatives. Aspects of this technology that highlight its minimal requirements for operations and maintenance include:

- Tray aeration requires no chemical addition.
- Tray aeration does not have any complicated backwash schemes.

- Tray aeration is simple from a mechanical standpoint.
- Trays can be cleaned several ways. The trays can be removed and cleaned, or the trays can be cleaned in place using a washing wand, pressure washer, or automated acid-wash system.

Cost Comparison of Uranium and PCE Treatment Alternatives

The following analysis compares costs for treatment alternatives recommended to remove uranium and PCE from selected groundwater wells. The evaluation compares costs for both well head treatment and centralized facilities. The costs for these alternatives are for comparison purposes only. The costs are not intended to reflect a true construction cost estimate. The costs should only be used to compare one treatment alternative to another for the same application. The costs do not include items common to each alternative such as engineering, site development, contractor markups, profit, yard piping, yard electrical, SCADA system, etc. See APPENDIX E, F and G for complete information on the cost analyses for the various alternatives.

Well Head Treatment

Wells No. 18 and 44 were evaluated as well head treatment alternatives for the purposes of this analysis. Well No. 44 contains uranium, but no PCE. Well No. 18 contains PCE, but it is unclear to what extent this well is affected by uranium[8]. During implementation, Well No. 18 may be considered for centralized treatment at the UGR.

The uranium treatment alternatives evaluated for Well No. 44 include:

- Enhanced Coagulation/Filtration (E-C/F)
- Non-Regenerating Ion Exchange (IX)
- Reverse Osmosis (RO)

IX is the least expensive alternative when compared to E-C/F and RO treatment technologies. See TABLE 5 for a cost summary of the uranium treatment alternatives considered for Well No. 44.

[8] A water sample taken from Well No. 18 in 2001 indicated a uranium concentration of 11 μg/L. Additional uranium data on this well is not yet available.

TABLE 5
Comparative Costs of Uranium Treatment Alternatives for Well No. 44

Treatment Type	Comparative Construction Costs (millions)	Annual Cost of Water(4) ($/1,000 gal)	Comparative O&M Costs Annual (millions)	Comparative O&M Costs Present Worth (millions)	Total Comparative Present Worth (millions)
E-C/F	$1.88	$0.50	$0.05	$0.67	$2.55
IX	$0.80	$0.36	$0.07	$1.02	$1.83
RO	$2.63	$0.80	$0.10	$1.47	$4.10

(1) Present worth analysis conducted using an interest rate of 5% and a life cycle of 25 years.

(2) All costs are comparative and do not include items common to each alternative such as engineering, site development, contractor markups, profit, yard piping, yard electrical, SCADA system, etc.

(3) See APPENDIX E for complete cost analysis information.

(4) Annualized cost of water per 1,000 gallons treated for life of equipment. Includes construction costs and O&M costs. Assumes 50% utilization of well.

The decision analysis compared the non-monetary criteria of each alternative with the cost. The result of the decision analysis is a Total Benefit Score. The Total Benefit Score relates the score of the non-monetary criteria for each alternative with respect to the cost. A higher Total Benefit Score indicates a more preferred treatment technology. See *FIGURE 8* for a summary of the Total Benefit Scores for the uranium treatment alternatives for Well No. 44. The combined score for non-monetary criteria and cost is represented by the orange line titled “BENEFIT/NORMALIZED TOTAL PRESENT WORTH COST RATIO”.

Based on this decision analysis comparing non-monetary criteria and cost of the various well head treatment alternatives for Well No. 44, IX is recommended for pilot testing.

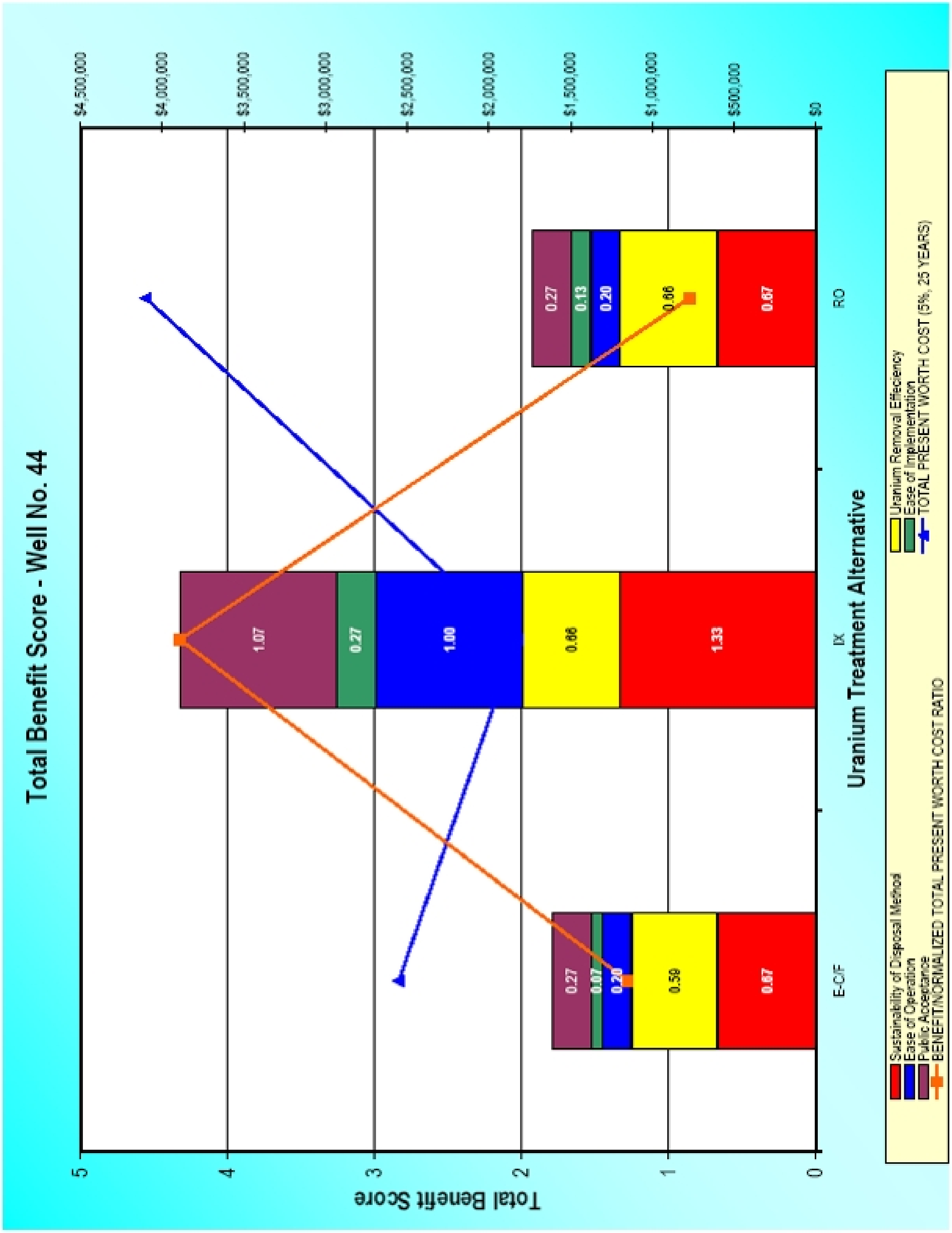

FIGURE 8. Total Benefit Score for Uranium Treatment Alternatives of Well No. 44

The PCE treatment alternatives evaluated for Well No. 18 include:

- Packed Tower Aeration (PTA) Air Stripping
- Tray Aeration Air Stripping
- Liquid-Phase GAC Adsorption
- Advanced Oxidation Process (AOP)

Tray aeration is the least expensive alternative when compared to PTA, liquid-phase GAC, and AOP treatment technologies. See TABLE 6 for a cost summary of the PCE treatment alternatives considered for Well No. 18.

TABLE 6
Comparative Costs of PCE Treatment Alternatives for Well No. 18(4)

Treatment Type	Comparative Construction Costs (millions)	Annual Cost of Water(5) ($/1,000 gal)	Comparative O&M Costs		Total Comparative Present Worth (millions)
			Annual (millions)	Present Worth (millions)	
PTA	$0.38	$0.14	$0.006	$0.08	$0.46
Tray Aeration	$0.26	$0.10	$0.004	$0.06	$0.31
Liquid-Phase GAC	$0.39	$0.16	$0.009	$0.13	$0.52
AOP	$0.93	$0.35	$0.016	$0.23	$1.16

(1) Present worth analysis conducted using an interest rate of 5% and a life cycle of 25 years.

(2) All costs are comparative and do not include items common to each alternative such as engineering, site development, contractor markups, profit, yard piping, yard electrical, SCADA system, etc.

(3) See APPENDIX F for complete cost analysis information.

(4) Well No. 18 is considered for well head treatment for the purposes of this analysis. However, during implementation, this well could be centralized with other wells near the UGR.

(5) Annualized cost of water per 1,000 gallons treated for life of equipment. Includes construction costs and O&M costs. Assumes 50% utilization of well.

See *FIGURE 9* for a summary of the Total Benefit Scores for the PCE treatment alternatives for Well No. 18. The combined score for non-monetary criteria and cost is represented by the orange line titled "BENEFIT/NORMALIZED TOTAL PRESENT WORTH COST RATIO".

Based on this decision analysis comparing non-monetary criteria and cost of the various well head treatment alternatives for Well No. 18, tray aeration is recommended.

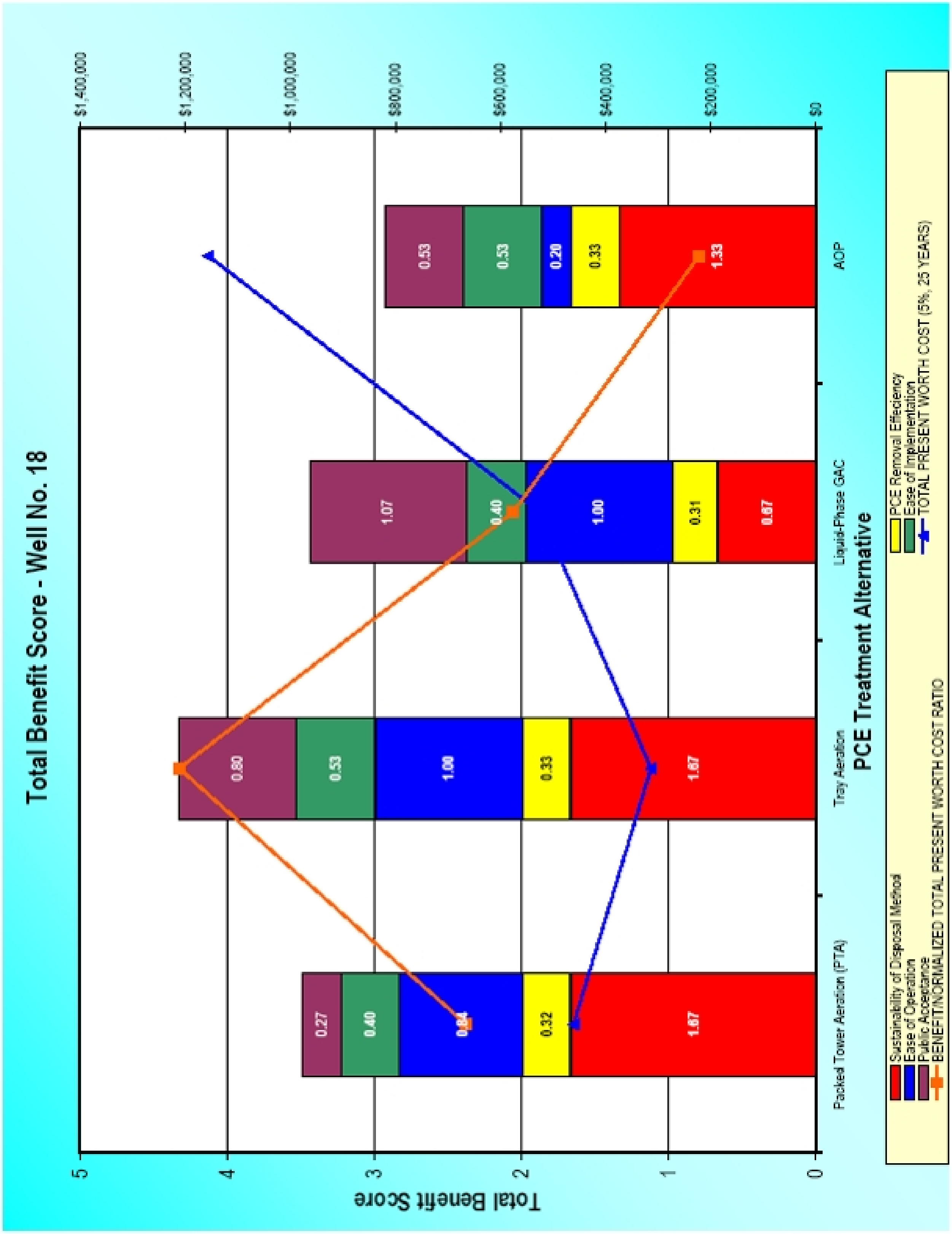

FIGURE 9. Total Benefit Score for PCE Treatment Alternatives of Well No. 18

Centralized Treatment

Wells No. 19, 21, and 27 were evaluated for a centralized treatment facility for uranium and PCE removal. All of these wells contain both uranium and PCE. The technologies for uranium treatment can be combined with the technologies for PCE treatment to develop a process train designed to remove both contaminants. The following treatment train alternatives were evaluated for combined treatment of uranium and PCE:

- Train #1: Tray Aeration followed by Ion Exchange.
- Train #2: Advanced Oxidation Process followed by Ion Exchange.
- Train #3: Enhanced Coagulation/Filtration using GAC filter media.
- Train #4: Tray Aeration followed by Reverse Osmosis.

Train #1 is the least expensive alternative when compared to the other process trains evaluated. See TABLE 7 for a cost summary of the combined treatment train alternatives considered for centralized treatment.

Based on the monetary and non-monetary evaluations of the various centralized treatment alternatives, Train #1 is recommended for pilot testing.

TABLE 7
Comparative Costs of Treatment Train Alternatives for a Centralized Facility for Wells No. 19, 21, and 27

Treatment Type	Comparative Construction Costs (millions)	Annual Cost of Water(4) ($/1,000 gal)	Comparative O&M Costs		Total Comparative Present Worth (millions)
			Annual (millions)	Present Worth (millions)	
Train #1	$2.53	$0.30	$0.16	$2.22	$4.75
Train #2	$3.23	$0.38	$0.19	$2.71	$5.95
Train #3	$3.33	$0.41	$0.22	$3.15	$6.48
Train #4	$5.30	$0.56	$0.25	$3.54	$8.84

(1) Present worth analysis conducted using an interest rate of 5% and a life cycle of 25 years.

(2) All costs are comparative and do not include items common to each alternative such as engineering, site development, contractor markups, profit, yard piping, yard electrical, SCADA system, etc.

(3) See APPENDIX G for complete cost analysis information.

(4) Annualized cost of water per 1,000 gallons treated for life of equipment. Includes construction costs and O&M costs. Assumes 50% utilization of wells.

Future Steps

- Develop an implementation plan to identify the wells to be treated.
- Pilot test IX for uranium treatment.
- Determine if the City wants to release PCE into the atmosphere or collect in GAC.

APPENDIX A

Table A-1

Water Quality Data of Wells Affected by Uranium(1)

	Well No. --->	UGR	10	19(2)	20(2)	21	27(3)	44
	Flow Capacity (gpm) --->	NA	500	750	1,050	1,000	650	780
Tested By	Date	U (µg/L)	U (µg/L)	U (µg/L)	U (µg/L)	U (µg/L)	U (µg/L)	U (µg/L)
NMED	2003		41	57		40	15	62
IM	2004-2005		36	54	70	40		36
NMED	May-05		38	51	58	33		20
NMED	Jul-05		35.6		52.3	30.4		4.4
CLC	07/08/2005	28.0				32.0		
CLC	08/17/2005	28.0				32.0		
CLC	08/31/2005	23.0				29.0		
CLC	09/12/2005	25.0				28.0		
CLC	09/16/2005					29.0		3.2
CLC	09/28/2005	26.0	34.0			29.0		3.3
NMED	10/06/2005		50.0			42.0		44.0
CLC	10/11/2005	27.0	32.0			32.0		68.0
CLC	11/08/2005	20.0	33.0			31.0		10.0
NMED	11/15/2005	98.3	33.6			41.0		80.6
CLC	12/06/2005	21.0				34.0		85.0
CLC	01/04/2006	11.0				39.0		66.0
CLC	02/07/2006	12				31		85
NMED	02/07/2006	20.7	123			51.8		19.8
CLC	03/13/2006	5.5				29		76
CLC	04/04/2006	14				31		91
NMED	04/06/2006	12	47			33		
NMED	04/20/2006				92.2			
CLC	05/02/2006	12			54	28		90
	Max	98.3	123.0	57.0	92.2	51.8	15.0	91.0
	Min	5.5	32.0	51.0	52.3	28.0	15.0	3.2
	Avg	24.0	45.7	54.0	65.3	33.9	15.0	49.7

(1) Uranium MCL = 30 µg/L.

(2) Well is not functional due to mechanical failures; currently out of service.

(3) Well No. 27 has not been used to provide drinking water since August 2001; currently out of service.

Legend:

U = Uranium

CLC = City of Las Cruces

NMED = New Mexico Environment Department

IM = Initial Monitoring - Under Radionuclides Rule

UGR = Upper Griggs Reservoir

Table A-2

Water Quality Data of Wells Affected by Tetrachloroethylene (PCE)[1]

	Well No. --->	18	19[2]	21[3]	27[4]
	Flow Capacity (gpm) --->	480	750	1,000	650
Tested By	Date	PCE (µg/L)	PCE (µg/L)	PCE (µg/L)	PCE (µg/L)
NMED	Jan-2003	-	2.8	4.5	4.3
NMED	Feb-2003	-	2.2	4.7	4.6
NMED	Mar-2003	-	2.1	4.7	3.8
CLC	Mar-2003	-	-	-	-
NMED	Apr-2003	-	4.3	6.0	5.7
NMED	May-2003	-	2.9	5.6	4.2
NMED	Jun-2003	-	3.2	4.8	6.2
NMED	Jul-2003	-	4.3	4.2	7.8
CLC	Jul-2003	-	-	-	-
CLC	Jul-2003	-	-	-	-
CLC	Jul-2003	-	-	-	-
CLC	Aug-2003	-	-	-	-
CLC	Aug-2003	-	-	-	-
CLC	Aug-2003	-	-	-	-
CLC	Aug-2003	-	-	-	-
CLC	Sep-2003	-	-	-	-
CLC	Sep-2003	-	-	-	-
CLC	Sep-2003	-	-	-	-
CLC	Sep-2003	-	-	-	-
CLC	Sep-2003	-	-	-	-
NMED	Oct-2003	-	3.9	4.4	-
NMED	Nov-2003	-	-	-	-
NMED	Dec-2003	-	-	-	-
NMED	Jan-2004	-	-	< 0.5	-
NMED	Jan-2004	-	-	2.9	-
CLC	Jan-2004	-	-	-	-
CLC	Feb-2004	-	3.3	2.2	-
CLC	Mar-2004	-	-	-	-
NMED	Apr-2004	-	3.9	1.6	-
CLC	Apr-2004	-	-	-	-
CLC	May-2004	-	-	-	-
CLC	Jun-2004	-	-	3.0	-
NMED	Jul-2004	-	4.3	4.6	-
CLC	Jul-2004	-	-	-	-
CLC	Aug-2004	-	-	-	-
CLC	Sep-2004	-	-	-	-
NMED	Oct-2004	-	5.1	2.3	-
CLC	Nov-2004	-	2.7	-	-
NMED	Dec-2004	-	-	-	-

Table A-2

Water Quality Data of Wells Affected by Tetrachloroethylene (PCE)[1]

	Well No. --->	18	19[2]	21[3]	27[4]
	Flow Capacity (gpm) --->	480	750	1,000	650
Tested By	Date	PCE (μg/L)	PCE (μg/L)	PCE (μg/L)	PCE (μg/L)
NMED	Jan-2005	14.0	3.7	2.3	-
NMED	Feb-2005	-	-	-	-
NMED	Mar-2005	-	-	-	-
NMED	Apr-2005	14.0	4.9	2.3	-
NMED	May-2005	-	-	-	-
NMED	Jun-2005	-	2.5	-	-
CLC	Jun-2005	-	2.2	3.7	-
CLC	Jun-2005	-	-	-	-
CLC	07/05/2005	-	2.0	3.7	-
NMED	07/19/2005	18.6	-	4.9	-
CLC	07/19/2005	-	-	3.9	-
CLC	08/02/2005	-	-	3.4	-
CLC	08/17/2005	-	-	3.5	-
CLC	08/31/2005	-	-	4.2	-
CLC	09/12/2005	-	-	3.5	-
CLC	09/16/2005	38.8	-	3.0	-
CLC	09/28/2005	-	-	3.7	-
NMED	10/06/2005	45.0	-	4.3	-
CLC	10/11/2005	-	-	3.9	-
CLC	10/25/2005	-	-	3.7	-
CLC	11/08/2005	-	-	4.1	-
CLC	11/22/2005	-	-	3.2	-
CLC	12/06/2005	-	-	3.3	-
CLC	12/20/2005	-	-	2.8	-
CLC	01/04/2006	-	-	2.9	-
CLC	01/18/2006	-	-	3.4	-
CLC	02/01/2006	-	-	3.5	-
CLC	02/07/2006	38.7	-	3.9	-
NMED	02/07/2006	50.2	-	4.5	-
CLC	03/14/2006	-	-	4.8	-
CLC	04/04/2006	-	-	3.4	-
NMED	04/06/2006	38.5	-	4.9	-
CLC	05/02/2006	-	-	3.9	-
	Max	50.2	5.1	6.0	7.8
	Min	14.0	2.0	1.6	3.8
	Avg	32.2	3.4	3.8	5.2

(1) PCE MCL = 5 μg/L.

(2) Well No. 19 suffered a structural failure during July 2005, and has been taken out of service until further notice.

(3) The point of compliance for Well No. 21 is the outlet from Upper Griggs Reservoir after blending with water from other wells (Blending Plan approved on 24 September 2002 by NMED Drinking Water Bureau.

(4) Well No. 27 has not been used to provide drinking water since August 2001; currently out of service.

Legend:

- Indicates "Not Sampled"

PCE = Tetrachloroethylene

CLC = City of Las Cruces

NMED = New Mexico Environment Department

Table A-3
Water Quality Data of Affected Wells - Miscellaneous Characteristics

Well No.	Date	Hardness (mg/L)	Alkalinity (mg/L)	Chloride (mg/L)	pH	TDS (mg/L)	Sulfate (mg/L)	Iron (mg/L)	Manganese (mg/L)	Nitrite/nitrate (mg/L)	Orthophos. as P (mg/L)	Silicon (mg/L)
Well No. 10	09/16/2005	291	137	110	7.8	610	145	<0.10	0.05	0.11		
Well No. 18	09/16/2005	600	246	230	7.5	1,280	368	<0.10	<0.01	6.29		
Well No. 20	05/03/2006	456	144	214	7.5	790	256	< 0.10	0.064	2.21	< 0.10	26.8
Well No. 21[(1)]	09/16/2005	532	173	225	7.5	1,130	325	<0.10	<0.01	3.83		
	05/03/2006	614	179	271	7.4	1,090	377	< 0.10	< 0.01	3.85	< 0.10	29.4
Well No. 44	09/16/2005	269	124	126	7.8	640	121	<0.10	0.042	0.16		
	05/03/2006	599	155	253	7.6	950	345	0.14	0.076	< 0.10	< 0.10	25.5

(1) The point of compliance for Well No. 21 is the outlet from Upper Griggs Reservoir after blending with water from
other wells (Blending Plan approved on 24 September 2002 by NMED Drinking Water Bureau.

APPENDIX B

When handling and disposing of radioactive wastes, it is important to understand the following:

- How will the waste be classified?
- What agency will regulate disposal?
- What licenses will be required for disposal?

Following is a discussion on the waste classification for uranium, the regulating authority, and the required licenses to handle and dispose of the radioactive waste.

Radioactive Waste Classification

The waste residuals from uranium treatment in this application would likely be classified as a Low-Level Radioactive Waste (LLRW) as defined in Chapter 42 of the U.S. Code (USC), Section 2021b(9) [42 USC 2021b(9)]. According to this regulation, a LLRW is defined as follows:

> *(9) Low-level radioactive waste*
>
> *The term "low-level radioactive waste" means radioactive material that—*
>
> *(A) is not high-level radioactive waste, spent nuclear fuel, or byproduct material (as defined in section 2014 (e)(2) of this title); and*
>
> *(B) the Nuclear Regulatory Commission, consistent with existing law and in accordance with paragraph (A), classifies as low-level radioactive waste.*

The natural uranium in the LLRW from a drinking water facility in this application would likely not be classified as "*byproduct material*". *Byproduct material* is defined in 42 USC 2014(e) as follows:

> *(e) The term "byproduct material" means*
>
> *(1) any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material, and*
>
> *(2) the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content.*

Instead, the natural uranium in the LLRW produced in this application would likely be classified as "*source material*". *Source material* is defined in 42 USC 2014(z) as follows:

> *(z) The term "source material" means*
>
> *(1) uranium, thorium, or any other material which is determined by the Commission pursuant to the provisions of section 2091 of this title to be source material; or*
>
> *(2) ores containing one or more of the foregoing materials, in such concentration as the Commission may by regulation determine from time to time.*

Source material is further defined in Title 20, Chapter 3, Part 1, Section 7(CZ), of the New Mexico Administrative Code (NMAC) [20.3.1.7(CZ) NMAC] as follows:

CZ. "Source material" means:

(1) uranium or thorium, or any combination thereof, in any physical or chemical form; or

(2) ores that contain by weight one-twentieth of 1 percent (0.05 percent) or more of uranium, thorium or any combination of uranium and thorium; source material does not include special nuclear material.

Regulating Authority

New Mexico is an "*agreement state*". An *agreement state* is defined by 42 USC 2021b(1) as follows:

(1) Agreement State

The term "agreement State" means a State that—

(A) has entered into an agreement with the Nuclear Regulatory Commission under section 2021 of this title; and

(B) has authority to regulate the disposal of low-level radioactive waste under such agreement.

Therefore, the New Mexico Environment Department (NMED) is responsible for regulating the disposal of residuals in this application.

Required Licenses

State and federal regulations require either a *general license* or *specific license* for the possession and disposal of radioactive material. These licenses are regulated under 20.3.3 NMAC and in Title 10, Part 40, of the Code of Federal Regulations (10 CFR 40).

Section 304(A) of 20.3.3. NMAC [20.3.3.304(A) NMAC] states:

A. A general license is hereby issued authorizing commercial and industrial firms, research, educational and medical institutions, and state and local government agencies to use and transfer not more than 15 pounds (6.82 kg) of source material at any one time for research, development, educational, commercial, or operational purposes. A person authorized to use or transfer source material, pursuant to this general license, but may not receive more than a total of 150 pounds (68.2 kg) of source material in any one calendar year.

According to this regulation, no more than 15 pounds of uranium can be held by the City of Las Cruces, including all treatment facilities, at any one time while operating under a *general license*. Also, the City may not dispose of more than 150 pounds of uranium in a calendar year.

It is unlikely that E-C/F or RO facilities would contain more than 15 pounds of uranium at any one time in this application. However, at a yearly utilization rate of 50 percent for each well and no bypass/blending operations, the total amount of uranium disposed of by all E-C/F or RO processes may exceed the *general license* limitation of 150 pounds per year. See TABLE B-1 (E-C/F) and TABLE B-2 (RO) for summaries of uranium disposal quantities from a centralized facility and well head treatment for the E-C/F and RO treatment alternatives.

TABLE B-1
Estimated Yearly Amount of Uranium Disposed of from E-C/F(2)

	Centralized Treatment				Well Head Treatment	Total (Centralized + Wellhead)
Well No. >	19(1)	21	27(1)	Combined	44	
Flow (gpm)(3) >	38	50	33	120	39	159
	U (lb/yr)	U (lb/yr)	U (lb/yr)	U (lb/yr)	U (lb/yr)	U (lb/yr)
Maximum	84	102	19	206	131	337
Minimum	75	55	19	150	5	155
Average	80	69	19	168	59	228

(1) Well currently out of service.

(2) Assumes 50% yearly utilization of each well, 90% uranium removal efficiency, and no bypass/blending operations.

(3) Assumes liquid waste flow is 5% of influent flow rate.

TABLE B-2
Estimated Yearly Amount of Uranium Disposed of from RO(2)

	Centralized Treatment				Well Head Treatment	Total (Centralized + Wellhead)
Well No. >	19(1)	21	27(1)	Combined	44	
Flow (gpm)(3) >	75	100	65	240	78	318
	U (lb/yr)	U (lb/yr)	U (lb/yr)	U (lb/yr)	U (lb/yr)	U (lb/yr)
Maximum	93	112	21	226	144	370
Minimum	83	61	21	165	5	170
Average	88	76	21	185	65	250

(1) Well currently out of service.

(2) Assumes 50% yearly utilization of each well, 99% uranium removal efficiency, and no bypass/blending operations.

(3) Assumes concentrate flow is 10% of influent flow rate.

The non-regenerating IX treatment alternative would most likely require a *specific license* since the media is only exchanged every year or more causing the total uranium held by the City to exceed 15 pounds. In addition, at a yearly utilization rate of 50 percent for each well and no bypass/blending operations, the total amount of uranium disposed of by all non-regenerating IX processes may exceed the *general license* limitation of 150 pounds per year. See TABLE B-3 for summaries of uranium disposal quantities from a centralized facility and well head treatment for the IX treatment alternative.

TABLE B-3
Estimated Yearly Amount of Uranium Disposed of from Non-Regenerating IX(2)

	Centralized Treatment				Well Head Treatment	Total (Centralized + Wellhead)
Well No. >	19(1)	21	27(1)	Combined	44	
	U (lb/yr)	U (lb/yr)	U (lb/yr)	U (lb/yr)	U (lb/yr)	U (lb/yr)
Maximum	89	108	20	217	138	355
Minimum	80	58	20	158	5	164
Average	84	73	20	177	63	240

(1) Well currently out of service.

(2) Assumes 50% yearly utilization of each well, 95% uranium removal efficiency, and no bypass/blending operations.

There are several variable parameters that affect the total amount of uranium that would be removed and disposed of from all uranium treatment facilities operated by the City. Some of these parameters include:

- The number of wells used for treatment.
- Flow rate and uranium concentration for each well.
- Yearly utilization rate of each well.
- Bypass/blending operations for each process.

It appears likely that the City would be required to obtain a *specific license* from NMED to operate uranium treatment facilities and dispose of the uranium wastes for the selected wells. However, it will not be certain which type of license would be required until a treatment alternative is selected and the variable parameters are defined.

Provisions for filing an application to NMED for a *specific license* can be found under 20.3.3.307 NMAC. Key elements of this provision include:

- License must be acquired before construction of any facilities.
- An environmental impact report would likely be required that specifically addresses the short-term and long-term environmental, radiological, and public health and safety aspects of the uranium treatment facilities.

General requirements for obtaining a *specific license* from NMED are outlined in 20.3.3.308 NMAC. A couple of these requirements include:

- Applicant shall have proper experience and training to use the radioactive materials in such a manner as to minimize danger to public health and safety.
- The equipment, facilities, and procedures of the applicant are adequate to minimize danger to public health and safety.

These regulations would allow NMED to assess the ability of the City to operate uranium treatment facilities prior to issuing a *specific license*. NMED may require the City to retain staff that are certified and trained to operate, maintain, transport, and otherwise handle radioactive residuals. Such requirements would incur additional operational costs to those normally observed in more conventional water treatment facilities.

APPENDIX C

The liquid waste from an E-C/F facility or concentrate from an RO process treating for uranium will contain elevated levels of uranium, or TENORM. The following discussion evaluates the federal and state requirements surrounding sanitary sewer discharge of radioactive liquid residuals.

The Nuclear Regulatory Commission (NRC) addresses discharge of radioactive wastes to the sanitary sewer system in 10 CFR 20.2003. NMED addresses such discharge in 20.3.4.435(A) NMAC. This section of the NMAC states:

> *A. A licensee or registrant may discharge licensed or registered material into sanitary sewerage if each of the following conditions is satisfied:*
>
> *(1) the material is readily soluble, or is readily dispersible biological material, in water;*
>
> *(2) the quantity of licensed or registered radioactive material that the licensee or registrant releases into the sewer in 1 month divided by the average monthly volume of water released into the sewer by the licensee or registrant does not exceed the concentration listed in table III of 20.3.4.461 NMAC;*
>
> *(3) if more than one radionuclide is released, the following conditions must also be satisfied:*
>
> *(a) the licensee or registrant shall determine the fraction of the limit in table III of 20.3.4.461 NMAC represented by discharges into sanitary sewerage by dividing the actual monthly average concentration of each radionuclide released by the licensee or registrant into the sewer by the concentration of that radionuclide listed in table III of 20.3.4.461 NMAC; and*
>
> *(b) the sum of the fractions for each radionuclide required by Subparagraph (a) of Paragraph (3) of Subsection A of 20.3.4.435 NMAC does not exceed unity; and*
>
> *(4) the total quantity of licensed or registered radioactive material that the licensee or registrant releases into the sanitary sewerage in a year does not exceed 5 Ci (185 gigabecquerels) of hydrogen-3, 1 Ci (37 gigabecquerels) of carbon-14, and 1 Ci (37 gigabecquerels) of all other radioactive materials combined.*

The requirements of Condition No. 1 of this regulation are met since the uranium found in the affected groundwater wells is dissolved. Naturally occurring uranium is likely to be readily soluble in water; however, this would need to be confirmed through pilot testing.

Condition No. 2 of this regulation indicates that the average monthly concentration of *radioactive material* disposed of in a sanitary sewer system shall not exceed the value listed in Table III of 20.3.4.461 NMAC. This table contains a list of many radionuclides and their isotopes. The *radioactive material* in the liquid wastes of this application is uranium from natural sources. The table indicates the average monthly concentration of *Uranium-natural* disposed of in a sanitary sewer shall not exceed 3E-6 μCi/mL (3,000 pCi/L). Assuming an activity of 0.677 pCi/μg, as indicated in the footnotes of this table, the average monthly concentration of *Uranium-natural* disposed of in a sanitary sewer shall not exceed 4,431 μg/L.

Assuming 90 percent uranium removal efficiency in an E-C/F facility, the estimated average monthly concentrations of *Uranium-natural* disposed of in a sanitary sewer would be significantly below 3,000 pCi/L. See TABLE C-1 for a summary of estimated monthly liquid waste uranium concentrations from a centralized facility and well head treatment. Therefore, the requirements of Condition No. 2 of this regulation are likely to be met by the liquid waste from the E-C/F treatment alternative, although this would also need to be confirmed through pilot testing.

TABLE C-1
Estimated Monthly Uranium Concentrations in Liquid Waste from E-C/F(2)

	Centralized Treatment				Well Head Treatment
Well No. >	19(1)	21	27(1)	Combined	44
Flow (gpm)(3) >	38	50	33	120	39
	U (pCi/L)	U (pCi/L)	U (pCi/L)	U (pCi/L)	U (pCi/L)
Maximum	695	631	183	530	1,036
Minimum	621	341	183	386	39
Average	658	425	183	432	471

(1) Well currently out of service.

(2) Assumes 90% of uranium is removed from E-C/F process and liquid waste flow is 5% of raw water flow.

(3) Assumes liquid waste flow is 5% of influent flow rate.

Assuming 99 percent uranium removal efficiency in an RO facility, the estimated average monthly concentrations of *Uranium-natural* disposed of in a sanitary sewer would be significantly below 3,000 pCi/L. See TABLE C-2 for a summary of estimated monthly uranium concentrations in the RO concentrate from a centralized facility and well head treatment. Therefore, the requirements of Condition No. 2 of this regulation are likely to be met by the concentrate from the RO treatment alternative.

The requirements of Condition No. 3 of this regulation are met since uranium is the only radionuclide found in the groundwater of this application.

Condition No. 4 of this regulation limits the total quantity of radioactive material disposed of in a sanitary sewer system in a year. The groundwater does not contain hydrogen-3 or carbon-14; therefore, the only applicable part of this requirement is the yearly limit of disposing of 1 Ci of natural uranium in the sewer system.

It is not expected that the 1 Ci/yr sanitary sewer disposal limit would be exceeded in either well head or centralized treatment scenarios of E-C/F or RO treatment. At a yearly utilization rate of 50 percent for each well, the yearly contribution of natural uranium to the sanitary sewer system by either an E-C/F or RO process is well below the regulated limit. See TABLE C-3 (E-C/F) and TABLE C-4 (RO) for summaries of contributions from a centralized facility and well head treatment for the E-C/F and RO treatment alternatives. The requirements of Condition No. 4 of this regulation are likely to be met by both the liquid waste from E-C/F treatment and concentrate from RO treatment.

TABLE C-2
Estimated Monthly Uranium Concentrations in RO Concentrate[2]

	Centralized Treatment				Well Head Treatment
Well No. >	19[1]	21	27[1]	Combined	44
Flow (gpm)[3] >	75	100	65	240	78
	U (pCi/L)	U (pCi/L)	U (pCi/L)	U (pCi/L)	U (pCi/L)
Maximum	382	347	101	291	570
Minimum	342	188	101	212	21
Average	362	234	101	238	259

(1) Well currently out of service.

(2) Assumes 99% of uranium is removed from RO process and concentrate flow is 10% of raw water flow.

(3) Assumes concentrate flow is 10% of influent flow rate.

TABLE C-3
Estimated Yearly Contribution of Natural Uranium to Sanitary Sewer by E-C/F Treatment[2]

	Centralized Treatment				Well Head Treatment
Well No. >	19[1]	21	27[1]	Combined	44
Flow (gpm)[3] >	38	50	33	120	39
	U (Ci/yr)	U (Ci/yr)	U (Ci/yr)	U (Ci/yr)	U (Ci/yr)
Maximum	0.026	0.031	0.006	0.063	0.040
Minimum	0.023	0.017	0.006	0.046	0.002
Average	0.025	0.021	0.006	0.052	0.018

(1) Well currently out of service.

(2) Assumes 50% yearly utilization of each well, 90% uranium removal efficiency, and an activity of 0.677 pCi/µg for natural uranium.

(3) Assumes liquid waste flow is 5% of influent flow rate.

TABLE C-4
Estimated Yearly Contribution of Natural Uranium to Sanitary Sewer by RO Treatment(2)

	Centralized Treatment				Well Head Treatment
Well No. >	19(1)	21	27(1)	Combined	44
Flow (gpm)(3) >	75	100	65	240	78
	U (Ci/yr)	U (Ci/yr)	U (Ci/yr)	U (Ci/yr)	U (Ci/yr)
Maximum	0.029	0.035	0.007	0.070	0.044
Minimum	0.026	0.019	0.007	0.051	0.002
Average	0.027	0.023	0.007	0.057	0.020

(1) Well currently out of service.

(2) Assumes 50% yearly utilization of each well, 99% uranium removal efficiency, and an activity of 0.677 pCi/µg for natural uranium.

(3) Assumes concentrate flow is 10% of influent flow rate.

At this time, federal regulations do not distinguish between NORM and TENORM wastes and all other radionuclide waste. The NMAC regulates NORM in the oil and gas industry under 20.3.14 NMAC. It is not clear whether or not NORM from a drinking water facility is subject to the requirements of this regulation.

Section 1403 (20.3.14.1403 NMAC) of this regulation establishes criteria required to claim exemption from this regulation. The regulation indicates that NORM is exempt from these regulations if it is present at concentrations less than 150 pCi/g, above background, in soil, in 15 cm layers, averaged over 100 square meters. Also, NORM is exempt from these regulations if the maximum radiation exposure reading at any accessible point does not exceed 50 microroentgens per hour (mR/hr) (0.5 mSv/hr), including background radiation levels.

If the NORM material is not exempt from these regulations, disposal is regulated by Section 1407 (20.3.14.1407 NMAC). This section does not include requirements for disposing of liquid NORM waste in the sanitary sewer. However, the regulation does indicate that alternative methods of disposal could be considered for approval. Item D of this section states:

> *D. Regulated NORM shall only be disposed by the methods enumerated below, except that the Department will consider and approve alternative methods of disposal if the applicant demonstrates that such alternative method(s) will protect the environment, public health and fresh waters, and otherwise is consistent with this Subpart [Part], with other provisions of this Part and with applicable Division rules and regulations.*

If the NORM regulations of the oil and gas industry apply to this drinking water application, then NMED would be responsible for evaluating and approving discharge of liquid waste to the sanitary sewer system.

APPENDIX D

Air stripping processes remove dissolved PCE from water by volatilization. The PCE volatilizes from the water into the air. Air contaminated with PCE can be discharged to the atmosphere if it meets the criteria of certain federal and state regulations. If the contaminated air does not meet these regulations, additional treatment, such as vapor-phase GAC adsorption, may be required. The following discussion evaluates the federal and state requirements surrounding PCE air emissions.

The Air Quality Board (ACB) of NMED is responsible for authorizing and permitting the emission of regulated air pollutants from a source that is either newly constructed or modified. NMED regulates who must obtain air quality permits for constructed or modified sources under 20.2.72.200(A) NMAC. The requirements of this regulation are as follows:

> *A. Permits must be obtained from the Department by:*
>
> > *(1) Any person constructing a stationary source which has a potential emission rate greater than 10 pounds per hour or 25 tons per year of any regulated air contaminant for which there is a National or New Mexico Ambient Air Quality Standard. If the specified threshold in this subsection is exceeded for any one regulated air contaminant, all regulated air contaminants with National or New Mexico Ambient Air Quality Standards emitted are subject to permit review. Within this subsection, the potential emission rate for nitrogen dioxide shall be based on total oxides of nitrogen;*
> >
> > *(2) Any person modifying a stationary source when all of the pollutant emitting activities at the entire facility, either prior to or following the modification, emit a regulated air contaminant for which there is a National or New Mexico Ambient Air Quality Standard with a potential emission rate greater than 10 pounds per hour or 25 tons per year and the regulated air contaminant is emitted as a result of the modification. If the specified threshold in this subsection is exceeded for any one regulated air contaminant, all regulated air contaminants with National or New Mexico Ambient Air Quality Standards emitted by the modification are subject to permit review. Within this subsection, the potential emission rate for nitrogen dioxide shall be based on total oxides of nitrogen;*
> >
> > *(3) Any person constructing or modifying any source or installing any equipment which is subject to 20.2.77 NMAC (New Source Performance Standards), 20.2.78 NMAC (Emission Standards for Hazardous Air Pollutants), or any other New Mexico Air Quality Control Regulation which contains emission limitations for any regulated air contaminant;*
> >
> > *(4) For toxic air pollutants, see 20.2.72.400 NMAC - 20.2.72.499 NMAC;*
> >
> > *(5) Any person constructing a stationary source which has a potential emission rate for lead greater than 5 tons per year or modifying a stationary source which either prior to or following the modification has a potential emission rate for lead greater than 5 tons per year; or*
> >
> > *(6) Sources which are major sources of hazardous air pollutants by the definitions in 20.2.83 NMAC (Construction or Modification of Major Sources of Hazardous Air Pollutants).*

PCE is not regulated by the National Primary and Secondary Ambient Air Quality Standards of 40 CFR 50 as established by the U.S. EPA, or the Ambient Air Quality

Standards of 20.2.3 NMAC as established by NMED. Therefore, the requirements of Condition No. 1 and 2 do not apply.

Condition No. 3 references 20.2.77 NMAC and 20.2.78 NMAC. The regulations of 20.2.77 NMAC do not appear to have any requirements for PCE. However, this regulation adopts 40 CFR 60 (Standards of Performance for New Stationary Sources) as promulgated by the U.S. EPA. These U.S. EPA regulations do not appear to contain any requirements for PCE emission from a drinking water treatment facility.

The regulations of 20.2.78 NMAC do not appear to have any requirements for PCE. However, this regulation adopts 40 CFR 61 (National Emission Standards for Hazardous Air Pollutants) as promulgated by the U.S. EPA. These U.S. EPA regulations do not appear to contain any requirements for PCE emission from a drinking water treatment facility. Therefore, the requirements of Condition No. 3 do not appear to apply.

PCE is not listed as a *toxic air pollutant* under 20.2.72. Therefore, the requirements of Condition No. 4 do not apply.

PCE does not contain lead, nor is lead emission expected in this application. Therefore, the requirements of Condition No. 5 do not apply.

Condition No. 6 references 20.2.83 NMAC, which does not exist at this time. This Part is designated as RESERVED in the regulations table of contents. Discussions with NMED staff have revealed this to be an error in the regulations. NMED staff indicated that the intention of Condition No. 6 may be to reference 20.2.82 NMAC (Maximum Achievable Control Technology Standards for Source Categories of Hazardous Air Pollutants). If this is the case, 20.2.82 NMAC references the requirements of Section 112 of the Clean Air Act (CAA) and 40 CFR 63 (National Emission Standards for Hazardous Air Pollutants for Source Categories).

A *hazardous air pollutant* is defined under 40 CFR 63.2 as follows:

> ***Hazardous air pollutant*** *means any air pollutant listed in or pursuant to section 112(b) of the Act.*

In this definition, "*the Act*" is defined as the CAA. According to Title 1, Part A, Section 112(b.1) of *the Act*, PCE is listed as a "*hazardous air pollutant*", or HAP.

A *major source* is defined under 40 CFR 63.2 as follows:

> ***Major source*** *means any stationary source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit considering controls, in the aggregate, 10 tons per year or more of any hazardous air pollutant or 25 tons per year or more of any combination of hazardous air pollutants, unless the Administrator establishes a lesser quantity, or in the case of radionuclides, different criteria from those specified in this sentence.*

Assuming 99 percent PCE removal efficiency in a tray aeration process, the estimated annual amount of PCE removed would be significantly below 10 tons per year. See TABLE D-1 for a summary of amounts of PCE removed by tray aeration from a centralized facility and well head treatment. Therefore, this application is not likely to be a *major source* of HAP.

TABLE D-1
Estimated Annual Amount of PCE Removed by Tray Aeration(2)

	Centralized Treatment				Well Head Treatment
Well No. >	19(1)	21	27(1)	Combined	18
	PCE (lb/yr)	PCE (lb/yr)	PCE (lb/yr)	PCE (lb/yr)	PCE (lb/yr)
Maximum	8.3	13.0	11.0	32.3	48.8
Minimum	3.3	3.5	5.4	12.1	15.2
Average	5.5	8.0	7.4	20.8	28.3

(1) Well currently out of service.

(2) Assumes 50% yearly utilization of each well and 99% PCE removal efficiency.

This application is more likely to be defined as an *area source* of HAP. An *area source* is defined under 40 CFR 63.2 as follows:

> ***Area source*** *means any stationary source of hazardous air pollutants that is not a major source as defined in this part.*

In summary, PCE is defined as a *hazardous air pollutant*, but the amounts produced are not expected to constitute a *major source*. Therefore, the requirements of Condition No. 6 do not apply.

APPENDIX E

Las Cruces Uranium Removal
Wellhead Treatment of Well #44
4/17/2006

Treatment Process	Comparative Construction Cost (Millions)	Comparative O&M Cost (Millions)		Total Comparative Present Worth (Millions)	Annual Cost of Water ($/1,000 gal)
		Annual	Present Worth		
WRT	$0.80	$0.07	$1.02	$1.83	$0.36
Coag/Sedimentation/Filtration	$1.88	$0.05	$0.67	$2.55	$0.50
Reverse Osmosis	$2.63	$0.10	$1.47	$4.10	$0.80

WRT Cost for Uranium Removal
Comparison Construction Cost
Wellhead Treatment of Well #44

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
SITEWORK:				
Excavation	296.2963	CY	$2.91	$862.28
Structural Backfill	296.2963	CY	$29.10	$8,622.83
Haul Excess	296.2963	CY	$5.82	$1,724.57
Allowance for Misc Items	0.05		$11,209.68	$560.48
Subtotal				$11,770.17
CONCRETE:				
Foundation	16.66667	CY	$309.56	$5,159.33
Slab on Grade	74.07407	CY	$281.13	$20,824.44
Allowance for Misc Items	0.05		$25,983.78	$1,299.19
Subtotal				$27,282.97
MASONRY:				
Type of Building Construction:	Moderate			
Building	1600	SF	$116.41	$186,253.16
Subtotal				$186,253.16
METALS:				
Grating	200	SF	$64.02	$12,804.91
Handrail	100	LF	$64.02	$6,402.45
Stairs	15	Risers	$349.22	$5,238.37
Allowance for Misc Items	0.05		$24,445.73	$1,222.29
Subtotal				$25,668.01
EQUIPMENT:				
WRT Equipment	1	EA	$350,000.00	$350,000.00
Two magmeters	1	EA	$8,000.00	$8,000.00
Two pipe systems	1	EA	$9,900.00	$9,900.00
Two FCVs	1	EA	$6,400.00	$6,400.00
Allowance for Misc Items	0.05		$374,300.00	$18,715.00
Subtotal				$393,015.00
Subtotal				$643,989.31
ALLOWANCES:				
Finishes Allowance	2%		$804,986.64	$16,099.73
I & C Allowance	4%		$804,986.64	$32,199.47
Mechanical Allowance	10%		$804,986.64	$80,498.66
Electrical Allowance	4%		$804,986.64	$32,199.47
WRT Facility Cost				**$804,986.64**

WRT Cost for Uranium Removal
Wellhead Treatment of Well #44
Comparison O&M Cost
4/17/2006

	Total HP	Utilization	Annual Usage (Hours / Year)	$/kwh	Power Cost
WRT Building Equipment Power	0	22.70%	8760	$0.07	$0.00
	Building Area (SF)	**Watts / SF**	**Annual Usage (Hours / Year)**	**$/kwh**	**Other Electrical Cost**
WRT Building Electrical	2500	2	8760	$0.07	$3,066.00
					Contract Cost
WRT Contract Fee (Annual cost for uranium disposal, media replacement, final close-out)					$57,500.00
				Subtotal	$60,566.00
				20% Contingency	$12,113.20
				Total Annual Cost	$72,679.20

Coag/Sedimentation/Filtration
Wellhead Treatment of Well #44
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Floc/Sed/Filter Building				
SITEWORK:				
Excavation	340.2958	CY	$2.91	$990.33
Imported Structural Backfill	104.0148	CY	$29.10	$3,027.05
Native Backfill	127.515	CY	$5.82	$742.19
Haul Excess	212.7808	CY	$5.82	$1,238.47
Allowance for Misc Items	0.05		$5,998.04	$299.90
Subtotal				$6,297.94
CONCRETE:				
Slab on Grade	111.0185	CY	$281.13	$31,210.64
Allowance for Misc Items	0.1		$31,210.64	$3,121.06
Subtotal				$34,331.70
MASONRY:	Moderate			
CMU Building	2019.6	SF	$116.41	$235,098.06
Subtotal				$235,098.06
METALS:				
Stairway	30	Risers	$349.22	$10,476.74
Grating Between Treatment Tanks	76.8	SF	$64.02	$4,917.08
Allowance for Misc Items	0.1		$15,393.82	$1,539.38
Subtotal				$16,933.21
EQUIPMENT:				
US Filter Trident HS Base Package Treatment System Including: 2-50% Capacity Tube Clarifier Tank & Sludge Collection/Pump Systems; 2-50% Capacity Adsorption Clarifier Systems; 2-50% Capacity Filter Systems; 2-50% Capacity Internal Transfer Pumping Systems; 2-50% Capacity Air Wash Blowers; Control Valves; Flow Meters; Liquid Level Controllers; Headloss Switches; Turbidimeters & Sample Pumps; Control Station; Delivery, & Installation Technical Direction	1050	GPM	$566.27	$594,579.36
Allowance for Misc Items	0.1		$594,579.36	$59,457.94
Subtotal				$654,037.29
USER DEFINED ESTIMATE ITEMS:	QUANT	UNIT	$/UNIT	TOTAL COST
One 10" Rapid Mixers, each rapid mixer rated for 1.75mgd	1		$7,300.00	$7,300.00
One magmeters	1		$8,000.00	$8,000.00
One pipe systems	1		$9,900.00	$9,900.00
One FCVs	1		$6,400.00	$6,400.00
2 BWS pumps, plus AFDs, plus 10%	2		$50,000.00	$100,000.00
Subtotal				$131,600.00
Subtotal				$1,078,298.19
ALLOWANCES:				

Coag/Sedimentation/Filtration
Wellhead Treatment of Well #44
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Finishes Allowance	2%		$1,364,934.42	$27,298.69
I & C Allowance	4%		$1,364,934.42	$54,597.38
Mechanical Allowance	10%		$1,364,934.42	$136,493.44
Electrical Allowance	5%		$1,364,934.42	$68,246.72
E-C/F Facility Cost				**$1,364,934.42**

Chem Building cost

SITEWORK:				
Excavation	317.1921	CY	$2.91	$923.09
Imported Structural Backfill	104.4444	CY	$29.10	$3,039.55
Native Backfill	35.96389	CY	$5.82	$209.32
Haul Excess	281.2282	CY	$5.82	$1,636.86
Allowance for Misc Items	0.05		$5,808.83	$290.44
Subtotal				$6,099.27
CONCRETE:				
Ferric Chloride				
Slab on Grade	14.5	CY	$281.13	$4,076.39
Containment Walls	7.46819	CY	$557.50	$4,163.52
Bulk Tank Pads	5.698519	CY	$281.13	$1,602.02
Metering Pump Pads	1.493638	CY	$281.13	$419.91
Sulfuric Acid				
Slab on Grade	14.5	CY	$281.13	$4,076.39
Containment Walls	6.606735	CY	$557.50	$3,683.26
Bulk Tank Pads	5.698519	CY	$281.13	$1,602.02
Metering Pump Pads	1.321347	CY	$281.13	$371.47
Sodium Hydroxide				
Slab on Grade	15.5	CY	$281.13	$4,357.52
Containment Walls	7.008958	CY	$557.50	$3,907.49
Bulk Tank Pads	5.698519	CY	$281.13	$1,602.02
Metering Pump Pads	1.342141	CY	$281.13	$377.32
Aqueous Ammonia				
Corridor				
Slab on Grade	21	CY	$281.13	$5,903.73
Allowance for Misc Items	0.05		$36,143.05	$1,807.15
Subtotal				$37,950.20
MASONRY:	Moderate			
CMU Building	1494	SF	$116.41	$173,913.89
Subtotal				$173,913.89
METALS:				
Metal Stairway	3	EA	$5,820.41	$17,461.23
Grating	3	EA	$1,396.90	$4,190.70
Allowance for Misc Items	0.1		$21,651.93	$2,165.19
Subtotal				$23,817.12
EQUIPMENT:				

Coag/Sedimentation/Filtration

Wellhead Treatment of Well #44

4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Ferric Chloride				
Bulk Tank	1	EA	$14,793.44	$14,793.44
Day Tank	0	EA	$162.63	$0.00
Transfer Pump	0	EA	$0.00	$0.00
Metering Pump	2	EA	$6,298.51	$12,597.02
Sulfuric Acid				
Bulk Tank	1	EA	$18,491.80	$18,491.80
Day Tank	0	EA	$128.90	$0.00
Transfer Pump	0	EA	$0.00	$0.00
Metering Pump	2	EA	$6,298.51	$12,597.02
Sodium Hydroxide				
Bulk Tank	1	EA	$13,560.65	$13,560.65
Metering Pump	2	EA	$6,298.51	$12,597.02
Allowance for Misc Items	0.1		$84,636.94	$8,463.69
Subtotal				$93,100.64
Subtotal				$334,881.12
ALLOWANCES:				
Finishes Allowance	2%		$515,201.73	$10,304.03
I & C Allowance	8%		$515,201.73	$41,216.14
Mechanical Allowance	20%		$515,201.73	$103,040.35
Electrical Allowance	5%		$515,201.73	$25,760.09
Chem Facility Cost				$515,201.73

Total Cost	**$1,880,136.15**

Coag/Sedimentation/Filtration
Wellhead Treatment of Well #44
4/17/2006

Comparison O&M Cost

	Total HP	Utilization	Annual Usage (Hours / Year)	$/kwh	Power Cost	
Chem Equipment Power	6	22.70%	8760	0.07	$622.79	
Coag/Sed/Filter Equipment Power	16	22.70%	8760	0.07	$1,660.78	
	Building Area (SF)	**Watts / SF**	**Annual Usage (Hours / Year)**	**$/kwh**	**Other Electrical Cost**	
Chem Building Electrical	1494	2	8760	$0.07	$1,832.24	
Coag/Sed/Filter Building Electrical	2020	2	8760	$0.07	$2,477.33	
Liquid Chemicals:	**Flow (mgd)**	**Utilization**	**Annual Usage (dry tons / year)**	**Cost ($/dry ton)**	**Chemical Cost**	
Ferric Chloride	1.12	22.70%	11.64960402	$371.53	$4,328.18	
Sulfuric Acid	1.12	22.70%	36.89041273	$138.09	$5,094.20	
Sodium Hydroxide	1.12	22.70%	28.34736978	$560.00	$15,874.53	
Total Chemical Cost					$25,296.90	
Backwash Waste Disposal to Sewer	**Flow (mgd)**	**Utilization**	**Waste Percentage of Influent**	**Total Annual Waste Volume (million gallons)**	**Sewer Disposal cost per million gallons**	**Total Cost**
Backwash Waste Disposal to Sewer	1.12	22.70%	5.0%	4.656116715	$1,670.90	$7,779.90
					Subtotal	$39,669.95
					20% Contingency	$7,933.99
					Total Annual Cost	$47,603.94

Reverse Osmosis
Wellhead Treatment of Well #44
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Pressure Filter Building				
SITEWORK:				
Excavation	256.9792	CY	$2.91	$747.86
Imported Structural Backfill	57.55556	CY	$29.10	$1,674.99
Native Backfill	49.375	CY	$5.82	$287.38
Haul Excess	207.6042	CY	$5.82	$1,208.34
Allowance for Misc Items	0.05		$3,918.57	$195.93
Subtotal				$4,114.50
CONCRETE:				
Slab on Grade	34.83333	CY	$281.13	$9,792.70
Allowance for Misc Items	0.05		$9,792.70	$489.63
Subtotal				$10,282.33
MASONRY:	Low			
CMU Building	1254	SF	$93.13	$116,780.73
Subtotal				$116,780.73
EQUIPMENT:				
Vertical Pressure Filter Systems	2	EA	$177,011.75	$354,023.51
(Includes Tanks, Underdrain, System Piping, Actuated Valves, Instrumentation, and Automatic PLC Control Panel)				
Filter Media	765.9	CF	$18.11	$13,869.08
Blowers	1	EA	$40,775.98	$0.00
Allowance for Misc Items	0.1		$367,892.59	$36,789.26
Subtotal				$404,681.85
USER DEFINED ESTIMATE ITEMS:	QUANT	UNIT	$/UNIT	TOTAL COST
Two 10" Rapid Mixers, each rapid mixer ra	2		$7,300.00	$14,600.00
Two magmeters	2		$8,000.00	$16,000.00
Two pipe systems	2		$9,900.00	$19,800.00
Two FCVs	2		$6,400.00	$12,800.00
Item 15 Description	0		$0.00	$0.00
Subtotal				$63,200.00
Subtotal				$599,059.41
ALLOWANCES:				
Finishes Allowance	0.02		$768,024.89	$15,360.50
I & C Allowance	0.05		$768,024.89	$38,401.24
Mechanical Allowance	0.1		$768,024.89	$76,802.49
Electrical Allowance	0.05		$768,024.89	$38,401.24
Pressure Filter Facility Cost				$768,024.89

Reverse Osmosis
Wellhead Treatment of Well #44
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST

RO Building

SITEWORK:				
Membrane Building:				
Process Building:				
Excavation	465.5926	CY	$2.91	$1,354.97
Imported Structural Backfill	88.67284	CY	$29.10	$2,580.56
Native Backfill	159.6833	CY	$5.82	$929.42
Haul Excess	305.9093	CY	$5.82	$1,780.52
Electrical Room:				
Excavation	138.7814	CY	$2.91	$403.88
Imported Structural Backfill	13.6467	CY	$29.10	$397.15
Native Backfill	133.7856	CY	$5.82	$778.69
Haul Excess	4.995807	CY	$5.82	$29.08
Non-Membrane Area:				
Excavation	134.5568	CY	$2.91	$391.59
Imported Structural Backfill	35.80884	CY	$29.10	$1,042.11
Native Backfill	75.52698	CY	$5.82	$439.60
Haul Excess	59.02986	CY	$5.82	$343.58
Cartridge Filter Area:				
Excavation	51.85648	CY	$2.91	$150.91
Imported Structural Backfill	10.56713	CY	$29.10	$307.53
Native Backfill	36.86667	CY	$5.82	$214.58
Haul Excess	14.98981	CY	$5.82	$87.25
Spent Cleaning Chemical Neutralization Tank:				
Excavation	114.7156	CY	$2.91	$333.85
Imported Structural Backfill	7.090906	CY	$29.10	$206.36
Native Backfill	70.97553	CY	$5.82	$413.11
Haul Excess	43.7401	CY	$5.82	$254.59
Allowance for Misc Items	0.05		$12,439.30	$621.97
Subtotal				$13,061.27
CONCRETE:				
Slab on Grade:				
Membrane Area:				
Process Building	74.66049	CY	$281.13	$20,989.30
Electrical Area	5.066114	CY	$281.13	$1,424.24
Non-Membrane Area	27.16599	CY	$281.13	$7,637.17
Cartridge Filter Area	6.054784	CY	$281.13	$1,702.18

Reverse Osmosis
Wellhead Treatment of Well #44
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Trench Walls:				
Walls for Below Membrane Trains	32.27778	CY	$557.50	$17,994.86
Spent Cleaning Chemical Neutralization Tank:				
Slab on Grade	7.167468	CY	$281.13	$2,014.99
Walls	18.19674	CY	$557.50	$10,144.68
Equipment Pads:				
Tanks:				
Acid/Base Cleaning Tank	0.58419	CY	$281.13	$164.23
Permeate Storage Tank for Flushing	2.093333	CY	$281.13	$588.50
Pumps:				
RO/NF High-Pressure Feed Pump	1.481481	CY	$281.13	$416.49
Allowance for Misc Items	0.05		$63,076.65	$3,153.83
Subtotal				$66,230.48
MASONRY:	Moderate			
CMU Building Over Membrane Area	2614.979	SF	$116.41	$304,405.13
Subtotal	2614.979	SF		$304,405.13
METALS:				
Grating Over Pipe Trench:				
Below Membrane Trains	498	SF	$64.02	$31,884.21
Handrail Around Spent Cleaning Chemical	31.34683	LF	$64.02	$2,006.97
Allowance for Misc Items	0.1		$33,891.18	$3,389.12
Subtotal				$37,280.30
EQUIPMENT:				
Reverse Osmosis Train:				
Membrane Elements	114	EA	$628.60	$71,660.91
Cartridge Filters (794 gpm)	2	EA	$13,470.90	$26,941.80
Tanks:				
Acid Cleaning Tank (480 gallons)	1	EA	$1,117.52	$1,117.52
Pumps:				
RO/NF High-Pressure Feed Pump (16 hp)	5	EA	$17,461.23	$87,306.17
Cleaning Solution Recirculation Pump (16	1	EA	$2,289.89	$2,289.89
Skids, Pressure Vessels & Manifold Piping	45600	SF	$6.11	$278,482.89
Allowance for Misc Items	0.1		$467,799.18	$46,779.92
Subtotal				$514,579.10
MECHANICAL:				
Ratio of AL6XN cost to SST cost	1.4			
Membrane System Main Feed Header Pip	23	LF	$34.52	$793.94

Reverse Osmosis
Wellhead Treatment of Well #44
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Membrane Train Row Feed Header Pipe (	39.25	LF	$34.52	$1,354.87
Membrane Train Feed Pipe (4 inch SST)	24	LF	$73.49	$1,763.85
Membrane Train Row Permeate Header Pi	49.25	LF	$73.49	$3,619.56
Membrane Train Row Concentrate Header	49.25	LF	$73.49	$3,619.56
Membrane Train Cleaning Solution Pipe (	139.4643	LF	$24.00	$3,347.16
Membrane Train SST Feed Flow Control V	5	EA	$2,002.42	$10,012.10
Allowance for Misc Items	0.1		$24,511.04	$2,451.10
Subtotal				$26,962.14
USER DEFINED ESTIMATE ITEMS:	QUANT	UNIT	$/UNIT	TOTAL COST
2 BWS pumps, plus AFDs, plus 10%	2		$74,815.00	$149,630.00
Subtotal				$149,630.00
Subtotal				$1,112,148.42
ALLOWANCES:		User Over-write		
Finishes Allowance	0.02		$1,425,831.30	$28,516.63
I & C Allowance	0.05		$1,425,831.30	$71,291.57
Mechanical Allowance	0.1		$1,425,831.30	$142,583.13
Electrical Allowance	0.05		$1,425,831.30	$71,291.57
RO Facility Cost				**$1,425,831.30**

Chem Building

SITEWORK:				
Excavation	279.1887	CY	$2.91	$812.50
Imported Structural Backfill	91.38889	CY	$29.10	$2,659.60
Native Backfill	33.44306	CY	$5.82	$194.65
Haul Excess	245.7456	CY	$5.82	$1,430.34
Allowance for Misc Items	0.05		$5,097.09	$254.85
Subtotal				$5,351.95
CONCRETE:				
Sulfuric Acid				
Slab on Grade	15.5	CY	$281.13	$4,357.52
Containment Walls	6.590113	CY	$557.50	$3,673.99
Bulk Tank Pads	5.698519	CY	$281.13	$1,602.02
Metering Pump Pads	1.261936	CY	$281.13	$354.77
Sodium Hydroxide				
Slab on Grade	15.5	CY	$281.13	$4,357.52
Containment Walls	7.008958	CY	$557.50	$3,907.49
Bulk Tank Pads	5.698519	CY	$281.13	$1,602.02
Metering Pump Pads	1.342141	CY	$281.13	$377.32
Other 1				
Slab on Grade	6.854167	CY	$281.13	$1,926.91

Reverse Osmosis
Wellhead Treatment of Well #44
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Containment Walls	1.69694	CY	$557.50	$946.04
Metering Pump Pads	0.477264	CY	$281.13	$134.17
Corridor				
Slab on Grade	18.08333	CY	$281.13	$5,083.77
Allowance for Misc Items	0.05		$28,323.54	$1,416.18
Subtotal				$29,739.72
MASONRY:	Moderate			
CMU Building	1269.75	SF	$116.41	$147,809.35
Subtotal				$147,809.35
METALS:				
Metal Stairway	3	EA	$5,820.41	$17,461.23
Grating	3	EA	$1,396.90	$4,190.70
Allowance for Misc Items	0.1		$21,651.93	$2,165.19
Subtotal				$23,817.12
EQUIPMENT:				
Sulfuric Acid				
Bulk Tank	1	EA	18491.79587	$18,491.80
Metering Pump	2	EA	6298.510122	$12,597.02
Sodium Hydroxide				
Bulk Tank	1	EA	13560.6503	$13,560.65
Metering Pump	2	EA	6298.510122	$12,597.02
Metering Pump	2	EA	6298.510122	$12,597.02
Allowance for Misc Items	0.1		69843.5069	$6,984.35
Subtotal				$76,827.86
Subtotal				$283,546.00
ALLOWANCES:				
Finishes Allowance	0.02		436224.6088	$8,724.49
I & C Allowance	0.08		436224.6088	$34,897.97
Mechanical Allowance	0.2		436224.6088	$87,244.92
Electrical Allowance	0.05		436224.6088	$21,811.23
Chem Facility Cost				$436,224.61

Total Facility Cost $2,630,080.80

Reverse Osmosis
Wellhead Treatment of Well #44
4/17/2006

Comparison O&M Cost

	Total HP	Utilization	Annual Usage (Hours / Year)	$/kwh	Power Cost	
Reverse Osmosis Equipment Power	60.44	22.70%	8760	0.07	$6,273.60	
Chem Equipment Power	6	22.70%	8760	0.07	$622.79	
	Building Area (SF)	**Watts / SF**	**Annual Usage (Hours / Year)**	**$/kwh**	**Other Electrical Cost**	
Pressure Filter Building Electrical	1254	2	8760	$0.07	$1,537.91	
Reverse Osmosis Building Electrical	2615	2	8760	$0.07	$3,207.04	
Chem Building Electrical	1270	2	8760	$0.07	$1,557.53	
Liquid Chemicals:	**Flow (mgd)**	**Utilization**	**Annual Usage (dry tons / year)**	**Cost ($/dry ton)**	**Chemical Cost**	
Antiscalant	1.123919	22.70%	0.776640268	$1,000.00	$776.64	
Sulfuric Acid	1.123919	22.70%	7.76640268	$138.09	$1,072.46	
Sodium Hydroxide	1.123919	22.70%	6.601442278	$560.00	$3,696.81	
Total Chemical Cost					$5,545.91	
Cartridge Filter and Membrane Element Replacement (every 5 years)					$52,542.08	
	Flow (mgd)	**Utilization**	**Concentrate Percentage of Influent**	**Total Annual Waste Volume (million gallons)**	**Sewer Disposal cost per gallon**	**Total Cost**
Concentrate Disposal to Sewer						
Concentrate Disposal to Sewer	1.123919	22.70%	10%	9.312233429	$1,670.90	$15,559.81
					Subtotal	$86,846.66
					20% Contingency	$17,369.33
					Total Annual Cost	$104,215.99

APPENDIX F

Las Cruces PCE Removal
Wellhead Treatment - Well # 18
6/22/2006

Treatment Process	Comparative Construction Cost (Millions)	Comparative O&M Cost (Millions)		Total Comparative Present Worth (Millions)	Annual Cost of Water ($/1,000 gal)
		Annual	Present Worth		
Tray Aerator	$0.26	$0.004	$0.06	$0.31	$0.10
Packed Tower Aerator	$0.38	$0.006	$0.08	$0.46	$0.14
AOP	$0.93	$0.016	$0.23	$1.16	$0.35
GAC	$0.39	$0.009	$0.13	$0.52	$0.16

Tray Aerator
Wellhead Treatment - Well # 18
Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Tray Aerator Building				
SITEWORK:				
Excavation	119.2593	CY	$2.91	$347.07
Structural Backfill	119.2593	CY	$29.10	$3,470.69
Haul Excess	119.2593	CY	$5.82	$694.14
Allowance for Misc Items	0.05		$4,511.90	$225.59
Subtotal				$4,737.49
CONCRETE:				
Foundation	16.66667	CY	$309.56	$5,159.33
Slab on Grade	29.81481	CY	$281.13	$8,381.84
Allowance for Misc Items	0.05		$13,541.17	$677.06
Subtotal				$14,218.23
MASONRY:				
Type of Building Construction:	Moderate			
Building	644	SF	$116.41	$74,966.90
Subtotal				$74,966.90
METALS:				
Grating	200	SF	$64.02	$12,804.91
Handrail	100	LF	$64.02	$6,402.45
Stairs	15	Risers	$349.22	$5,238.37
Allowance for Misc Items	0.05		$24,445.73	$1,222.29
Subtotal				$25,668.01
EQUIPMENT:				
NEEP Tray Aerator	1	EA	$62,000.00	$62,000.00
One 6" magmeters	1	EA	$7,200.00	$7,200.00
One 6" pipe systems	1	EA	$6,500.00	$6,500.00
One 4" FCVs	1	EA	$5,800.00	$5,800.00
Allowance for Misc Items	0.05		$81,500.00	$4,075.00
Subtotal				$85,575.00
Subtotal				$205,165.64
ALLOWANCES:				
Finishes Allowance	2%		$256,457.04	$5,129.14
I & C Allowance	4%		$256,457.04	$10,258.28
Mechanical Allowance	10%		$256,457.04	$25,645.70
Electrical Allowance	4%		$256,457.04	$10,258.28
Tray Aerator Facility Cost				**$256,457.04**

Tray Aerator
Wellhead Treatment - Well # 18
Comparison O&M Cost
4/17/2006

	Total HP	Utilization	Annual Usage (Hours / Year)	$/kwh	Power Cost
Tray Aerator Equipment Power	25	22.70%	8760	$0.07	$2,594.97
	Building Area (SF)	**Watts / SF**	**Annual Usage (Hours / Year)**	**$/kwh**	**Other Electrical Cost**
Tray Aerator Building Electrical	644	2	8760	$0.07	$789.80
				Subtotal	$3,384.77
				20% Contingency	$676.95
				Total Annual Cost	$4,061.72

Packed Tower Aerator
Wellhead Treatment - Well # 18
Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Packed Tower Aerator Building				
SITEWORK:				
Excavation	74.07407	CY	$2.91	$215.57
Structural Backfill	74.07407	CY	$29.10	$2,155.71
Haul Excess	74.07407	CY	$5.82	$431.14
Allowance for Misc Items	0.05		$2,802.42	$140.12
Subtotal				**$2,942.54**
CONCRETE:				
Foundation	16.66667	CY	$309.56	$5,159.33
Slab on Grade	18.51852	CY	$281.13	$5,206.11
Allowance for Misc Items	0.05		$10,365.44	$518.27
Subtotal				**$10,883.72**
MASONRY:				
Type of Building Construction:	Moderate			
Building	400	SF	$116.41	$46,563.29
Subtotal				**$46,563.29**
METALS:				
Grating	200	SF	$64.02	$12,804.91
Handrail	100	LF	$64.02	$6,402.45
Stairs	15	Risers	$349.22	$5,238.37
Allowance for Misc Items	0.05		$24,445.73	$1,222.29
Subtotal				**$25,668.01**
EQUIPMENT:				
Packed Tower Aerator	1	EA	$190,000.00	$190,000.00
One 6" magmeters	1	EA	$7,200.00	$7,200.00
One 6" pipe systems	1	EA	$6,500.00	$6,500.00
One 4" FCVs	1	EA	$5,800.00	$5,800.00
Allowance for Misc Items	0.05		$209,500.00	$10,475.00
Subtotal				**$219,975.00**
Subtotal				**$306,032.56**
ALLOWANCES:				
Finishes Allowance	2%		$382,540.70	$7,650.81
I & C Allowance	4%		$382,540.70	$15,301.63
Mechanical Allowance	10%		$382,540.70	$38,254.07
Electrical Allowance	4%		$382,540.70	$15,301.63
Packed Tower Aerator Facility Cost				**$382,540.70**

Packed Tower Aerator
Wellhead Treatment - Well # 18
Comparison O&M Cost
4/17/2006

	Total HP	Utilization	Annual Usage (Hours / Year)	$/kwh	Power Cost
Packed Tower Aerator Blower Equipment Power	25	22.70%	8760	$0.07	$2,594.97
Packed Tower Aerator Pump Power	15	22.70%	8760	$0.07	$1,556.98
	Building Area (SF)	**Watts / SF**	**Annual Usage (Hours / Year)**	**$/kwh**	**Other Electrical Cost**
Packed Tower Aerator Building Electrical	400	2	8760	$0.07	$490.56
				Subtotal	$4,642.51
				20% Contingency	$928.50
				Total Annual Cost	$5,571.01

AOP
Wellhead Treatment - Well # 18
Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
AOP Building				
SITEWORK:				
Excavation	234.2593	CY	$2.91	$681.74
Structural Backfill	234.2593	CY	$29.10	$6,817.43
Haul Excess	234.2593	CY	$5.82	$1,363.49
Allowance for Misc Items	0.05		$8,862.65	$443.13
Subtotal				$9,305.79
CONCRETE:				
Foundation	16.66667	CY	$309.56	$5,159.33
Slab on Grade	58.56481	CY	$281.13	$16,464.33
Allowance for Misc Items	0.05		$21,623.66	$1,081.18
Subtotal				$22,704.84
MASONRY:				
Type of Building Construction:	Moderate			
Building	1265	SF	$116.41	$147,256.41
Subtotal				$147,256.41
METALS:				
Grating	200	SF	$64.02	$12,804.91
Handrail	100	LF	$64.02	$6,402.45
Stairs	15	Risers	$349.22	$5,238.37
Allowance for Misc Items	0.05		$24,445.73	$1,222.29
Subtotal				$25,668.01
EQUIPMENT:				
One HiPOx skid	1	EA	$500,000.00	$500,000.00
One 6" pipe systems	1	EA	$6,500.00	$6,500.00
One 4" FCVs	1	EA	$5,800.00	$5,800.00
Allowance for Misc Items	0.05		$512,300.00	$25,615.00
Subtotal				$537,915.00
Subtotal				$742,850.05
ALLOWANCES:				
Finishes Allowance	0.02		$928,562.57	$18,571.25
I & C Allowance	0.04		$928,562.57	$37,142.50
Mechanical Allowance	0.1		$928,562.57	$92,856.26
Electrical Allowance	0.04		$928,562.57	$37,142.50
AOP Facility Cost				**$928,562.57**

AOP
Wellhead Treatment - Well # 18
Comparison O&M Cost
4/17/2006

	Total annual kwh usage for full-time operation	Utilization	Annual Usage (Hours / Year)	$/kwh	Power Cost
AOP Equipment Power	160000	22.70%	8760	$0.07	$2,542.40
	Building Area (SF)	**Watts / SF**	**Annual Usage (Hours / Year)**	**$/kwh**	**Other Electrical Cost**
AOP Building Electrical	1265	2	8760	$0.07	$1,551.40
AOP Chemicals	**Total annual useage for full-time operation (gallons or 100scf)**	**Utilization**	**$/gal or $/100scf**		**Chemical Cost**
AOP Hydrogen Peroxide (gallons)	4470	22.70%	$4.25		$4,312.43
AOP oxygen gas (100 scf)	37000	22.70%	$0.60		$5,039.40

		Contract Cost
WRT Contract Fee (Annual cost for uranium disposal, media replacement, final close-out)		$108,066.00
	Subtotal	$13,445.63
	20% Contingency	$2,689.13
	Total Annual Cost	$16,134.75

Liquid Phase GAC
Wellhead Treatment - Well # 18
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
GAC Building				
SITEWORK:				
Excavation	166.1111	CY	$ 2.91	$ 483.42
Structural Backfill	166.1111	CY	$ 29.10	$ 4,834.18
Haul Excess	166.1111	CY	$ 5.82	$ 966.84
Allowance for Misc Items	0.05		$ 6,284.43	$ 314.22
Subtotal				$ 6,598.65
CONCRETE:				
Foundation	16.66667	CY	$ 309.56	$ 5,159.33
Slab on Grade	41.52778	CY	$ 281.13	$ 11,674.70
Allowance for Misc Items	0.05		$ 16,834.04	$ 841.70
Subtotal				$ 17,675.74
MASONRY:				
Type of Building Construction:	Moderate			
Building	897	SF	$ 116.41	$ 104,418.18
Subtotal				$ 104,418.18
METALS:				
Grating	200	SF	$ 64.02	$ 12,804.91
Handrail	100	LF	$ 64.02	$ 6,402.45
Stairs	15	Risers	$ 349.22	$ 5,238.37
Allowance for Misc Items	0.05		$ 24,445.73	$ 1,222.29
Subtotal				$ 25,668.01
EQUIPMENT:				
One Calgon Model 10	1	EA	$ 140,000.00	$ 140,000.00
One 6" pipe systems	1	EA	$ 6,500.00	$ 6,500.00
One 4" FCVs	1	EA	$ 5,800.00	$ 5,800.00
Allowance for Misc Items	0.05		$ 152,300.00	$ 7,615.00
Subtotal				$ 159,915.00
Subtotal				$ 314,275.58
ALLOWANCES:				
Finishes Allowance	0.02		$ 392,844.48	$ 7,856.89
I & C Allowance	0.04		$ 392,844.48	$ 15,713.78
Mechanical Allowance	0.1		$ 392,844.48	$ 39,284.45
Electrical Allowance	0.04		$ 392,844.48	$ 15,713.78
GAC Facility Cost				**$ 392,844.48**

Liquid Phase GAC
Wellhead Treatment - Well # 18
4/17/2006

Comparison O&M Cost

	Building Area (SF)	Watts / SF	Annual Usage (Hours / Year)	$/kwh	Other Electrical Cost	
GAC Building Electrical	897	2	8760	$0.07	$1,100.08	
GAC Disposal	**GAC Mass per Vessel (lbs)**	**Replacement Frequency (years)**	**Replacement Cost ($/1000 lbs)**	**Cost of replacement ($)**	**Annualized Cost of Replacement ($)**	
GAC Disposal	20000	2	$700	$418,600.00	$6,686.18	
					Subtotal	$7,786.26
					20% Contingency	$1,557.25
					Total Annual Cost	$9,343.51

interest rate 5%
life 25 years

GAC Replacement Year	Cost of replacement	cost of GAC at end of life cycle
2	$14,000.00	$43,001.33
4	$14,000.00	$39,003.48
6	$14,000.00	$35,377.30
8	$14,000.00	$32,088.26
10	$14,000.00	$29,104.99
12	$14,000.00	$26,399.09
14	$14,000.00	$23,944.75
16	$14,000.00	$21,718.60
18	$14,000.00	$19,699.41
20	$14,000.00	$17,867.94
22	$14,000.00	$16,206.75
24	$14,000.00	$14,700.00
	Total	$319,111.89
	Annualized amount	$6,686.18

APPENDIX G

Las Cruces Uranium Removal
Centralized Treatment - Wells 19, 21, & 27
Treatment Train Costs
4/17/2006

Treatment Process	Comparative Construction Cost (Millions)	Comparative O&M Cost (Millions)		Total Comparative Present Worth (Millions)	Annual Cost of Water ($/1,000 gal)
		Annual	Present Worth		
Train #1 - Tray Aerator/WRT	$2.53	$0.16	$2.22	$4.75	$0.30
Train #2 - AOP/WRT	$3.23	$0.19	$2.71	$5.95	$0.38
Train #3 - Coag/Sedimentation/GAC Filtration	$3.33	$0.22	$3.15	$6.48	$0.41
Train #4 - Tray Aerator/Reverse Osmosis	$5.30	$0.25	$3.54	$8.84	$0.56

Treatment Train #1 - Tray Aerator + WRT
Centralized Treatment - Wells 19, 21, & 27
Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Tray Aerator Building				
SITEWORK:				
Excavation	259.2593	CY	$2.91	$754.50
Structural Backfill	259.2593	CY	$29.10	$7,544.98
Haul Excess	259.2593	CY	$5.82	$1,509.00
Allowance for Misc Items	0.05		$9,808.47	$490.42
Subtotal				$10,298.89
CONCRETE:				
Foundation	16.66667	CY	$309.56	$5,159.33
Slab on Grade	64.81481	CY	$281.13	$18,221.39
Allowance for Misc Items	0.05		$23,380.72	$1,169.04
Subtotal				$24,549.76
MASONRY:				
Type of Building Construction:	Moderate			
Building	1400	SF	$116.41	$162,971.52
Subtotal				$162,971.52
METALS:				
Grating	200	SF	$64.02	$12,804.91
Handrail	100	LF	$64.02	$6,402.45
Stairs	15	Risers	$349.22	$5,238.37
Allowance for Misc Items	0.05		$24,445.73	$1,222.29
Subtotal				$25,668.01
EQUIPMENT:				
NEEP Tray Aerators	3	EA	$96,000.00	$288,000.00
Three 6" magmeters	3	EA	$7,200.00	$21,600.00
Three 6" pipe systems	3	EA	$6,500.00	$19,500.00
Three 4" FCVs	3	EA	$5,800.00	$17,400.00
Allowance for Misc Items	0.05		$346,500.00	$17,325.00
Subtotal				$363,825.00
Subtotal				$587,313.19
ALLOWANCES:				
Finishes Allowance	0.02		$734,141.48	$14,682.83
I & C Allowance	0.04		$734,141.48	$29,365.66
Mechanical Allowance	0.1		$734,141.48	$73,414.15
Electrical Allowance	0.04		$734,141.48	$29,365.66
Tray Aerator Facility Cost				$734,141.48

Treatment Train #1 - Tray Aerator + WRT
Centralized Treatment - Wells 19, 21, & 27
Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
WRT Building				
SITEWORK:				
Excavation	462.963	CY	$2.91	$1,347.32
Structural Backfill	462.963	CY	$29.10	$13,473.17
Haul Excess	462.963	CY	$5.82	$2,694.63
Allowance for Misc Items	5%		$17,515.13	$875.76
Subtotal				$18,390.88
CONCRETE:				
Foundation	16.66667	CY	$309.56	$5,159.33
Slab on Grade	115.7407	CY	$281.13	$32,538.19
Allowance for Misc Items	5%		$37,697.53	$1,884.88
Subtotal				$39,582.40
MASONRY:				
Building	2500	SF	$116.41	$291,020.57
Subtotal				$291,020.57
METALS:				
Grating	200	SF	$64.02	$12,804.91
Handrail	100	LF	$64.02	$6,402.45
Stairs	15	Risers	$349.22	$5,238.37
Allowance for Misc Items	0.05		$24,445.73	$1,222.29
Subtotal				$25,668.01
EQUIPMENT:				
WRT Equipment	1	EA	$950,000.00	$950,000.00
Two 10" Rapid Mixers, each rapi	2	EA	$7,300.00	$14,600.00
Two magmeters	2	EA	$8,000.00	$16,000.00
Two pipe systems	2	EA	$9,900.00	$19,800.00
Two FCVs	2	EA	$6,400.00	$12,800.00
Allowance for Misc Items	5%		$1,013,200.00	$50,660.00
Subtotal				$1,063,860.00
Subtotal				$1,438,521.87
ALLOWANCES:				
Finishes Allowance	2%		$1,798,152.34	$35,963.05
I & C Allowance	4%		$1,798,152.34	$71,926.09
Mechanical Allowance	10%		$1,798,152.34	$179,815.23
Electrical Allowance	4%		$1,798,152.34	$71,926.09
WRT Facility Cost				**$1,798,152.34**

Treatment Train #1 - Tray Aerator + WRT
Centralized Treatment - Wells 19, 21, & 27
Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
	Total Treatment Train Cost			$2,532,293.82

Treatment Train #1 - Tray Aerator + WRT
Centralized Treatment - Wells 19, 21, & 27
Comparison O&M Cost
4/17/2006

	Total HP	Utilization	Annual Usage (Hours / Year)	$/kwh	Power Cost
Tray Aerator Equipment Power	120	33.40%	8760	$0.07	$18,327.11
WRT Building Equipment Power	0	33.40%	8760	$0.07	$0.00
	Building Area (SF)	**Watts / SF**	**Annual Usage (Hours / Year)**	**$/kwh**	**Other Electrical Cost**
Tray Aerator Building Electrical	1400	2	8760	$0.07	$1,716.96
WRT Building Electrical	2500	2	8760	$0.07	$3,066.00
					Contract Cost
WRT Contract Fee (Annual cost for uranium disposal, media replacement, final close-out)					$108,066.00
				Subtotal	$131,176.07
				20% Contingency	$26,235.21
				Total Annual Cost	$157,411.28

Treatment Train #2 - AOP + WRT
Centralized Treatment - Wells 19, 21, & 27
Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
AOP Building				
SITEWORK:				
Excavation	390.1852	CY	$2.91	$1,135.52
Structural Backfill	390.1852	CY	$29.10	$11,355.19
Haul Excess	390.1852	CY	$5.82	$2,271.04
Allowance for Misc Items	0.05		$14,761.75	$738.09
Subtotal				$15,499.84
CONCRETE:				
Foundation	16.66667	CY	$309.56	$5,159.33
Slab on Grade	97.5463	CY	$281.13	$27,423.19
Allowance for Misc Items	0.05		$32,582.52	$1,629.13
Subtotal				$34,211.65
MASONRY:				
Type of Building Construction:	Moderate			
Building	2107	SF	$116.41	$245,272.14
Subtotal				$245,272.14
METALS:				
Grating	200	SF	$64.02	$12,804.91
Handrail	100	LF	$64.02	$6,402.45
Stairs	15	Risers	$349.22	$5,238.37
Allowance for Misc Items	0.05		$24,445.73	$1,222.29
Subtotal				$25,668.01
EQUIPMENT:				
Three HiPOx skids	3	EA	$250,000.00	$750,000.00
Three 6" pipe systems	3	EA	$6,500.00	$19,500.00
Three 4" FCVs	3	EA	$5,800.00	$17,400.00
Allowance for Misc Items	0.05		$786,900.00	$39,345.00
Subtotal				$826,245.00
Subtotal				$1,146,896.64
ALLOWANCES:				
Finishes Allowance	0.02		$1,433,620.80	$28,672.42
I & C Allowance	0.04		$1,433,620.80	$57,344.83
Mechanical Allowance	0.1		$1,433,620.80	$143,362.08
Electrical Allowance	0.04		$1,433,620.80	$57,344.83
AOP Facility Cost				**$1,433,620.80**

Treatment Train #2 - AOP + WRT
Centralized Treatment - Wells 19, 21, & 27
Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
WRT Building				
SITEWORK:				
Excavation	462.963	CY	$2.91	$1,347.32
Structural Backfill	462.963	CY	$29.10	$13,473.17
Haul Excess	462.963	CY	$5.82	$2,694.63
Allowance for Misc Items	5%		$17,515.13	$875.76
Subtotal				$18,390.88
CONCRETE:				
Foundation	16.66667	CY	$309.56	$5,159.33
Slab on Grade	115.7407	CY	$281.13	$32,538.19
Allowance for Misc Items	5%		$37,697.53	$1,884.88
Subtotal				$39,582.40
MASONRY:				
Building	2500	SF	$116.41	$291,020.57
Subtotal				$291,020.57
METALS:				
Grating	200	SF	$64.02	$12,804.91
Handrail	100	LF	$64.02	$6,402.45
Stairs	15	Risers	$349.22	$5,238.37
Allowance for Misc Items	0.05		$24,445.73	$1,222.29
Subtotal				$25,668.01
EQUIPMENT:				
WRT Equipment	1	EA	$950,000.00	$950,000.00
Two 10" Rapid Mixers, each rapid mixe	2	EA	$7,300.00	$14,600.00
Two magmeters	2	EA	$8,000.00	$16,000.00
Two pipe systems	2	EA	$9,900.00	$19,800.00
Two FCVs	2	EA	$6,400.00	$12,800.00
Allowance for Misc Items	5%		$1,013,200.00	$50,660.00
Subtotal				$1,063,860.00
Subtotal				$1,438,521.87
ALLOWANCES:				
Finishes Allowance	2%		$1,798,152.34	$35,963.05
I & C Allowance	4%		$1,798,152.34	$71,926.09
Mechanical Allowance	10%		$1,798,152.34	$179,815.23
Electrical Allowance	4%		$1,798,152.34	$71,926.09
WRT Facility Cost				**$1,798,152.34**

Treatment Train #2 - AOP + WRT
Centralized Treatment - Wells 19, 21, & 27
Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
		Total Treatment Train Cost		**$3,231,773.13**

Treatment Train #1 - AOP + WRT
Centralized Treatment - Wells 19, 21, & 27
Comparison O&M Cost
4/17/2006

	Total annual kwh usage for full-time operation	Utilization	Annual Usage (Hours / Year)	$/kwh	Power Cost
AOP Equipment Power	440000	33.40%	8760	$0.07	$10,287.20
WRT Building Equipment Power	0	33.40%	8760	$0.07	$0.00
	Building Area (SF)	**Watts / SF**	**Annual Usage (Hours / Year)**	**$/kwh**	**Other Electrical Cost**
AOP Building Electrical	2107	2	8760	$0.07	$2,584.02
WRT Building Electrical	2500	2	8760	$0.07	$3,066.00
AOP Chemicals	**Total annual useage for full-time operation (gallons or 100scf)**	**Utilization**	**$/gal or $/100scf**		**Chemical Cost**
AOP Hydrogen Peroxide (gallons)	12000	33.40%	$4.25		$17,034.00
AOP oxygen gas (100 scf)	97000	33.40%	$0.60		$19,438.80
					Contract Cost
WRT Contract Fee (Annual cost for uranium disposal, media replacement, final close-out)					$108,066.00
				Subtotal	$160,476.02
				20% Contingency	$32,095.20
				Total Annual Cost	$192,571.23

Treatment Train #3
Centralized Treatment - Wells 19, 21, & 27
Coag/Sedimentation/GAC Filtration
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Floc/Sed/Filter Building				
SITEWORK:				
Excavation	541.6517	CY	$2.91	$1,576.32
Imported Structural Backfill	173.133	CY	$29.10	$5,038.53
Native Backfill	182.523	CY	$5.82	$1,062.36
Haul Excess	359.1287	CY	$5.82	$2,090.28
Allowance for Misc Items	5%		$9,767.48	$488.37
Subtotal				$10,255.85
CONCRETE:				
Slab on Grade	191.8292	CY	$281.13	$53,928.93
Allowance for Misc Items	10%		$53,928.93	$5,392.89
Subtotal				$59,321.83
MASONRY:				
CMU Building	3644.43	SF	$116.41	$424,241.64
Subtotal				$424,241.64
METALS:				
Stairway	30	Risers	$349.22	$10,476.74
Grating Between Treatment Tanks	143.31	SF	$64.02	$9,175.35
Allowance for Misc Items	10%		$19,652.10	$1,965.21
Subtotal				$21,617.30
EQUIPMENT:				
US Filter Trident HS Base Package Treatment System Including: 2-50% Capacity Tube Clarifier Tank & Sludge Collection/Pump Systems; 2-50% Capacity Adsorption Clarifier Systems; 2-50% Capacity Filter Systems; 2-50% Capacity Internal Transfer Pumping Systems; 2-50% Capacity Air Wash Blowers; Control Valves; Flow Meters; Liquid Level Controllers; Headloss Switches; Turbidimeters & Sample Pumps; Control Station; Delivery, & Installation Technical Direction	2800	GPM	$485.89	$1,360,478.19
Allowance for Misc Items	10%		$1,360,478.19	$136,047.82
Subtotal				$1,496,526.00
Specials:	QUANT	UNIT	$/UNIT	TOTAL COST
Two 10" Rapid Mixers, each rapid mixer rated for 1.75mgd	2		$7,300.00	$14,600.00
Two magmeters	2		$8,000.00	$16,000.00
Two pipe systems	2		$9,900.00	$19,800.00
Two FCVs	2		$6,400.00	$12,800.00
2 BWS pumps, plus AFDs, plus 10%	2		$74,815.00	$149,630.00
Subtotal				$212,830.00
Subtotal				$2,224,792.63
ALLOWANCES:				
Finishes Allowance	2%		$2,816,193.20	$56,323.86
I & C Allowance	4%		$2,816,193.20	$112,647.73

Treatment Train #3
Centralized Treatment - Wells 19, 21, & 27
Coag/Sedimentation/GAC Filtration
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Mechanical Allowance	10%		$2,816,193.20	$281,619.32
Electrical Allowance	5%		$2,816,193.20	$140,809.66
Floc/Sed/Filtration Facility Cost				**$2,816,193.20**

Chemcial Building

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
SITEWORK:				
Excavation	317.1921	CY	$2.91	$923.09
Imported Structural Backfill	104.4444	CY	$29.10	$3,039.55
Native Backfill	35.96389	CY	$5.82	$209.32
Haul Excess	281.2282	CY	$5.82	$1,636.86
Allowance for Misc Items	5%		$5,808.83	$290.44
Subtotal				$6,099.27
CONCRETE:				
Ferric Chloride				
Slab on Grade	14.5	CY	$281.13	$4,076.39
Containment Walls	7.46819	CY	$557.50	$4,163.52
Bulk Tank Pads	5.698519	CY	$281.13	$1,602.02
Metering Pump Pads	1.493638	CY	$281.13	$419.91
Sulfuric Acid				
Slab on Grade	14.5	CY	$281.13	$4,076.39
Containment Walls	6.606735	CY	$557.50	$3,683.26
Bulk Tank Pads	5.698519	CY	$281.13	$1,602.02
Metering Pump Pads	1.321347	CY	$281.13	$371.47
Sodium Hydroxide				
Slab on Grade	15.5	CY	$281.13	$4,357.52
Containment Walls	7.427802	CY	$557.50	$4,141.00
Bulk Tank Pads	5.698519	CY	$281.13	$1,602.02
Metering Pump Pads	1.422345	CY	$281.13	$399.86
Corridor				
Slab on Grade	21	CY	$281.13	$5,903.73
Allowance for Misc Items	5%		$36,399.10	$1,819.95
Subtotal				$38,219.05
MASONRY:				
CMU Building	1494	SF	$116.41	$173,913.89
Subtotal				$173,913.89
METALS:				
Metal Stairway	3	EA	$5,820.41	$17,461.23
Grating	3	EA	$1,396.90	$4,190.70
Allowance for Misc Items	0.1		$21,651.93	$2,165.19
Subtotal				$23,817.12
EQUIPMENT:				
Ferric Chloride				

Treatment Train #3
Centralized Treatment - Wells 19, 21, & 27
Coag/Sedimentation/GAC Filtration
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Bulk Tank	1	EA	$14,793.44	$14,793.44
Metering Pump	2	EA	$6,298.51	$12,597.02
Sulfuric Acid				
Bulk Tank	1	EA	$18,491.80	$18,491.80
Metering Pump	2	EA	$6,298.51	$12,597.02
Sodium Hydroxide				
Bulk Tank	1	EA	$14,793.44	$14,793.44
Metering Pump	2	EA	$6,298.51	$12,597.02
Allowance for Misc Items	0.1		$85,869.73	$8,586.97
Subtotal				$94,456.70
Subtotal				$336,506.05
ALLOWANCES:				
Finishes Allowance	2%		$517,701.61	$10,354.03
I & C Allowance	8%		$517,701.61	$41,416.13
Mechanical Allowance	20%		$517,701.61	$103,540.32
Electrical Allowance	5%		$517,701.61	$25,885.08
Chem Bldg Facility Cost	1494	Building SF	$346.52	$517,701.61

Total Treatment Train Cost **$3,333,894.81**

Treatment Train #3
Centralized Treatment - Wells 19, 21, & 27
Coag/Sedimentation/GAC Filtration
4/17/2006

Comparison O&M Cost

	Total HP	Utilization	Annual Usage (Hours / Year)	$/kwh	Power Cost	
Chem Equipment Power	6	33.40%	8760	0.07	$916.36	
Coag/Sed/Filter Equipment Power	32	33.40%	8760	0.07	$4,891.41	
	Building Area (SF)	**Watts / SF**	**Annual Usage (Hours / Year)**	**$/kwh**	**Other Electrical Cost**	
Chem Building Electrical	1494	2	8760	$0.07	$1,832.24	
Coag/Sed/Filter Building Electrical	3644	2	8760	$0.07	$4,469.00	
Liquid Chemicals:	**Flow (mgd)**	**Utilization**	**Annual Usage (dry tons / year)**	**Cost ($/dry ton)**	**Chemical Cost**	
Ferric Chloride	3.5	33.40%	53.3782935	$371.53	$19,831.64	
Sulfuric Acid	3.5	33.40%	169.0312628	$138.09	$23,341.53	
Sodium Hydroxide	3.5	33.40%	129.8871809	$560.00	$72,736.82	
Total Chemical Cost					$115,909.99	
GAC Disposal	**GAC Volume (cf)**	**Replacement Frequency (years)**	**Replacement Cost ($/1000 lbs)**	**Cost of replacement ($)**	**Annualized Cost of Replacement ($)**	
GAC Disposal	2240	2	$700	$46,883.20	$22,390.67	
Backwash Waste Disposal to Sewer	**Flow (mgd)**	**Utilization**	**Waste Percentage of Influent**	**Total Annual Waste Volume (million gallons)**	**Sewer Disposal cost per million gallons**	**Total Cost**
Backwash Waste Disposal to Sewer	3.5	33.40%	5.0%	21.33425	$1,670.90	$35,647.39
					Subtotal	$186,057.06
					20% Contingency	$37,211.41
					Total Annual Cost	$223,268.47

interest rate 5%
life 25 years

GAC Replacement

Year	Cost of replacement	cost of GAC at end of life cycle
2	$46,883.20	$144,002.86
4	$46,883.20	$130,614.84
6	$46,883.20	$118,471.51
8	$46,883.20	$107,457.15
10	$46,883.20	$97,466.81
12	$46,883.20	$88,405.27
14	$46,883.20	$80,186.18
16	$46,883.20	$72,731.23
18	$46,883.20	$65,969.37
20	$46,883.20	$59,836.16
22	$46,883.20	$54,273.16
24	$46,883.20	$49,227.36
	Total	$1,068,641.91
	Annualized amount	$22,390.67

Treatment Train #4
Centralized Treatment - Wells 19, 21, & 27
Tray Aerator - Reverse Osmosis
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Pressure Filter Building				
SITEWORK:				
Excavation	629	CY	***$2.91***	$1,830
Imported Structural Backfill	149	CY	***$29.10***	$4,346
Native Backfill	83	CY	***$5.82***	$480
Haul Excess	546	CY	***$5.82***	$3,179
Allowance for Misc Items	5%		$9,835.28	$492
Subtotal				$10,327
CONCRETE:				
Slab on Grade	98	CY	***$281.13***	$27,488
Allowance for Misc Items	5%		$27,488	$1,374
Subtotal				$28,863
MASONRY:	**Low**			
CMU Building	3,520	SF	***$93.13***	$327,806
Subtotal				$327,806
EQUIPMENT:				
Vertical Pressure Filter Systems (Includes Tanks, Underdrain, System Piping, Actuated Valves, Instrumentation, and Automatic PLC Control Panel)	3	EA	***$252,469.23***	$757,408
Filter Media	2,358	CF	***$18.11***	$42,693
Blowers	1	EA	***$41,479.91***	$0
Allowance for Misc Items	10%		$800,100.34	$80,010
Subtotal				$880,110
USER DEFINED ESTIMATE ITEMS:	**QUANT**	**UNIT**	**$/UNIT**	**TOTAL COST**
Two 10" Rapid Mixers, each rapid mixer rated for 1.75mgd	2		$7,300.00	$14,600
Two magmeters	2		$8,000.00	$16,000
Two pipe systems	2		$9,900.00	$19,800
Two FCVs	2		$6,400.00	$12,800
Subtotal				$63,200
Subtotal				$1,310,306
ALLOWANCES:				

Treatment Train #4
Centralized Treatment - Wells 19, 21, & 27
Tray Aerator - Reverse Osmosis
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Finishes Allowance	2.0%		$1,679,879	$33,598
I & C Allowance	5%		$1,679,879	$83,994
Mechanical Allowance	10%		$1,679,879	$167,988
Electrical Allowance	5%		$1,679,879	$83,994
Pressure Filter Facility Cost	**3,458,213**			**$1,679,879**

Tray Aerator Building

SITEWORK:				
Excavation	259	CY	***$2.91***	$754
Structural Backfill	259	CY	***$29.10***	$7,545
Haul Excess	259	CY	***$5.82***	$1,509
Allowance for Misc Items	5%		$9,808.47	$490
Subtotal				$10,299
CONCRETE:				
Foundation	17	CY	***$309.56***	$5,159
Slab on Grade	65	CY	***$281.13***	$18,221
Allowance for Misc Items	5%		$23,381	$1,169
Subtotal				$24,550
MASONRY:				
Type of Building Construction:	**Moderate**			
Building	1,400	SF	***$116.41***	$162,972
Subtotal				$162,972
METALS:				
Grating	200	SF	***$64.02***	$12,805
Handrail	100	LF	***$64.02***	$6,402
Stairs	15	Risers	***$349.22***	$5,238
Allowance for Misc Items	5%		$24,445.73	$1,222
Subtotal				$25,668
EQUIPMENT:				
NEEP Tray Aerators	3	EA	$96,000.00	$288,000
Three 6" magmeters	3	EA	$7,200.00	$21,600
Three 6" pipe systems	3	EA	$6,500.00	$19,500
Three 4" FCVs	3	EA	$5,800.00	$17,400
Allowance for Misc Items	5%		$346,500.00	$17,325
Subtotal				$363,825

Treatment Train #4
Centralized Treatment - Wells 19, 21, & 27
Tray Aerator - Reverse Osmosis
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Subtotal				$587,313
ALLOWANCES:				
Finishes Allowance	2.0%		$734,141	$14,683
I & C Allowance	4%		$734,141	$29,366
Mechanical Allowance	10%		$734,141	$73,414
Electrical Allowance	4%		$734,141	$29,366
Tray Aerator Facility Cost				**$734,141**

Reverse Osmosis Building

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
SITEWORK:				
Membrane Building:				
Process Building:				
Excavation	649	CY	***$2.91***	$1,888
Imported Structural Backfill	119	CY	***$29.10***	$3,456
Native Backfill	208	CY	***$5.82***	$1,213
Haul Excess	440	CY	***$5.82***	$2,563
Electrical Room:				
Excavation	190	CY	***$2.91***	$553
Imported Structural Backfill	21	CY	***$29.10***	$597
Native Backfill	179	CY	***$5.82***	$1,041
Haul Excess	11	CY	***$5.82***	$65
Non-Membrane Area:				
Excavation	137	CY	***$2.91***	$399
Imported Structural Backfill	37	CY	***$29.10***	$1,077
Native Backfill	76	CY	***$5.82***	$441
Haul Excess	61	CY	***$5.82***	$357
Cartridge Filter Area:				
Excavation	57	CY	***$2.91***	$167
Imported Structural Backfill	12	CY	***$29.10***	$359
Native Backfill	39	CY	***$5.82***	$228
Haul Excess	18	CY	***$5.82***	$106
Spent Cleaning Chemical Neutralization Tank:				
Excavation	222	CY	***$2.91***	$646
Imported Structural Backfill	11	CY	***$29.10***	$307

Treatment Train #4
Centralized Treatment - Wells 19, 21, & 27
Tray Aerator - Reverse Osmosis
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Native Backfill	129	CY	***$5.82***	$751
Haul Excess	93	CY	***$5.82***	$541
Allowance for Misc Items	5%		$16,757.86	$838
Subtotal				$17,596
CONCRETE:				
Slab on Grade:				
Membrane Area:				
Process Building	102	CY	***$281.13***	$28,668
Electrical Area	9	CY	***$281.13***	$2,542
Non-Membrane Area	28	CY	***$281.13***	$7,931
Cartridge Filter Area	7	CY	***$281.13***	$2,080
Trench Walls:				
Walls for Below Membrane Trains	48	CY	***$557.50***	$26,760
Spent Cleaning Chemical Neutralization Tank:				
Slab on Grade	12	CY	***$281.13***	$3,448
Walls	35	CY	***$557.50***	$19,508
Equipment Pads:				
Tanks:				
Acid/Base Cleaning Tank	0.81	CY	***$281.13***	$228
Permeate Storage Tank for Flushing	2	CY	***$281.13***	$588
Pumps:				
RO/NF High-Pressure Feed Pump	1.48	CY	***$281.13***	$416
Allowance for Misc Items	5%		$92,170.41	$4,609
Subtotal				$96,779
MASONRY:	**Moderate**			
CMU Building Over Membrane Area	3,440	SF	***$116.41***	$400,396
Subtotal	3,440	SF		$400,396
METALS:				
Grating Over Pipe Trench:				
Below Membrane Trains	810	SF	***$64.02***	$51,860
Handrail Around Spent Cleaning Chemical Neutralization Tank	43	LF	***$64.02***	$2,783
Allowance for Misc Items	10%		$54,642.97	$5,464
Subtotal				$60,107

Treatment Train #4
Centralized Treatment - Wells 19, 21, & 27
Tray Aerator - Reverse Osmosis
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
EQUIPMENT:				
Reverse Osmosis Train:				
Membrane Elements	336	EA	***$628.60***	$211,211
Cartridge Filters (2168 gpm)	2	EA	***$18,618.50***	$37,237
Tanks:				
Acid Cleaning Tank (960 gallons)	1	EA	***$2,235.04***	$2,235
Pumps:				
RO/NF High-Pressure Feed Pump (51 hp)	5	EA	***$17,461.23***	$87,306
Cleaning Solution Recirculation Pump (320 gpm, 20 hp)	1	EA	***$3,751.61***	$3,752
Skids, Pressure Vessels & Manifold Piping	134,400.0	SF	***$4.72***	$634,314
Allowance for Misc Items	10%		$976,055.05	$97,606
Subtotal				$1,073,661
MECHANICAL:				
Ratio of AL6XN cost to SST cost	1.4			
Membrane System Main Feed Header Pipe (12 inch SST)	23.00	LF	***$257.98***	$5,934
Membrane Train Row Feed Header Pipe (12 inch SST)	58.00	LF	***$257.98***	$14,963
Membrane Train Feed Pipe (6 inch SST)	32.00	LF	***$119.62***	$3,828
Membrane Train Row Permeate Header Pipe (8 inch SST)	68.00	LF	***$165.74***	$11,270
Membrane Train Row Concentrate Header Pipe (4 inch SST)	68.00	LF	***$73.49***	$4,998
Membrane Train Cleaning Solution Pipe (4 inch PVC)	179.20	LF	***$24.00***	$4,301
-	-	LF	***$0.00***	$0
-	-	LF	***$0.00***	$0
Membrane Train SST Feed Flow Control Valves (6 inch)	5.00	EA	***$3,539.99***	$17,700
Allowance for Misc Items	10%		$62,993.00	$6,299
Subtotal				$69,292

USER DEFINED ESTIMATE ITEMS:	**QUANT**	**UNIT**	**$/UNIT**	**TOTAL COST**
2 BWS pumps, plus AFDs, plus 10%	2		$74,815.00	$149,630
Subtotal				$149,630
Subtotal				$1,867,460

Treatment Train #4
Centralized Treatment - Wells 19, 21, & 27
Tray Aerator - Reverse Osmosis
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
ALLOWANCES:				
Finishes Allowance	2.0%		$2,394,180	$47,884
I & C Allowance	5%		$2,394,180	$119,709
Mechanical Allowance	10%		$2,394,180	$239,418
Electrical Allowance	5%		$2,394,180	$119,709
RO Building Cost	**1,991,354**			**$2,394,180**

Chemical Building

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
SITEWORK:				
Excavation	345	CY	***$2.91***	$1,004
Imported Structural Backfill	114	CY	***$29.10***	$3,318
Native Backfill	38	CY	***$5.82***	$220
Haul Excess	307	CY	***$5.82***	$1,788
Allowance for Misc Items	5%		$6,330.77	$317
Subtotal				$6,647
CONCRETE:				
Sulfuric Acid				
Slab on Grade	16	CY	***$281.13***	$4,358
Containment Walls	7	CY	***$557.50***	$3,674
Bulk Tank Pads	6	CY	***$281.13***	$1,602
Day Tank Pads	0	CY	***$281.13***	$0
Transfer Pump Pads	0	CY	***$281.13***	$0
Metering Pump Pads	1	CY	***$281.13***	$355
Hydrofluorosilicic Acid				
Slab on Grade	0	CY	***$281.13***	$0
Containment Walls	0	CY	***$557.50***	$0
Bulk Tank Pads	0	CY	***$281.13***	$0
Day Tank Pads	0	CY	***$281.13***	$0
Transfer Pump Pads	0	CY	***$281.13***	$0
Metering Pump Pads	0	CY	***$281.13***	$0
Sodium Hydroxide				
Slab on Grade	16	CY	***$281.13***	$4,358
Containment Walls	7	CY	***$557.50***	$3,907
Bulk Tank Pads	6	CY	***$281.13***	$1,602
Metering Pump Pads	1	CY	***$281.13***	$377
Other 1				
Slab on Grade	15	CY	***$281.13***	$4,313
Containment Walls	2	CY	***$557.50***	$1,304
Corridor				

Treatment Train #4
Centralized Treatment - Wells 19, 21, & 27
Tray Aerator - Reverse Osmosis
4/17/2006

Comparison Construction Cost

DESCRIPTION	QUANT	UNIT	$/UNIT	TOTAL COST
Slab on Grade	23	CY	***$281.13***	$6,505
Allowance for Misc Items	5%		$32,485.35	$1,624
Subtotal				$34,110
MASONRY:	**Moderate**			
CMU Building	1,549	SF	***$116.41***	$180,345
Subtotal				$180,345
METALS:				
Metal Stairway	3	EA	***$5,820.41***	$17,461
Grating	3	EA	***$1,396.90***	$4,191
Allowance for Misc Items	10%		$21,651.93	$2,165
Subtotal				$23,817
EQUIPMENT:				
Sulfuric Acid				
Bulk Tank	1	EA	***$18,491.80***	$18,492
Metering Pump	2	EA	***$6,298.51***	$12,597
Sodium Hydroxide				
Bulk Tank	1	EA	***$13,560.65***	$13,561
Metering Pump	2	EA	***$6,298.51***	$12,597
Other 1				
Metering Pump	2	EA	***$6,298.51***	$12,597
Allowance for Misc Items	10%		$69,843.51	$6,984
Subtotal				$76,828
Subtotal				$321,747.36
ALLOWANCES:				
Finishes Allowance	2.0%		$494,996	$9,900
I & C Allowance	8%		$494,996	$39,600
Mechanical Allowance	20%		$494,996	$98,999
Electrical Allowance	5%		$494,996	$24,750
Chem Building Cost				**$494,996**

Total Treatment Train Cost **$5,303,196**

Treatment Train #4
Centralized Treatment - Wells 19, 21, & 27
Tray Aerator - Reverse Osmosis
4/17/2006

Comparison O&M Cost

	Total HP	Utilization	Annual Usage (Hours / Year)	$/kwh	Power Cost	
Tray Aerator Equipment Power	120	33.40%	8760	0.07	$18,327.11	
Reverse Osmosis Equipment Power	186	33.40%	8760	0.07	$28,407.02	
Chem Equipment Power	6	33.40%	8760	0.07	$916.36	
	Building Area (SF)	**Watts / SF**	**Annual Usage (Hours / Year)**	**$/kwh**	**Other Electrical Cost**	
Pressure Filter Building Electrical	3520	2	8760	$0.07	$4,316.93	
Tray Aerator Building Electrical	1400	2	8760	$0.07	$1,716.96	
Reverse Osmosis Building Electrical	3440	2	8760	$0.07	$4,218.82	
Chem Building Electrical	1549	2	8760	$0.07	$1,899.69	
Liquid Chemicals:	**Flow (mgd)**	**Utilization**	**Annual Usage (dry tons / year)**	**Cost ($/dry ton)**	**Chemical Cost**	
Antiscalant	3.5	33.40%	3.5585529	$1,000.00	$3,558.55	
Sulfuric Acid	3.5	33.40%	35.585529	$138.09	$4,914.01	
Sodium Hydroxide	3.5	33.40%	30.24769965	$560.00	$16,938.71	
Total Chemical Cost					$25,411.27	
Cartridge Filter and Membrane Element Replacement (every 5 years)					$52,542.08	
	Flow (mgd)	**Utilization**	**Concentrate Percentage of Influent**	**Total Annual Waste Volume (million gallons)**	**Sewer Disposal cost per gallon**	**Total Cost**
Concentrate Disposal to Sewer						
Concentrate Disposal to Sewer	3.5	33.40%	10%	42.6685	$1,670.90	$71,294.78
					Subtotal	$209,051.02
					20% Contingency	$41,810.20
					Total Annual Cost	$250,861.22