environmental
properties management, LLC

June 30, 2011

Mr. Ken Kalman
U.S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852-2738

Mr. David Cates
Oklahoma Department of Environmental Quality
707 North Robinson
Oklahoma City, OK 73101-1677

Re: Cimarron Environmental Response Trust
Evaluation of Potential Alternative Groundwater Remediation Technologies

Dear Mr. Kalman and Cates:

Environmental Properties Management LLC (EPM) is pleased to submit herein the Evaluation of Potential Alternative Groundwater Remediation Technologies in accordance with the Consent Order and Settlement Agreement for the Cimarron Environmental Response Trust. This report presents the results of the 2011 groundwater assessment performed to delineate nitrate and fluoride, and the evaluation of several monitor wells for Tc-99 activity. The report also provides screening, evaluation and estimated costs for potential groundwater remediation technologies.

The report is being provided in both hard copy and electronic formats for your convenience. We would be available to meet with you in person or via teleconference to provide an overview of the evaluation, or to provide additional description or information relative to this evaluation.

We look forward to your selection of a groundwater remediation technology and the preparation of a remedial design to complete the remediation of the Site. Should you desire additional information or to schedule a meeting or teleconference, please contact us at 816-822-3545 (Bill Halliburton) or 405-642-5152 (Jeff Lux).

Sincerely,

Bill Halliburton
Administrator, Cimarron Environmental Response Trust

Enclosure

cc: Blair Spitzberg, NRC

9400 Ward Parkway
Kansas City, MO 64114
816-333-9400

Draft
Cimarron Environmental Response Trust Evaluation of Potential Alternative Groundwater Remediation Technologies

Prepared for

U. S. Nuclear Regulatory Commission
Rockville, MD
and

Oklahoma Department of Environmental Quality
Oklahoma City, OK

June 2011

Project No. 60813/60640

prepared by

Environmental Properties Management LLC
Kansas City, Missouri

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CHAPTER I - INTRODUCTION

This report is being submitted to the U.S. Nuclear Regulatory Commission (NRC) and the Oklahoma Department of Environmental Quality (DEQ) in accordance with the Cimarron Environmental Response Trust Agreement (The Agreement) dated February 14, 2011. This report presents an evaluation of groundwater remediation technologies which could be employed at the Cimarron site to reduce the concentration of chemicals of concern to both NRC and DEQ to levels below those required for license termination and release of the site from further remedial action.

A. BACKGROUND

The Cimarron Environmental Response Trust (the Trust) is responsible for the decommissioning and remediation of the Cimarron Site located approximately seven miles west of Guthrie, Oklahoma, at the intersection of state Highways 33 and 74. A map of the site is presented as Figure 1.

The Trust is the successor licensee to the Cimarron Corporation (Cimarron), which was owned by Kerr-McGee Corporation (KMC), and transferred to Tronox LLC (Tronox) when KMC spun off its chemical subsidiary. KMC and Tronox personnel had conducted several internal evaluations of potential alternative groundwater remediation technologies since before 2000, and had proposed to remediate groundwater for uranium using in-situ immobilization via bioremediation.

Tronox filed for protection under Chapter 11 of US bankruptcy law in January 2009. Upon emerging from Chapter 11 bankruptcy in February 2011, the Cimarron site was transferred to the Trust. The Trust is funded from a combination of funding provided by Tronox upon emerging from bankruptcy, and the cash value of an existing letter of credit. At some unknown time in the future, the Trust may receive additional funding from ongoing litigation. Environmental Properties Management LLC (EPM) is the Trustee for the Trust. The NRC, the DEQ, and the U.S. Environmental Protection Agency are the designated beneficiaries of the Trust (Beneficiaries).

Upon creation of the Trust, and the transfer of the site and funds to the Trust, NRC transferred license SNM-928 to the Trust. The Agreement imposes certain requirements upon the Trustee, including the submittal of an evaluation of potential alternative groundwater remediation technologies to the NRC and DEQ. This evaluation report is intended to provide the NRC and DEQ with sufficient information to enable them to select the optimal combination of technologies to utilize at the site. This Evaluation of Potential Alternative Groundwater Remediation Technologies represents the initial step in accomplishing the overriding objective assigned the Trustee. That objective is to remediate the Cimarron Site to comply with established Federal and State criteria for the unrestricted future use of the property.

The Site has been undergoing decommissioning of equipment, buildings, and soil in accordance with NRC license SNM-928, which governs the radiological decommissioning of the Site, since 1975, when the facility ceased operations. Equipment, buildings, and soil have been decommissioned, and final status surveys have been performed to demonstrate that decommissioning criteria have been met for those media. License SNM-928 and its supporting documentation stipulates 180 picoCuries per liter (pCi/l) total uranium and 3,790 pCi/l Technitium-99 (Tc-99) as the criteria for the unrestricted radiological release of groundwater. This limit for uranium is based on a dose model that equates 180 pCi/l with a residual dose of 25 millirem per year (mrem/yr) based on a drinking water scenario. The limit for Tc-99 has been promulgated by NRC as an unrestricted release criterion. According to the license, to comply with these criteria, groundwater in every monitor well in the monitoring program must comply with the criteria. NRC also cites EPA's Tc-99 limit of 900 pCi/l for Tc-99 as a second unrestricted release criterion.

DEQ has also approved risk-based unrestricted use criteria for uranium, nitrate, and fluoride in groundwater at the Site. These criteria were developed in a risk assessment, and are based on a 10^{-5} risk under an unrestricted use scenario (Roberts/Schornick & Associates, Inc., 1998). The criteria are 110 micrograms per liter (µg/l) for uranium, 52 milligrams per liter (mg/l) for nitrate, and 4 mg/l for fluoride (this is also the EPA-promulgated maximum concentration limit for fluoride in drinking water).

It is the intent of the Trustee, to the extent allowed by the limited funding available to the Cimarron Environmental Response Trust, to remediate groundwater to less than the criteria established by both NRC and DEQ for the Cimarron Site.

B. GROUNDWATER ASSESSMENT RESULTS

Uranium exceeds the license release criterion of 180 pCi/l in three areas: Burial Area #1 (BA #1), the Western Upland (WU) Area and the Western Alluvial (WA) Area (ENSR 2006c and Cimarron, 2007). These areas are illustrated in Figure 1. Uranium exceeds the DEQ criterion of 110 µg/l in these same areas, and the extent within those areas roughly matches the extent of uranium exceeding the NRC criterion. The extent of uranium impact to groundwater has been adequately delineated for the development of a groundwater remedy. Years of environmental monitoring have already demonstrated that nitrate and/or fluoride exceed DEQ criteria in the following areas: the WU Area, the WA Area, the Uranium Pond #1 (UP1) Area, the Uranium Pond #2 (UP2) Area, and the uranium plant storage yard (Well 1319 Area). The extent of nitrate and fluoride impact had not been adequately delineated to enable an evaluation of potential alternative groundwater remediation technologies.

A groundwater assessment program was proposed to further define the extent of nitrate and fluoride impact to groundwater. Locations for the installation of new groundwater monitor wells, locations from which to collect groundwater samples, and parameters and analytical methods for groundwater sample analysis were agreed upon by EPM, NRC and DEQ. The following sections present the results of that assessment. Appendix A of this report presents the soil boring logs and monitor well installation diagrams generated during this groundwater assessment.

Table 1 presents the data collected during the groundwater assessment project. One data quality issue was noted for the uranium analysis of groundwater from Monitor Well T-76. Recovery of the 50 μg/l spike for uranium in the matrix spike duplicate (added to this sample) was low; the data could therefore be biased low. Because the uranium concentration reported for this sample was well above the DEQ criterion, this data quality issue has no impact on the usability of the data.

1. Nitrate and Fluoride Assessment

A total of seven (7) new groundwater monitor wells were installed in the WA Area. The groundwater assessment performed has delineated the extent of nitrate and fluoride in groundwater sufficiently to perform this evaluation. A map showing the locations of existing and newly installed monitor wells in the Well 1319, Western Upland, UP1, UP2, and Western Alluvial Areas (collectively referred to as the Western Area) is presented in Figure 2. Figure 2 shows the assessment area, identifies the locations of the newly installed monitor wells, and posts current, 2009, and 2010 data for select locations (as available).

Table 2 presents nitrate and fluoride data for samples collected from 2009 and 2011 for all locations sampled in 2011. Areas exceeding the criteria for these analytes are outlined. One or two additional monitor wells may need to be installed and sampled prior to the preparation of a remedial design to complete the delineation of groundwater north of monitor well T-89.

2. Uranium Assessment

Uranium had already been sufficiently delineated for the purposes of this evaluation (ENSR, 2006c; Cimarron, 2003; and Cimarron, 2005). Analysis of samples in the Western Area shows that there are instances where groundwater complies with the DEQ mass concentration limit, but exceeds the NRC activity limit, and vice versa. Delineation of uranium in the Western Area is complete. Figure 3 shows the assessment area, identifies the locations of the newly installed monitor wells, and posts current and some historical uranium data. Figure 3 shows the assessment area, identifies the locations of the newly installed monitor wells, and posts current, 2009, and 2010 data for select locations (as available). Table 3 presents uranium activity data for groundwater samples analyzed in 2009 and 2010 (as available), as well as uranium concentration and calculated activity data for all locations sampled in 2011. Areas which exceed concentration and/or activity criteria for uranium are outlined.

Figure 4 shows the extent of the uranium plume in Burial Area #1, and posts the 2004 and 2010 uranium activity data for locations in Burial Area #1 that were sampled both in 2004 and 2010. Table 4 tabulates the 2004 and 2010 uranium data for these locations. One or two additional monitor wells may need to be installed and sampled in the BA #1 Area, north of 02W43, prior to the preparation of a remedial design to define the extent of groundwater recovery in this area.

Finally, groundwater assessment results for uranium, which reported concentrations in μg/l, indicated that the ratio between concentration results in μg/l and activity results in pCi/l may vary widely. At background or low concentrations, concentration values were essentially the same as prior activity values at numerous locations (e.g., 1319B-4, 1354, T-64, and T-60). At other locations, values for concentration significantly exceeded prior activity values (e.g., T-62, T-68, and T-59). At other locations, prior activity values significantly exceeded concentration values (e.g., 1351, MWWA-03, and T-77).

If groundwater will be treated to remove uranium, certain groundwater monitoring must include analysis for concentration, because it will be necessary to monitor the total mass of uranium being extracted by ion exchange media. Analyzing for activity may be necessary to determine the amount of U-235 being extracted to maintain compliance with the license condition limiting possession of U-235 to 1,200 grams. Consequently, monitoring to demonstrate compliance with both DEQ and NRC release criteria will require analysis for both mass concentration and isotopic activity.

3. Tc-99 Assessment

In 2005, Cimarron determined that additional monitoring for Tc-99 should be performed to demonstrate that specified wells would yield less than the license criterion of 3,790 pCi/l for eight consecutive quarters (Chase Environmental Group, 2003). The additional recommended in that report was completed, and in a letter dated August 31, 2007, Cimarron stated that Tc-99 had been below the license criterion for eight consecutive quarters, and requested that NRC release Cimarron from further monitoring for Tc-99, and approve the abandonment of monitor wells installed for Tc-99 assessment.

As part of the 2011 groundwater assessment, NRC requested that five monitor wells be sampled and analyzed for gross alpha, gross beta, and Tc-99 activity. The highest activity recorded for any of the wells was 2,030 pCi/l, in Monitor Well 1346. The next highest activity was 647 pCi/l, in Monitor Well 1336A. All these results are well below the NRC license criterion of 3,790 pCi/l.

Although all sampled locations comply with NRC limits, EPA has established a dose-based criterion of 900 pCi/l for Tc-99, and Well 1346 exceeded that limit. Consequently, the groundwater remediation effort may need to ensure that Tc-99 concentrations are reduced below the EPA criterion. Because this same location yielded groundwater exceeding the limits for both nitrate and fluoride, Tc-99 will be addressed by all the technologies presented in this evaluation. Consequently, the remediation of Tc-99 will not be addressed specifically in the discussion of individual technologies within this report.

C. CONCLUSIONS

There are a total of six areas of concern, in which chemicals of concern (COCs) exceed release criteria. These six areas, which are delineated in Figure 1, include:

- Burial Area #1 (uranium only)
- Western Alluvial Area (uranium and nitrate)
- Western Upland Area (uranium, nitrate, and fluoride)
- Uranium Pond #1 Area (nitrate and fluoride)
- Uranium Pond #2 Area (nitrate and fluoride)
- Well 1319 Area (nitrate only)

The areas delineated on Figure 1 include a "buffer" area as appropriate, extending beyond locations where groundwater concentrations exceed release criteria.

No further groundwater assessment is needed to evaluate potential alternative groundwater remedial technologies. Limited additional assessment for nitrate may be required to prepare a groundwater remediation design. Future groundwater monitoring to demonstrate that uranium in groundwater complies with both DEQ and NRC release criteria may require both isotopic activity and mass concentration analysis. The extent of Tc-99 exceeding the EPA limit is highly localized, and is co-located with both nitrate and fluoride excursions. Consequently, the technologies that will provide for remediation for nitrate and fluoride will address Tc-99.

* * * * *

CHAPTER II - OVERVIEW OF SCREENING EVALUATION

EPM considered numerous groundwater remediation technologies and employed a qualitative screening process to reduce the number of technologies for which detailed evaluation, including cost and schedule estimates, would be performed. This section provides an overview of those technologies that were considered in this screening process, and the rationale for evaluation or rejection from further consideration.

A. TECHNOLOGIES NOT RETAINED

1. Monitored Natural Attenuation

At the time the 1995 Site Decommissioning Plan (Chase Environmental Group, 1995) and the 1998 Decommissioning Plan – Groundwater Evaluation Report (Chase Environmental Group, 1998a) were submitted to NRC, KMC (the licensee at that time) believed that natural attenuation may reduce groundwater impact to releasable levels in an acceptable time frame. This assumption was based on the declines seen in environmental monitoring parameters over the preceding years. After another 12 years of monitoring, it has become apparent that it would take decades for the natural attenuation process to reduce concentrations to acceptable levels (Kerr-McGee Corporation, 2004). This alternative was rejected due to the schedule and limited funding available to the Trust.

2. Passive Treatment Trenches

Passive treatment trenches are typically installed near the leading edge of a groundwater plume, and are backfilled with reactants that will either destroy or immobilize chemicals of concern in the groundwater. The treated groundwater, free of its contaminants, then migrates downgradient. Multiple trenches can be installed within a plume, but the key to the effectiveness of these trenches is unimpeded groundwater flow.

Based on available data, it appears that impacted groundwater has only migrated several hundreds of feet in the 40 years since the Cimarron facility terminated operations and, as with natural attenuation, it would take additional decades for groundwater to move through even multiple passive treatment trenches. This alternative was rejected due to the schedule and limited funding available to the Trust.

3. Zero-Valent Iron Immobilization

This technology provides for the immobilization of uranium by injecting zero-valent iron into the groundwater, fostering a reaction whereby uranium is immobilized. Because the activity of uranium in groundwater is below 5,000 pCi/l at the Cimarron site, the transfer of uranium from the dissolved to the solid phase would result in the remediation of uranium in groundwater without causing subsurface soil to exceed decommissioning criteria. The injection of zero-valent iron would not address nitrate contamination, and it would be difficult if not impractical to demonstrate adequate distribution of the iron throughout the low permeability transition zones as well as the fractured sandstone of the upland areas. Long-term (e.g., decades) monitoring would likely be required to demonstrate permanence. This alternative was rejected due to cost and the uncertainty associated with demonstrating effectiveness.

4. Bio-Immobilization

In-situ immobilization of uranium by injecting total organic carbon (e.g., a dilute solution of molasses) was proposed as a remediation technology for the Cimarron site (ARCADIS, 2009). The cost of this technology was high. Although the process could be effective in remediating groundwater for nitrate, the cost estimates generated did not include remediation of large areas that have nitrate in groundwater exceeding the limit. It would be difficult if not impractical to demonstrate adequate distribution of the reactant throughout the low permeability transition zones as well as the fractured sandstone of the upland areas. Long-term (e.g., decades) monitoring would likely be required to demonstrate permanence. This alternative was rejected due to cost and the uncertainty associated with demonstrating effectiveness.

5. Hydroxy-Apatite Immobilization

This technology provides for the immobilization of uranium by injecting hydroxyl-apatite into the groundwater, fostering a reaction whereby uranium is immobilized. Because the activity of uranium in groundwater is less than 5,000 pCi/l at the Cimarron site, the transfer of uranium from the dissolved to the solid phase would result in the remediation of uranium in groundwater without causing subsurface soil to exceed decommissioning criteria. The injection of hydroxy-apatite would not address nitrate contamination, and it would be difficult if not impractical to demonstrate adequate distribution of the reactant throughout the low permeability transition zones as well as the fractured sandstone of the upland areas. Long-term (e.g., decades) monitoring would likely be required to demonstrate permanence. This alternative was rejected due to cost and the uncertainty associated with demonstrating effectiveness.

6. Excavation with On-Site Disposal

Dewatering and limited excavation, to remove the portions of the water bearing zones containing the highest concentrations of contaminants in groundwater, was evaluated by Cimarron several times (Envirocon, Inc., 2003 and Envirocon, Inc., 2008). On-site disposition of excavated soils in a soil management area was evaluated. The inclusion of areas with nitrate exceeding re-opening criteria would result in the generation of volumes of spoils too great to cost-effectively manage on site. In addition, since much of the material generated exists within geotechnically unstable "flowing" saturated sands, the excavation of this material would be challenging. This technology was rejected to difficulty in implementation, high cost, and low regulatory acceptance.

7. Excavation with Off-Site Disposal

Dewatering and limited excavation, to remove the portions of the water bearing zones containing the highest concentrations of contaminants in groundwater, was evaluated by Cimarron several times. Since much of the material generated exists within geotechnically unstable "flowing" saturated sands, the excavation of this material would be challenging. The volume of material excavated would make off-site disposal far more expensive than all other remedial options considered. This technology was rejected to difficulty in implementation and high cost.

B. TECHNOLOGIES RETAINED

1. No action

This alternative consists of maintaining the license and access controls, with no effort to remediate groundwater. It was only retained as a "base" for this evaluation, as is typical for all RCRA and/or CERCLA evaluations.

2. Extract and Discharge

This alternative consists of extracting groundwater from all areas of concern (BA #1, UP2, WU, UP1, WA, and Well 1319). Extracted groundwater from all six areas would be routed to a 2-acre impoundment. Blending the groundwater from all six areas would result in generally low concentrations of COCs, but the discharge would likely exceed release criteria for uranium and nitrate, when groundwater extraction recovers the highest concentrations of COCs. As time progresses, concentrations of COCs would decline in the blended water. This blended water would be discharged directly into the Cimarron River.

3. Extract, Treat BA #1, and Irrigate

This alternative consists of extracting groundwater from all six areas of concern. Groundwater from BA #1 would be treated to remove the uranium. The effluent from the water treatment unit would then be combined with groundwater from all other areas (except the Well 1319 Area) in a 2-acre impoundment. Blending the groundwater from all five areas would result in generally low concentrations of COCs, but the impounded water would likely exceed release criteria for nitrate initially, when groundwater extraction recovers the highest concentrations of COCs.

A 150-acre irrigation system would be constructed in the Cimarron River floodplain, and the water would be used for irrigation. A small irrigation system would be installed in the Well 1319 Area, and the water from the single extraction well installed in this area would be used for irrigation. Natural vegetation in the irrigation areas would consume the nitrate. Operation would continue through eight months, while vegetation is actively growing and can consume the nitrate. Groundwater recovery and treatment would be shut down during the four months which comprise the non-growing season.

4. Extract and Recharge, Treat BA #1, and Irrigate

This alternative consists of extracting groundwater from the BA #1, WA, and Well 1319 Areas. Groundwater from BA #1 would be treated to remove the uranium. Injection wells would be installed in the WU, UP1, and UP2 Areas. The water treatment unit effluent, containing COC concentrations below release criteria, would be injected into the WU, UP1, and UP2 Areas to flush the impacted groundwater to the alluvium for recovery and treatment. Groundwater from the WA and Well 1319 Areas would contain nitrate exceeding its release criterion. Groundwater from the WA Area would be combined in a 2-acre impoundment with any portion of BA #1 effluent that cannot be injected into the WU, UP1, and UP2 Areas.

A 150-acre irrigation system would be constructed in the Cimarron River floodplain, and the groundwater from the impoundment would be used for irrigation. A small irrigation system would be installed in the Well 1319 Area, and the water from the single extraction well installed in this area would be used for irrigation. Natural vegetation in the irrigation areas would consume the nitrate in the groundwater. Operation would continue through approximately eight months, while vegetation is actively growing and can consume the nitrate. Groundwater recovery and treatment would be shut down during the four months which comprise the non-growing season.

5. Extract and Recharge, Treat BA #1 and WA, and Discharge

This alternative consists of extracting groundwater from the BA #1, WA, and Well 1319 Areas. Groundwater from BA #1 and from the WA wells in which uranium exceeds its criteria would be treated to remove the uranium. Injection wells would be installed in the WU, UP1 and UP2 Areas. A small irrigation system would be installed in the Well 1319 Area, and the water from the single extraction well installed in this area would be used for irrigation. The water treatment unit effluent, containing COC concentrations below release criteria, would be injected into the WU, UP1, and UP2 Areas to flush the impacted groundwater to the alluvium for recovery and treatment.

The remaining water treatment unit effluent would be combined with groundwater from the rest of the WA Area in a 2-acre impoundment. This blended groundwater would likely exceed the criterion for nitrate initially, when groundwater extraction recovers the highest concentrations of COCs, and would contain uranium below the MCL. This blended water would be discharged directly into the Cimarron River.

6. Extract and Recharge, Treat BA #1 and WA (8 month), and Irrigate

This alternative consists of extracting groundwater from the BA #1, WA, and Well 1319 Areas. Groundwater from BA #1 and from the WA wells in which uranium exceeds its criteria would be treated to remove the uranium. Injection wells would be installed in the WU, UP1, and UP2 Areas. The water treatment unit effluent, containing COC concentrations below release criteria, would be injected into the WU, UP1, and UP2 Areas to flush the impacted groundwater to the alluvium for recovery and treatment. The remaining water treatment unit effluent would be combined with groundwater from the other wells in the WA Area in a 2-acre impoundment. This blended groundwater would likely exceed the criterion for nitrate initially, when groundwater extraction recovers the highest concentrations of COCs, and would contain uranium below the MCL.

A 150-acre irrigation system would be constructed in the Cimarron River floodplain, and the groundwater from the impoundment would be used for irrigation. A small irrigation system would be installed in the Well 1319 Area, and the water from the single extraction well installed in this area would be used for irrigation. Natural vegetation in the irrigation areas would consume the nitrate in the groundwater. Operation would continue through approximately eight months, while vegetation is actively growing and can consume the nitrate. Groundwater recovery and treatment would be shut down during the four months which comprise the non-growing season.

7. Extract and Recharge, Treat BA #1 and WA (12 month), Irrigate

This alternative consists of extracting groundwater from the BA #1, WA, and Well 1319 Areas. Groundwater from BA #1 and from the WA wells in which uranium exceeds its criteria would be treated to remove the uranium. Injection wells would be installed in the WU, UP1, and UP2 Areas. The water treatment unit effluent, containing COC concentrations below release criteria, would be injected into the WU, UP1, and UP2 Areas to flush the impacted groundwater to the alluvium for recovery and treatment. The remaining water treatment effluent would be combined with groundwater from the other wells in the WA Area in a 5-acre impoundment. This blended groundwater would likely exceed the criterion for nitrate initially, when groundwater extraction recovers the highest concentrations of COCs, and would contain uranium below the MCL.

A 150-acre irrigation system would be constructed in the Cimarron River floodplain, and the groundwater from the impoundment would be used for irrigation. A small irrigation system would be installed in the Well 1319 Area, and the water from the single extraction well installed in this area would be used for irrigation. Natural vegetation in the irrigation areas would consume the nitrate in the groundwater. Operation of the Well 1319 and WA Area wells containing only nitrate above its criteria would continue through approximately eight months, while vegetation is actively growing and can consume the nitrate. The BA #1 and WA wells containing uranium above the criteria would continue to operate when irrigation must be discontinued. Water treatment unit effluent that cannot be injected into the WU and UP1 areas will be stored in the 5-acre impoundment until irrigation can be resumed in the spring.

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CHAPTER III - DESCRIPTION OF EVALUATED ALTERNATIVES

This section provides sufficient description of each alternative to identify where impacted groundwater is extracted from the formation, how recovered groundwater is managed, and the disposition of water. Management of recovered groundwater may consist of storing it in an impoundment, running it through a water treatment unit to remove uranium, or using it for irrigation to consume the nitrate. Disposition of water may consist of discharging it to the Cimarron River, using it for irrigation, or injecting it into water-bearing zones to stimulate movement of groundwater.

The descriptions of each alternative include identification of those components of groundwater recovery, management, or disposition that would be utilized in that alternative. Figure 5 is a map of the site showing the potential locations of the following components:

- Groundwater extraction wells
- Groundwater injection trenches and wells
- Piping
- Groundwater storage impoundment
- Water treatment unit
- Irrigation systems
- Discharge piping

Note that not all components will be used in any single alternative. For instance, there is no alternative that uses both irrigation and a discharge line to direct discharge to the Cimarron River.

For all alternatives, the groundwater remediation program would include a groundwater monitoring program to monitor declining concentrations of COCs in each area. As COC concentrations fall below the release criteria in an area, extraction wells would be shut down. When all areas comply with the release criteria, a post-remediation monitoring program would begin. When eight consecutive quarterly sampling events demonstrate that COC concentrations in all wells are below the release criteria, NRC and DEQ concurrence that groundwater remediation is complete would be requested. Groundwater remediation equipment would then be removed and all groundwater extraction and monitoring wells would be plugged and abandoned.

If irrigation is used to treat water, the potential for concentration of uranium in the surficial soils exists, and a final status survey will be conducted in the subject area to demonstrate that soil in the area still complies with license criteria for unrestricted release.

Groundwater recovery well spacing and recovery rates were based on previous reports (ENSR Corporation, 2006a, ESR Corporation, 2006b, and ENSR Corporation, 2006d). Required irrigation areas based on assumed flow rates and nitrate concentrations, were estimated by Burns & McDonnell personnel with experience in the remediation of wastewaters via irrigation.

Upon completion of groundwater remediation, a Post-remediation report that demonstrates compliance with all groundwater criteria in all decommissioning monitor program wells would be prepared. The post-remediation report would include a dose model demonstrating that the site complies with NRC's 25 mrem/yr criterion for license termination. Upon finalization of the report, a request for termination of the license by NRC and release of the Site for unrestricted future use from DEQ would be submitted.

The following sections present a description of each of the potential alternative groundwater remediation technologies that are evaluated in this report.

A. ALTERNATIVE 1 – NO ACTION

Because the only exposure pathway is via drinking water, the only controls needed to prevent workers or members of the public from exposure to chemicals of concern (COCs) are those that would prevent water wells from being utilized for drinking water. Periodic site inspections for evidence of tampering with wells would be performed in areas in which COC concentrations exceed release criteria.

The existing environmental monitoring program would be revised to enable the Trustee to monitor COC concentrations in all six areas of concern. Select wells in each area would be sampled and analyzed on an annual basis to monitor the natural attenuation of COCs. Historical trends of data indicate that COC concentrations in groundwater would not degrade to release criteria for decades.

Annual costs for this alternative would consist of NRC and DEQ fees and administrative expenses, as well as the cost of maintaining the Site and license controls, which would consist primarily of implementation of the radiation protection and quality assurance programs, and conduct annual environmental monitoring.

B. ALTERNATIVE 2 – EXTRACT AND DISCHARGE

Groundwater extraction wells would be installed in the BA #1, WA, WU, UP1, UP2, and Well 1319 Areas, and a groundwater extraction trench would be installed in the BA #1 upland area. It is estimated that a combined stream of approximately 190 gallons of water per minute (± 20%) (ENSR Corporation, 2006b)would be produced from these areas. The groundwater generated from all six areas would be routed to a 2-acre impoundment.

It is anticipated that this water stream would yield fluoride at essentially background concentration and Tc-99 at less than 50 pCi/l. Uranium and nitrate would likely exceed the limits for groundwater, with anticipated initial concentrations likely less than 250 µg/l (400 pCi/l) uranium and 80 mg/l nitrate. COC concentrations would begin to decline within the first several months of pumping, as contaminant mass is removed, so these initial concentrations are temporary maximum concentrations. This blended water would be discharged directly into the Cimarron River in accordance with an Oklahoma Pollution Discharge Elimination System (OPDES) permit. This is the only alternative evaluated which assumes that water containing uranium above the MCL can be discharged directly to the Cimarron River.

C. ALTERNATIVE 3 – EXTRACT, TREAT BA #1, AND IRRIGATE

Groundwater extraction wells would be installed in the BA #1, WA, WU, UP1, UP2, and Well 1319 Areas, and a groundwater extraction trench would be installed in the BA #1 upland area. A water treatment unit for uranium would be constructed near the BA #1 Area to extract the uranium from the BA #1 Area water stream, estimated at 40 gallons per minute ± 20% (ENSR Corporation, 2006b). The effluent from the water treatment unit would then be routed to a 2-acre impoundment, where it would be combined with the incoming groundwater from the WA, WU, UP1, and UP2 Areas for a total of approximately 190 gallons of water per minute ± 20% (ENSR Corporation, 2006b, expanded). It is anticipated that this water stream would likely yield concentrations of approximately 90 µg/l (150 pCi/l) uranium and 80 mg/l nitrate initially. As with Alternative 2, this water stream would likely yield fluoride at essentially background concentration and Tc-99 at less than 50 pCi/l.

A small stand-alone irrigation system would be installed in the Well 1319 Area, and groundwater produced from the single extraction well in this area would be used for irrigation via the stand-alone irrigation system. A 2-acre impoundment storing 10 acre-feet of water will provide sufficient retention for approximately 12 days of groundwater extraction. This capacity is needed to store water that cannot be used for irrigation during or immediately after significant precipitation events.

Approximately 150 acres of grassland would be needed to phyto-remediate the approximately 45,000 pounds of nitrogen that could be generated during the eight-month growing season. Sensors installed throughout the irrigated area would regulate the application of water so it is only applied when soil conditions allow for the infiltration of the water, and prevent over-saturation, so that nitrogen in the water can be utilized by the grasses. Irrigation will significantly increase the rate of growth of the native grasses in the irrigation area(s). This grass will be periodically mowed and harvested as cattle feed.

As nitrate concentrations decline, pumping rates could be increased to provide maximum irrigation capacity. This would accelerate the remediation of groundwater for nitrate. Groundwater remediation activities would be performed only during the approximately eight month period during which vegetation can consume the nitrate. During the remaining approximately four months all groundwater recovery and treatment systems will be shut down.

D. ALTERNATIVE 4 – EXTRACT AND RECHARGE, TREAT BA #1, AND IRRIGATE

Groundwater extraction wells would be installed in the BA #1, WA, and Well 1319 Areas. A Groundwater extraction trench would be installed in the BA #1 upland area. Injection wells would be installed in Sandstone A in the WU, and UP1 Areas, and in both Sandstone A and Sandstone B in the UP2 Area. A water treatment unit for uranium would be constructed near the BA #1 Area to extract the uranium from the BA #1 Area water stream estimated at 40 gallons per minute ± 20% (ENSR Corporation, 2006b).

The effluent from the water treatment unit would then be routed to the injection wells in the WU, UP2, and UP2 Areas. Although it is not known how much water can be injected into the formation via these wells, it is assumed that only a portion of the effluent stream can be injected. Because there is very little nitrate in groundwater in the BA #1 Area, the effluent is anticipated to contain less than 5 mg/l nitrate. This injection will flush impacted groundwater from Sandstone A in the WU and UP1 Areas, and from Sandstones A and B in the UP2 Area. A portion of the water injected into Sandstone A is anticipated to discharge from joints in the escarpment, where it will infiltrate into the sandy alluvial deposits of the Cimarron River floodplain. A portion of the water injected into Sandstone A, as well as all the water injected into Sandstone B, will discharge directly into the alluvium, where the sandstone "subcrop" is buried by alluvial deposits. It will then be recovered for treatment by groundwater extraction wells installed in the alluvial deposits.

Groundwater produced from the WA Area will be combined with that portion of the effluent from the BA #1 treatment unit that is not directed for injection. It is estimated that a combined stream of approximately 170 gallons of water per minute ± 20% (ENSR Corporation, 2006b) would be produced from these areas. It is anticipated that this water stream would yield concentrations of approximately 90 μg/l (150 pCi/l) uranium and 80 mg/l nitrate. As with Alternative 2, this water stream would yield fluoride at essentially background concentration and Tc-99 at less than 50 pCi/l.

A 2-acre impoundment storing 10 acre-feet of water will provide sufficient retention for approximately 13 days of groundwater extraction. This capacity is needed to store water that cannot be used for irrigation during or immediately after significant precipitation events. Approximately 150 acres of grassland would be needed to phyto-remediate the approximately 45,000 pounds of nitrogen that could be generated during the eight-month growing season. Sensors installed throughout the irrigated area would regulate the application of water so it only applied when soil conditions allow for the infiltration of the water, and prevent over-saturation, so that nitrogen in the water can be utilized by the grasses. Irrigation will significantly increase the rate of growth of the native grasses in the irrigation area(s). This grass will be periodically mowed and harvested as cattle feed.

A small stand-alone irrigation system would be installed in the Well 1319 Area, and groundwater produced from the single extraction well in this area would be used for irrigation via the stand-alone irrigation system.

As nitrate concentrations decline, pumping rates could be increased to provide maximum irrigation capacity. This would accelerate the remediation of groundwater for nitrate. Groundwater remediation activities would be performed only during the approximately eight month period during which vegetation can consume the nitrate. During the remaining approximately four months all groundwater recovery and treatment systems will be shut down.

E. ALTERNATIVE 5 – EXTRACT AND RECHARGE, TREAT BA #1 AND WA, AND DISCHARGE

Groundwater extraction wells would be installed in the BA #1, WA, and Well 1319 Areas. A groundwater extraction trench would be installed in the BA #1 upland area. Injection wells would be installed in Sandstone A in the WU, and UP1 Areas, and in both Sandstone A and Sandstone B in the UP2 Area. A water treatment unit for uranium would be constructed near the BA #1 Area. Groundwater from a subset of wells in the WA Area (those that yield uranium above criteria) and groundwater from the BA #1 Area would be routed to the water treatment unit, which would extract the uranium from the combined stream, estimated to be 90 gallons per minute ±20% (ENSR Corporation, 2006b). A portion of the effluent from the water treatment unit would then be routed to the injection wells in the WU, UP2, and UP2 Areas. The effluent is anticipated to contain less than 60 mg/l nitrate initially, although that concentration will decline rapidly as nitrate is removed from the groundwater.

Although it is not known how much water can be injected into the formation via these wells, it is assumed that only a portion of the effluent stream can be injected. This injection will flush impacted groundwater from Sandstone A in the WU and UP1 Areas, and from Sandstones A and B in the UP2 Area. A portion of the water injected into Sandstone A is anticipated to discharge from joints in the escarpment, where it will infiltrate into the sandy alluvial deposits of the Cimarron River floodplain. A portion of the water injected into Sandstone A, as well as all the water injected into Sandstone B, will discharge directly into the alluvium, where the sandstone "subcrop" is buried by alluvial deposits. It will then be recovered for treatment by groundwater extraction wells installed in the alluvial deposits.

A 2-acre impoundment will be constructed near BA #1. Groundwater from the remaining WA wells will be combined with that portion of the effluent from the water treatment unit in the impoundment that is not directed for injection. It is estimated that a combined stream of approximately 170 gallons of water per minute ± 20% (ENSR Corporation, 2006b) would be produced from these areas. It is anticipated that this water stream would yield a concentration of < 20 µg/l (30 pCi/l) uranium and 80 mg/l nitrate. As with Alternative 2, this water stream would yield fluoride at essentially background concentration and Tc-99 at less than 50 pCi/l. This blended water would be discharged directly into the Cimarron River in accordance with an OPDES permit.

A small stand-alone irrigation system would be installed in the Well 1319 Area, and groundwater produced from the single extraction well in this area would be used for irrigation via the stand-alone irrigation system. During the remaining approximately four months the groundwater recovery and irrigation system for this area will be shut down.

F. ALTERNATIVE 6 – EXTRACT AND RECHARGE, TREAT BA #1 AND WA (8 MONTHS), AND IRRIGATE

Groundwater extraction wells would be installed in the BA #1, WA, and Well 1319 Areas. A groundwater extraction trench would be installed in the BA #1 upland area. Injection wells would be installed in Sandstone A in the WU, and UP1 Areas, and in both Sandstone A and Sandstone B in the UP2 Area. A water treatment unit for uranium would be constructed near the BA #1 Area. Groundwater from a subset of wells in the WA Area (those that yield uranium above criteria) and groundwater from the BA #1 Area would be routed to the water treatment unit, which would extract the uranium from the combined stream, estimated to be 90 gallons per minute(±20% (ENSR Corporation, 2006b). A portion of the effluent from the water treatment unit would then be routed to the injection wells in the WU, UP2, and UP2 Areas. The effluent is anticipated to contain less than 60 mg/l nitrate initially, although that concentration will decline rapidly as nitrate is removed from the groundwater.

Although it is not known how much water can be injected into the formation via these wells, it is assumed that only a portion of the effluent stream can be injected. This injection will flush impacted groundwater from Sandstone A in the WU and UP1 Areas, and from Sandstones A and B in the UP2 Area. A portion of the water injected into Sandstone A is anticipated to discharge from joints in the escarpment, where it will infiltrate into the sandy alluvial deposits of the Cimarron River floodplain. A portion of the water injected into Sandstone A, as well as all the water injected into Sandstone B, will discharge directly into the alluvium, where the sandstone "subcrop" is buried by alluvial deposits. It will then be recovered for treatment by groundwater extraction wells installed in the alluvial deposits.

A 2-acre impoundment will be constructed near BA #1. Groundwater from the remaining WA wells will be combined with that portion of the effluent from the water treatment unit in the impoundment that is not directed for injection. It is estimated that a combined stream of approximately 170 gallons of water per minute, ± 20% (ENSR Corporation, 2006b), would be produced from these areas. It is anticipated that this water stream would yield a concentration of < 20 µg/l (30 pCi/l) uranium and 80 mg/l nitrate. As with Alternative 2, this water stream would yield fluoride at essentially background concentration and Tc-99 at less than 50 pCi/l.

A 2-acre impoundment storing 10 acre-feet of water will provide sufficient retention for approximately 13 days of groundwater extraction. This capacity is needed to store water that cannot be used for irrigation during or immediately after significant precipitation events. A 150-acre irrigation system will be installed in the Cimarron River floodplain. Approximately 150 acres of grassland would be needed to phyto-remediate the approximately 45,000 pounds of nitrogen that could be generated during the eight-month growing season. Sensors installed throughout the irrigated area would regulate the application of water so it only applied when soil conditions allow for the infiltration of the water, and prevent over-saturation, so that nitrogen in the water can be utilized by the grasses. Irrigation will significantly increase the rate of growth of the native grasses in the irrigation area(s). This grass will be periodically mowed and harvested as cattle feed.

A small stand-alone irrigation system would be installed in the Well 1319 Area, and groundwater produced from the single extraction well in this area would be used for irrigation via the stand-alone irrigation system.

As nitrate concentrations decline, pumping rates could be increased to provide maximum irrigation capacity. This would accelerate the remediation of groundwater for nitrate. Groundwater remediation activities would be performed only during the approximately eight month period during which vegetation can consume the nitrate. During the remaining approximately four months all groundwater recovery and treatment systems will be shut down.

G. ALTERNATIVE 7 – EXTRACT AND RECHARGE, TREAT BA #1 AND WA, AND IRRIGATE (12 MONTHS)

Groundwater extraction wells would be installed in the BA #1, WA, and Well 1319 Areas. A groundwater extraction trench would be installed in the BA #1 upland area. Injection wells would be installed in Sandstone A in the WU, and UP1 Areas, and in both Sandstone A and Sandstone B in the UP2 Area. A water treatment unit for uranium would be constructed near the BA #1 Area. Groundwater from a subset of wells in the WA Area (those that yield uranium above criteria) and groundwater from the BA #1 Area would be routed to the water treatment unit, which would extract the uranium from the combined stream, estimated to be 90 gallons per minute (±20%). A portion of the effluent from the water treatment unit would then be routed to the injection wells in the WU, UP2, and UP2 Areas. The effluent is anticipated to contain less than 60 mg/l nitrate initially, although that concentration will decline rapidly as nitrate is removed from the groundwater.

Although it is not known how much water can be injected into the formation via these wells, it is assumed that only a portion of the effluent stream can be injected. This injection will flush impacted groundwater from Sandstone A in the WU and UP1 Areas, and from Sandstones A and B in the UP2 Area. A portion of the water injected into Sandstone A is anticipated to discharge from joints in the escarpment, where it will infiltrate into the sandy alluvial deposits of the Cimarron River floodplain. A portion of the water injected into Sandstone A, as well as all the water injected into Sandstone B, will discharge directly into the alluvium, where the sandstone "subcrop" is buried by alluvial deposits. It will then be recovered for treatment by groundwater extraction wells installed in the alluvial deposits.

A 5-acre impoundment will be constructed near BA #1. Groundwater from the remaining WA wells will be combined with that portion of the effluent from the water treatment unit in the impoundment that is not directed for injection. It is estimated that a combined stream of approximately 170 gallons of water per minute ± 20% (ENSR Corporation, 2006b) would be produced from these areas. It is anticipated that this water stream would yield a concentration of < 20 µg/l (30 pCi/l) uranium and 80 mg/l nitrate. As with Alternative 2, this water stream would yield fluoride at essentially background concentration and Tc-99 at less than 50 pCi/l.

A 150-acre irrigation system will be installed in the Cimarron River floodplain. Approximately 150 acres of grassland would be needed to phyto-remediate the approximately 45,000 pounds of nitrogen that could be generated during the eight-month growing season. Sensors installed throughout the irrigated area would regulate the application of water so it only applied when soil conditions allow for the infiltration of the water, and prevent over-saturation, so that nitrogen in the water can be utilized by the grasses. Irrigation will significantly increase the rate of growth of the native grasses in the irrigation area(s). This grass will be periodically mowed and harvested as cattle feed.

A small stand-alone irrigation system would be installed in the Well 1319 Area, and groundwater produced from the single extraction well in this area would be used for irrigation via the stand-alone irrigation system.

As nitrate concentrations decline, pumping rates could be increased to provide maximum irrigation capacity. This would accelerate the remediation of groundwater for nitrate. Groundwater remediation activities for nitrate would be performed only during the approximately eight month period during which vegetation can consume the nitrate.

A 5-acre impoundment storing 25 acre-feet of water will provide sufficient retention for approximately 125 days of limited groundwater extraction from BA #1 Area wells and WA wells which exceed the criteria for uranium. The installation of this impoundment would enable continued operation of the water treatment unit and continuing removal of uranium from groundwater in these limited areas throughout the approximately four month period during which vegetation cannot consume the nitrate. Because uranium has a much higher distribution coefficient than nitrate, removal of uranium from the water-bearing zones will not progress as quickly as removal of nitrate. The construction of a larger impoundment will enable EPM to continue groundwater extraction from uranium-impacted areas, treatment for uranium, disposal of spent resin, and injection of treated effluent throughout the colder months.

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CHAPTER IV - DESCRIPTION OF COMPONENTS

The purpose of this section is to provide a description of each major component of the potential alternative groundwater remediation technologies. Figure 5 is a map of the site showing the locations of all potential components, only some of which would apply to any one of the groundwater remediation strategies. Components portrayed in Figure 5 include:

- Groundwater extraction wells
- A groundwater extraction trench
- Piping to transfer groundwater to an impoundment
- Alternate piping to transfer uranium-impacted groundwater to a water treatment unit
- A 2-acre impoundment
- An alternate 5-acre impoundment
- A discharge line that may discharge groundwater and/or treated water to the Cimarron River
- The location of a water treatment unit
- An alternate location for a water treatment unit if a 5-acre impoundment is built
- Piping to transfer treated groundwater to injection wells
- Piping to transfer impounded water to irrigation systems
- Irrigation systems

Utilities are not portrayed separately on Figure 5. At this stage in the remedial design process, it is assumed that they will follow the same pathways as piping installed to transfer water to the impoundment and/or water treatment unit.

Table 5 presents cost estimates for the components described in this section. For each component, the cost of installation, annual operation and maintenance (O&M), and removal/closure are estimated. In the following descriptions of the components, the rationale for the allocation of cost between Federal and State accounts is discussed.

A. GROUNDWATER EXTRACTION AND TRANSFER

1. Description

The use of groundwater extraction wells to recover groundwater for treatment is a proven technology. In areas such as the alluvium and transition zones present in the WA and BA #1

Areas, the use of extraction wells to recover groundwater is a well-established and effective technology. Groundwater extraction wells would also be effective in recovering groundwater within the small area of impact in the Well 1319 Area. Groundwater extraction wells are also shown for the Western Upland, UP1, and UP2 Areas. The use of extraction wells in of Sandstone A in the WU and UP1 Areas, and both Sandstones A and B in the UP2 Area is less certain due to the fractured nature of these sandstones. Figure 5 shows the approximate locations of potential groundwater extraction wells. The number and locations of groundwater extraction wells was estimated based on professional judgment and the nature of the water bearing zones, based on previous evaluations (ENSR Corporation 2006b; Envirocon, Inc., 2003; and Envirocon Inc., 2008). This level of accuracy is generally acceptable for a comparison of alternative technologies. Groundwater modeling performed during preparation of the remedial design will determine the actual number and locations of wells after a remedial technology has been selected.

Groundwater extraction wells could be constructed from 2" or 4" schedule 40 PVC well casing and screen. The size of the well is a function of the pumping rate. Electric submersible pumps would be installed in each well, with electronic controllers installed at each location.

Because the wells in the Cimarron River floodplain could be subject to periodic flooding, the pump controllers for these wells would be installed high enough to be protected from the 100-year flood. The flooding experienced in 2007 exceeded the 100-year flood event, and the maximum depth of surface water in those areas in which groundwater extraction would be installed was less than 4 feet. Controllers would be installed a minimum of 4 feet above grade in the floodplain. All groundwater extraction wells in the floodplain would be installed with pitless adapters and caps to prevent floodwaters from entering the wells.

A groundwater extraction trench would be installed in the southern end of the BA #1 Area, where uranium-impacted groundwater is contained in Sandstone B. This sandstone layer is shallow enough that an excavator could be used to create a trench through the sandstone. In addition, the presence of loose backfill in the former burial trenches will enable groundwater to migrate to the trench. This technology is proven and will be effective in recovering groundwater from Sandstone B in this area. This technology was rejected for the WU, UP1, and UP2 Areas because the water-bearing zones extend too far below grade to make excavation of these water-bearing units practical.

Trenches will be excavated to run schedule 40 PVC piping from groundwater extraction wells (and the groundwater extraction trench in BA #1) to the impoundment or water treatment unit as illustrated by the yellow lines on Figure 5. A dashed yellow line shows the potential location of an alternate line that would carry groundwater only from those groundwater extraction wells in the WA Area where uranium exceeds its criteria to a water treatment unit near BA #1. If it is more economical, piping may be run in the same trenches dug for the primary water line rather than in a separate trench.

2. Cost Allocation

In the BA #1 Area, all extraction wells and the extraction trench will be installed to recover groundwater for which uranium is the only COC which exceeds its criteria; the cost of well installation and trench construction in this area is allocated entirely to the Federal Account. In the Well 1319, UP1, and UP2 Areas, nitrate and/or fluoride are the only COCs which exceed their criteria; the cost of extraction well installation in these areas is allocated entirely to the State Account. In the WU Area, both uranium and nitrate exceed their criteria; 50% of the cost of extraction well installation in this area is allocated to each account. In the WA Area, sixteen (16) extraction wells will be installed in areas in which nitrate is the only COC which exceeds its criterion; the cost of these extraction wells is allocated entirely to the State Account. Sixteen (6) extraction wells will be installed in areas in which both uranium and nitrate exceed their criteria; 50% of the cost of these extraction wells is allocated to each account.

The installation cost for piping to transfer water from the Well 1319 Area to the line installed at the WU Area was allocated entirely to the State Account; however, this line is only included in one alternative. The installation cost for piping to transfer water from the BA #1 Area to the impoundment was allocated entirely to the Federal Account. 50% of the installation cost for piping to transfer water from all other areas to the impoundment was allocated to each account. Should water from the six groundwater extraction wells in the WA Area which exceed the criteria for uranium be transferred separately to the water treatment unit, the installation cost for this piping was allocated entirely to the Federal Account.

B. GROUNDWATER RETENTION IMPOUNDMENT

1. Description

Groundwater extracted from the various areas must be accumulated for mixing prior to discharge, or for retention prior to irrigation. Surface water impoundments have been demonstrated to be the most cost-effective method of storing large quantities of water. The use of a clay liner in the impoundments considered in this evaluation is also based on cost, since usable clay material is present either in or in close proximity to the locations of the proposed impoundments. A 2-acre impoundment with an average depth of 5 feet (plus 2 feet of freeboard) provides sufficient capacity for Alternatives 2 through 6. A 5-acre impoundment with an average depth of 5 feet (plus 2 feet of freeboard) would be required for Alternative 7. Figure 5 shows the proposed locations of both the 2-acre and 5-acre impoundments.

Impoundments would be constructed by excavating the residual soils and/or mudstones that overlie Sandstone B in the proposed area, and using the excavated material to build up a berm for the impoundment. Both interior and exterior side slopes would be no steeper than 3:1. The cost of these impoundments is based upon the assumption that sufficient low-permeability material is available within the footprint of the impoundment to supply acceptable soil for a compacted clay liner for the impoundment. If the sandstone is too shallow, or the mudstone is too hard to compact adequately, and sufficient material cannot be obtained within the footprint of the impoundment, clayey soil will be obtained from Subarea B, immediately south of the impoundment area.

Receiving structures would be installed to receive groundwater from the areas from which groundwater is extracted in each alternative. A suction line and pumping station would also be constructed to pump water from the impoundment to a discharge line or an irrigation system.

For alternatives which include irrigation, it will be necessary to ensure that the impoundment does not overflow should weather and/or soil conditions result in an extended period of groundwater pumping without irrigation. High-level switches would be installed in the impoundment to shut off the groundwater extraction system (and water treatment unit, if included) to prevent overfilling of the impoundment.

2. Cost Allocation

For those alternatives which require the construction of a 2-acre impoundment, 50% of the cost of construction is allocated to each account. Alternative 7 requires additional retention capacity to store the water that would be generated as water from wells in which uranium is the only COC exceeding its criteria continues to be pumped through the water treatment unit during the non-growing season. Because the impoundment expansion is only needed to provide for the removal of uranium from groundwater, the cost to construct associated with the additional capacity was allocated entirely to the Federal Account.

C. DISCHARGE LINE

1. Description

Alternatives 2 and 5 involve the discharge of mixed and/or treated water to the Cimarron River in accordance with an OPDES permit. A discharge line constructed of schedule 40 PVC pipe would extend from the pumping station located at the impoundment to the Cimarron River, as shown in Figure 5.

Discharge would be on a continuous basis, as long as sufficient water is available for discharge. The flow rate would be 170 or 190 gpm, depending on whether a portion of the water is being injected to recharge the WU, UP1, and UP2 Areas. These discharge rates represent less than 1% of low flow conditions in the Cimarron River, estimated at over 130 cubic feet per second (United States Geological Survey, 2007). Even if the discharge averaged 80 mg/l nitrate and 250 µg/l uranium (assuming no treatment prior to discharge of combined extracted groundwater), the post -mixing-zone concentration of nitrate in the Cimarron River would be less than 1 mg/l nitrate and 2.5 µg/l uranium. These concentrations are less than EPA's maximum concentration limits for drinking water. At average and/or high flow rates, the post-mixing zone increase in concentration of these COCs would be nearly undetectable.

A sampling port would be installed in the discharge line near the river. Most of the pipe would be installed below grade in a trench, but a discharge structure would be constructed at the northern end of the pipe which would provide access to the sampling port.

2. Cost Allocation

50% of the cost of construction of the discharge pipe and structure is allocated to each account.

D. WATER TREATMENT UNIT

1. Description

Removal of uranium by ion exchange in a resin bed is a proven technology. Over the past ten years, improvements in the development of ion-specific resin beds have improved both the performance and cost-effectiveness of ion exchange for water treatment (EnergySolutions, 2011). Alternatives 3 through 7 all involve the treatment of uranium-impacted groundwater. The water treatment unit would be installed in one of the two areas indicated on Figure 5. The unit would be located in the northern area shown on the drawing if a 2-acre impoundment is utilized, and in the southern area if a 5-acre impoundment is utilized.

The water treatment unit would be designed to treat up to 100 gpm of flow. It would consist of primary stage filters which would remove particulates from the water stream. This filtered water would flow through an ion-specific resin contained in a tank designed to maximize even distribution of water throughout the resin bed. Influent and effluent samples analyzed for isotopic uranium would enable quantification of the amount of uranium (and specifically U-235) that has accumulated in the resin bed. The effluent from the resin bed would flow through another filter to minimize the potential for uranium-contaminated particulates to be discharged to the impoundment.

To minimize the potential for human error and the need for daily monitoring, the water treatment unit will be equipped with sensors, automated valves, and telemetry to alert personnel of conditions that indicate a need for attention. For instance, when the pressure differential across the primary stage filters reaches a specified limit, personnel will be notified via cell phone. This will provide sufficient time to go to the Site, turn off the system, change the filters, and re-start the system. Should no one arrive at the Site to change the filters before a higher specified pressure differential is reached, the entire system will be automatically shut down to prevent breakthrough, leakage, or a potential uncontrolled release of licensed material. Several such pressure sensors across various components will provide similar notification and/or shutdown measures.

Filters will be removed and evaluated for radioactive content when the pressure differential across the filter exceeds established criteria (yet to be determined). Filters will be sent to a licensed disposal facility or a Class D landfill based on their radioactive contents. When the total mass of U-235 approaches the 1,200 gram license limit, flow would be diverted to a second parallel system. Residual water would be drained from the system and the resin would be removed and packaged for shipment to a licensed disposal facility. It is possible that the resin would be initially shipped to a licensed facility to degrade either the enrichment or the quantity of U-235 prior to disposal.

2. Cost Allocation

100% of the cost of construction and operation of the water treatment system, as well as the packaging, shipping, and disposal of resin and filters that must be treated as low level radioactive waste (LLRW), are allocated to the Federal Account. 100% of the cost of health physics (HP) and quality assurance (QA) support associated with water treatment, and all analytical costs associated with water treatment, are also allocated to the Federal Account.

E. TREATED WATER TRANSFER AND INJECTION

1. Description

Alternatives 4 through 7 involve the injection of treated water into the WU, UP1, and UP2 Areas. In the WU and UP1 Areas, treated water will be injected into Sandstone A. In the UP2 Area, treated water will be injected in both Sandstone A and Sandstone B. In these alternatives, as much treated water as possible will be injected into these wells to maximize the flushing of the sandstones into the WA Area.

The effluent from the water treatment unit will be the water used for injection. If coming only from the BA #1 Area (Alternative 4), this water would contain concentrations of all COCs below their criteria. If influent water to the water treatment unit comes from both the BA #1 and the WA Area wells containing uranium above its criteria, the effluent from the water treatment unit may initially contain nitrate at a concentration above its release criterion. However, the effluent would contain uranium at a concentration far below its criteria.

Injection wells would be installed at locations shown on Figure 5. For this evaluation, a well spacing of 100 feet was assumed. Actual well spacing and locations will be determined during the development of the remedial design, but this spacing is sufficient for the purpose of this evaluation.

Injection wells will be constructed of 2" schedule 40 PVC casing and screen. The filter pack around these wells will utilize coarse sands to maximize the transfer of water to the formation. Controls at each well will shut off flow should the elevation of water in the well approach the ground surface, to minimize the potential for injected water to reach the surface. Maintaining water levels as high as possible without allowing surfacing of injected water will maximize the flushing of the sandstones in which these wells are completed. An underground injection control permit from the Oklahoma Water Resources Board (OWRB) may be required. Based on the quantity of water injected, the formations into which the groundwater is injected, and the concentration of COCs being injected, the OWRB may only require periodic notification when groundwater is being injected.

Injection wells are a proven technology; however, due to the fractured nature of the sandstones in which the water will be injected, it is uncertain how effective these wells will be in flushing the underlying sandstones. Consequently, the use of horizontal wells may also be evaluated should one of these alternatives be selected.

2. Cost Allocation

100% of the cost of installing injection wells in the WU Area is allocated to the Federal Account. 100% of the cost of installing injection wells in the UP1 and UP2 Areas is allocated to the State Account. 50% of the cost of running piping from the water treatment unit to the injection wells is allocated to each account.

F. IRRIGATION SYSTEMS

1. Description

Alternatives 3, 4, 6, and 7 include the use of irrigation as a means of treating extracted groundwater for nitrate. Irrigation is a proven technology for the degradation of nitrate, since indigenous vegetation can use the nitrogen in the nitrate as a nutrient. The primary drawback to the use of irrigation for nitrate remediation is that this technology can only be employed during the growing season, and even then only as precipitation and soil moisture allow.

The basis for determining the area needed for irrigation is the quantity of nitrogen that must be taken up by the indigenous vegetation. Based on a projected 170 gpm of water containing an average of 80 mg/l nitrate, up to 150 acres would be needed to provide for full uptake of the nitrogen that would be generated. Two center-pivot irrigation systems, illustrated on Figure 5, would be able to provide irrigation for at least 150 acres.

Irrigation systems would include piping to transfer water from the impoundment to a receiving station located between the two irrigation areas, a pump to supply the center-pivot sprinklers, and sensors distributed throughout the two irrigation areas to trigger irrigation only when soil moisture is at levels that would enable the absorption of the irrigation water.

A groundwater extraction well in the Well 1319 Area would be anticipated to produce an average of approximately 1 gpm. The cost of a separate irrigation system for this small quantity of water is less than the cost to install the piping that would be needed to transfer the water to the WU Area or to the WA Area to be combined with the water being sent to the impoundment. Consequently, all alternatives that include irrigation include the use of a small irrigation system in the Well 1319 Area. This irrigation system would consist of a storage tank to retain the water pumped from the extraction well, with high-level and low-level shutoff switches, and a sprinkler system that would provide irrigation for an area slightly less than one acre.

2. Cost Allocation

The irrigation system for the Well 1319 Area is only needed to remediate groundwater for nitrate; consequently, 100% of the cost for this irrigation system is allocated to the State Account. Because the 150-acre irrigation is primarily intended to remediate groundwater for nitrate, but is needed for disposal of all groundwater, 1/3 of the cost of the 150-acre irrigation system is allocated to the Federal Account, and 2/3 of the cost of the 150-acre irrigation system is allocated to the State Account.

G. OPERATION AND MAINTENANCE

1. Description

Although not a "component" of remediation, the operation and maintenance of each alternative is addressed in this section to explain how the durations for remediation were estimated, and how costs were allocated to Federal and State Accounts for each alternative.

Alternatives 2 and 5 do not require irrigation; extracted and/or treated groundwater can be discharged directly to the Cimarron River. These alternatives were assigned remediation durations of two years for nitrate in both cases, three years for uranium (without recharge), and four years for uranium with recharge. This was based on the fact that, although it will be possible to maximize the production of groundwater from all areas, the significantly higher distribution coefficient (Kd) for uranium (3mg/kg [solid] per mg/l [in solution] vs. <0.1 3mg/kg [solid] per mg/l [in solution]) will require more pore volumes of uranium-impacted groundwater to be removed than for nitrate.

For Alternatives 3, 4, and 6, the rate-limiting factor is the limitation on irrigation to 8 months out of each year, (also influenced during the first year by the amount of nitrogen that can be placed on the ground). For all three of these cases, it was assumed that nitrate remediation would occur in three years, and remediation for uranium would require six years. Alternative 7 involved construction of a larger impoundment to enable uranium treatment to extend throughout the year. Flow rates would still be limited by irrigation rates, but the duration of uranium remediation was decreased to five years due to the ability to treat uranium-impacted groundwater year-round.

2. Cost Allocation

Annual costs for the following items are allocated between Federal and State Accounts:

- Recovery system O&M,
- Irrigation system O&M,
- Maintenance of an underground injection permit,
- Maintenance of a land application permit, and
- Maintenance of a Corps of Engineers permit.

These costs were allocated to Federal and State Accounts based on the number of years those operations are needed to address Federal or State issues. Using Alternative 3 as an example, nitrate is remediated in three years; 50% of the total cost of recovery system O&M is allocated to each account for the first three years. Another three years of operation are required to complete remediation for uranium; 100% of the cost of recovery system O&M is allocated to the Federal account for these three years.

100% of the annual costs for operations that address Federal issues were allocated to the Federal Account. Using Alternative 3 as an example, the cost for the following operations is allocated exclusively to the Federal Account:

- Treat BA #1 groundwater for uranium,
- Packaging, transportation, and disposal of BA #1 spent resin (and filters, if necessary),
- HP and QA support during the remediation process,
- Uranium analysis for the water treatment process,
- NRC license compliance,
- NRC Fees,
- Radiological groundwater monitoring (in accordance with an approved remedial design).

100% of the annual costs for operations that address State issues were allocated to the State Account. Using Alternative 3 as an example, the cost for the following operations is allocated exclusively to the State Account:

- DEQ fees,
- Non-radiological groundwater monitoring (in accordance with an approved remedial design).

The cost for Trustee oversight of remediation operations is estimated at $100,000 per year. 93.2% of this cost was allocated to the Federal Account, and 6.8% of this cost was allocated to the State Account.

H. POST-REMEDIATION OPERATIONS

1. Description

Although not a "component" of remediation, post-remediation operations for each alternative are addressed in this section to explain how the durations of post-remediation operations were estimated, and how costs were allocated to Federal and State Accounts for each alternative.

Alternatives 2 and 5 do not require irrigation; extracted and/or treated groundwater can be discharged directly to the Cimarron River. For these alternatives, it was assumed that no final status surveys will be required to obtain license termination; only a dose model demonstrating that residual dose complies with the license termination criteria in 10 CFR 20 will be generated. For these two alternatives, it was assumed that eight quarters of post-remediation monitoring will be performed. One year would be required to generate a completion report and a dose model, which would accompany a request for license termination from NRC and a No Further Action ruling from DEQ.

For Alternatives 3, 4, 6, and 7, it is assumed that final status surveys will be performed in the 150-acre irrigation area as well as for the 2-acre or 5-acre impoundment. Although survey plans can be finalized and much of the field data collected during post-remediation monitoring, it is assumed that the final status survey process will add one year to the post-remediation process.

2. Cost Allocation

100% of the annual costs for the following post-remediation operations that address Federal issues were allocated to the Federal Account:

- Radiological post-remediation groundwater monitoring,
- NRC license compliance,
- Removal of the water treatment unit,
- Final status survey plans, field work, and reporting,
- HP and QA support during the post-remediation process,
- NRC fees, and
- Dose modeling and license termination request.

100% of the annual costs for the following post-remediation activities that address State issues were allocated to the State Account:

- Removal of the Well 1319 irrigation system, and
- DEQ fees.

Costs for the following items are allocated between Federal and State Accounts:

- Termination of all permits,
- Abandonment of all extraction and injection wells,
- Impoundment closure,
- Removal of the 150-acre irrigation system,
- Removal of all piping and utilities,
- Preparation of a post-remediation report,
- Trustee costs for oversight of post-remediation activities.

93.2% of these costs were allocated to Federal Account. 6.8% of these costs were allocated to the State Account.

Note: For all three categories of costs presented in the cost estimate spreadsheet, the same 93.2% / 6.8% allocation ratio is used for Trustee expenses, as well as for a number of post-remediation activities. The basis for this allocation is the ratio of Federal (or State) funding and the total funding available to the Federal and State accounts, including the Standby Trust Fund. The total funding available to both Federal and State accounts is $10,934,495, which is the sum *of $6,588,381 (Federal Cost Account), plus $3,600,000 (Standby Trust Fund), plus $746,114 (State Cost Account). The $746,114 available to the State is 6.8% of this total. The $1,188,381 available to the Federal Cost Account is 93.2% of this total.*

* * * * *

CHAPTER V - EVALUATION OF ALTERNATIVES

Each of the seven potential alternative groundwater remediation technologies evaluated in this report area herein evaluated on the basis of four criteria; effectiveness, regulatory and public acceptance, schedule, and cost. For each alternative, a score of 1 to 5 was assigned to each of these five criteria, with a "1" indicating the lowest degree of favorability, and a "5" indicating the highest level of favorability. Due to the limitations placed on costs by the existence of a finite fund, one criterion (cost), was given a weighting factor of 2, giving this criterion a range from 2 to 10. Scores were then added to generate a Total Score for each alternative. Table 5 tabulates the results of this evaluation.

A. ALTERNATIVE 1 – NO ACTION

1. Effectiveness

This alternative will not reduce contaminant concentrations in groundwater within an acceptable time frame. Consequently, this alternative was given a score of "1" for Effectiveness.

2. Regulatory and Public Acceptance

This alternative is not likely to be not acceptable to either regulatory agencies or to the public, and was given a score of "1" for Regulatory and Public Acceptance.

3. Schedule

This alternative will not reduce contaminant concentrations in groundwater for many years. Consequently, this alternative was given a score of "1" for Schedule.

4. Cost

This alternative will require annual funding for maintaining the site, administrative expenses, and license compliance for decades. Little remediation will be accomplished upon depletion of the Trust fund. This alternative had the highest cost, estimated to be over $16 million over 30 years, and was given the lowest weighted score of "2" for Cost.

5. Total

This alternative was given a Total score of "5".

B. ALTERNATIVE 2 – EXTRACT AND DISCHARGE

1. Effectiveness

This alternative will be effective in reducing all contaminant concentrations in groundwater in all areas. The effectiveness of the extraction wells in the WU, UP1 and UP2 Areas in removing the source of uranium is of concern. Consequently, this alternative was given a score of "3" for Effectiveness.

2. Regulatory and Public Acceptance

Streams of groundwater with different COC concentrations will be blended together and discharged without treatment, extraction and discharge without water treatment may not be acceptable to either regulatory agencies or the public. This alternative would result in the discharge of enriched uranium at concentrations above the license criteria directly into the Cimarron River. Because groundwater extraction can be maximized, simple extraction and discharge has the potential to reduce COC concentrations more rapidly and cost effectively than any other alternative may increase the potential for regulatory and public approval. This alternative was given a score of "2" for Regulatory and Public Acceptance.

3. Schedule

Due to the ability to pump greater quantities of groundwater than for any alternative except Alternative 5, this alternative will complete remediation more quickly than any other alternative. Consequently, this alternative was given a score of "5" for Schedule.

4. Cost

The installation cost for all the necessary components for this alternative is estimated to be $1,370,000 and the annual operating and maintenance cost is estimated to be $763,000. The total cost for this alternative is estimated to be $6,695,500. This alternative presents the lowest initial and total cost of all the alternatives (excluding No Action for initial cost), and was given a weighted score of "10" for Cost.

5. Total

This alternative was given a Total score of "20".

C. ALTERNATIVE 3 – EXTRACT, TREAT BA #1, AND IRRIGATE

1. Effectiveness

This alternative will be effective in reducing all contaminant concentrations in groundwater in all areas. The effectiveness of the extraction wells in the WU, UP1 and UP2 Areas in removing the source of uranium is of concern. Consequently, this alternative was given a score of "3" for Effectiveness.

2. Regulatory and Public Acceptance

Streams of groundwater with different COC concentrations will be blended together and discharged with treatment of only the BA #1 stream of water. Land application of water which still contains enriched uranium above drinking water criteria may not be acceptable to either regulatory agencies or the public. The requirement for a final status survey should increase the potential for regulatory and public acceptance. This alternative was given a score of "3" for Regulatory and Public Acceptance.

3. Schedule

This alternative is estimated to require six years of remediation and four years of post-remediation activity. Though it may be possible to pump more water from remaining areas after the areas of lower activity are remediated, each year added to the schedule results in additional cost. This alternative was given a "2" for Schedule.

4. Cost

The installation cost for all the necessary components for this alternative is estimated to be $2,296,000 and the annual operating and maintenance cost is estimated to be $1,139,050. The total cost for this alternative is estimated to be $12,859,000. This alternative ranks among the higher cost alternatives and was given a weighted score of "4" for Cost.

5. Total

This alternative was given a Total score of "12".

D. ALTERNATIVE 4 – EXTRACT AND RECHARGE, TREAT BA #1, AND IRRIGATE

1. Effectiveness

This alternative will be effective in reducing all contaminant concentrations in groundwater in all areas. The effectiveness of injection in the WU, UP1 and UP2 Areas in removing the source of uranium is believed to be superior to the effectiveness of extraction wells alone in these areas. Consequently, this alternative was given a score of "5" for Effectiveness.

2. Regulatory and Public Acceptance

Streams of groundwater with different COC concentrations will be blended together and discharged with treatment of only the BA #1 stream of water. Land application of water which still contains enriched uranium above drinking water criteria may not be acceptable to either regulatory agencies or the public. The requirement for a final status survey should increase the potential for regulatory and public acceptance. This alternative was given a score of "3" for Regulatory and Public Acceptance.

3. Schedule

This alternative is estimated to require six years of remediation and four years of post-remediation activity. Though it may be possible to pump more water from remaining areas after the areas of lower activity are remediated, each year added to the schedule results in additional cost. This alternative was given a "2" for Schedule.

4. Cost

The installation cost for all the necessary components for this alternative is estimated to be $2,341,000 and the annual operating and maintenance cost is estimated to be $1,139,050. The total cost for this alternative is estimated to be $12,974,000. This alternative ranks among the higher cost alternatives and was given a score of "4" for Cost.

5. Total

This alternative was given a Total score of "14".

E. ALTERNATIVE 5 – EXTRACT AND RECHARGE, TREAT BA #1 AND WA, AND DISCHARGE

1. Effectiveness

This alternative will be effective in reducing all contaminant concentrations in groundwater in all areas. The effectiveness of injection in the WU, UP1 and UP2 Areas in removing the source of uranium is believed to be superior to the effectiveness of extraction wells alone in these areas. Consequently, this alternative was given a score of "5" for Effectiveness.

2. Regulatory and Public Acceptance

Streams of groundwater containing uranium above its criteria will be treated for uranium. Consequently, COC concentrations in the water that will be blended together in the impoundment will contain only nitrate above its criterion. Discharge of water which no longer contains enriched uranium above drinking water criteria should be acceptable to both regulatory agencies and the public. It is not yet known whether a permit authorizing the discharge of the mass of nitrate that would be generated in the initial year can be obtained. This alternative was given a score of "4" for Regulatory and Public Acceptance.

3. Schedule

This alternative is estimated to require four years of remediation and three years of post-remediation activity. Except for extraction and discharge without treatment, this is the shortest schedule available. This alternative was given a "5" for Schedule.

4. Cost

The installation cost for all the necessary components for this alternative is estimated to be $2,030,000 and the annual operating and maintenance cost is estimated to be $1,217,000. The total cost for this alternative is estimated to be $9,780,700. This alternative ranks among the lowest cost alternatives and was given a score of "8" for Cost.

5. Total

This alternative was given a Total score of "22".

F. ALTERNATIVE 6 – EXTRACT AND RECHARGE, TREATE BA #1 AND WA, AND IRRIGATE (8 MONTH)

1. Effectiveness

This alternative will be effective in reducing all contaminant concentrations in groundwater in all areas. The effectiveness of injection in the WU, UP1 and UP2 Areas in removing the source of uranium is believed to be superior to the effectiveness of extraction wells alone in these areas. Consequently, this alternative was given a score of "5" for Effectiveness.

2. Regulatory and Public Acceptance

Streams of groundwater containing uranium above its criteria will be treated for uranium. Consequently, COC concentrations in the water that will be blended together and land applied will contain only nitrate above its criterion. Land application of water which still no longer contains enriched uranium above drinking water criteria should be acceptable to both regulatory agencies and the public. The requirement for a final status survey should further increase the potential for regulatory and public acceptance. This alternative was given a score of "5" for Regulatory and Public Acceptance.

3. Schedule

This alternative is estimated to require six years of remediation and four years of post-remediation activity. Though it may be possible to pump more water from remaining areas after the areas of lower activity are remediated, each year added to the schedule results in additional cost. This alternative was given a "2" for Schedule.

4. Cost

The installation cost for all the necessary components for this alternative is estimated to be $2,380,000 and the annual operating and maintenance cost is estimated to be $1,214,050. The total cost for this alternative is estimated to be $13,463,000. This alternative ranks among the highest cost alternatives (including No Action) and was given a score of "4" for Cost. Although the cost of Alternative 6 ($13.5 MM) is close to the cost of Alternatives 3, 4, and 7 ($12.9 MM to $13.1 MM, it was given a lower score to differentiate it from the other three very close estimated costs.

5. Total

This alternative was given a Total score of "14".

G. ALTERNATIVE 7 – EXTRACT AND RECHARGE, TREAT BA #1 AND WA, AND IRRIGATE (12 MONTH)

1. Effectiveness

This alternative will be effective in reducing all contaminant concentrations in groundwater in all areas. The effectiveness of injection in the WU, UP1 and UP2 Areas in removing the source of uranium is believed to be superior to the effectiveness of extraction wells in these areas. Consequently, this alternative was given a score of "5" for Effectiveness.

2. Regulatory and Public Acceptance

Streams of groundwater containing uranium above its criteria will be treated for uranium. Consequently, COC concentrations in the water that will be blended together and land applied will contain only nitrate above its criterion. Land application of water which still no longer contains enriched uranium above drinking water criteria should be acceptable to both regulatory agencies and the public. The requirement for a final status survey should further increase the potential for regulatory and public acceptance. This alternative was given a score of "5" for Regulatory and Public Acceptance.

3. Schedule

This alternative is estimated to require five years of remediation and four years of post-remediation activity. Though it may be possible to pump more water from remaining areas after the areas of lower activity are remediated, each year added to the schedule results in additional cost. Because this alternative includes a shorter schedule than other "Irrigation" alternatives, it was given a "3" for Schedule.

4. Cost

The installation cost for all the necessary components for this alternative is estimated to be $2,530,000 and the annual operating and maintenance cost is estimated to be $1,277,440. The total cost for this alternative is estimated to be $13,083,500. This alternative ranks among the higher cost alternatives and was given a score of "4" for Cost.

5. Total

This alternative was given a Total score of "17".

* * * * *

CHAPTER VI - CONCLUSIONS AND RECOMMENDATIONS

Numerous potential alternative groundwater remediation technologies were initially screened, and those which were retained were evaluated based on Effectiveness, Regulatory and Public Acceptance, Schedule, and Cost. Seven potential alternative groundwater remediation technologies, all but one involving various combinations of groundwater extraction and/or injection, mixing, treatment, and direct discharge or irrigation, were evaluated.

Alternative 5, Extract and Recharge, Treat BA #1 and WA, and Discharge, received the highest ranking. Next to Alternative 2, this alternative provides the quickest, most economical means of reducing the concentration of COCs to less than their criteria. This and Alternative 2 are the only two alternatives for which existing funding is sufficient to complete remediation and post-remediation activities. Additional funding from the Anadarko litigation will be required for all other alternatives. This operation can be conducted year-round, and is not dependent upon the ability of the ecosystem to absorb irrigation water and utilize nitrogen. It therefore offers the greatest potential to increase the production of water from higher-concentration areas as wells are shutoff, and accelerate the remediation effort. EPM recommends the selection of this alternative.

Alternative 2, Extract and Discharge, received the second highest ranking. It is the most economical of any of the alternatives. This and Alternative 3 are the only two alternatives for which existing funding is sufficient to complete remediation and post-remediation activities. Additional funding from the Anadarko litigation will be required for all other alternatives. However, two aspects of this alternative may eliminate it from selection as the remedial technology that can be implemented. First, it may not be permissible to discharge the concentrations of enriched uranium that would be produced directly to the Cimarron River, regardless of how great the dilution factor would be. Second, it may not be possible to extract the sorbed contaminants from the sandstones in the WU, UP1, and UP2 Areas without regard to the number of wells installed. Extraction of the groundwater would leave the formation unsaturated, and without the potential for significant recharge, concentrations would recover after remediation activities were terminated. This alternative would be EPM's second recommendation among those evaluated.

Alternative 7, Extract and Recharge, Treat BA #1 and WA, and Irrigate, received the third highest ranking. Although it is significantly more expensive than either of the two higher-ranked alternatives, it offers the quickest reasonably economical means of reducing the concentration of COCs to less than their criteria. Additional funds from the Anadarko litigation will be required to complete remediation and post-remediation activities using this technology. Because it can be operated year-round, it may be possible to increase the extraction of uranium-impacted groundwater from the areas of highest concentration, thereby accelerating the remediation effort and reducing total cost. Should direct discharge to the Cimarron River of <u>any</u> concentration of enriched uranium not be possible, EPM recommends the selection of this alternative.

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CHAPTER VII - REFERENCES

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TABLES

TABLE 1
2011 GROUNDWATER ASSESSMENT DATA SUMMARY
EVALUATION OF POTENTIAL GROUNDWATER REMEDIATION TECHNOLOGIES

Sample Location	Sample Date	Uranium (ug/l)	Uranium (pCi/l)	Fluoride (mg/l)	Nitrate (mg/l)	Gross Alpha (pCi/l)		Gross Beta (pCi/l)		Tc-99 (pCi/l)	
1312	4/15/2011	17	28	9.42	279						
1312DUP	4/15/2011	17.3	28	12.2	287						
1313	4/18/2011	18.8	30	43.1	464						
1319B1	4/15/2011	42.8	69	0.32	85.5						
1319B3	4/15/2011	24.8	40	0.307	75.5						
1319B4	4/15/2011	1.48	2	0.424	3.63						
1319B5	4/15/2011	1.89	3	0.43	6.45						
1336A	4/15/2011	25.3	41	9.75	283	51.4	± 12.9	458	± 24.8	647	± 37.7
1337	4/14/2011	7.02	11	12.7	63.7	16.7	± 7.08	46.6	± 8.58	93.8	± 23.1
1340	4/18/2011	7.83	13	11.2	42.9						
1341	4/18/2011	2.14	3	0.563	26.8						
1346	4/15/2011	1.44	2	7.11	376	4.66	± 5.53	1,420	± 43.8	2,030	± 61.0
1347	4/14/2011	18.3	30	4.09	5.35	29.8	± 10.0	12.0	± 5.72	34.4 U	± 19.4
1348	4/19/2011	70.1	114	9.18	10						
1349	4/19/2011	22.9	37	0.589	6.04						
1351	4/19/2011	43.5	71	0.739	58.4						
1352	4/18/2011	132	214	0.455	57						
1354	4/18/2011	2.95	5	0.491	63.5						
1354DUP	4/18/2011	2.79	5	0.486	61						
1356	4/18/2011	531	861	0.339	9.8						
1357	4/19/2011	1.77	3	0.557	34.4						
1360	4/19/2011	16.9	27	1.6	16.4						
MWWA-03	4/19/2011	479	777	4.74	25.7						
MWWA-09	4/19/2011	116	188	3.58	47.8						
T-51	4/21/2011	21.5	35	0.452	16						
T-52	4/20/2011	20.6	33	1.64	58						
T-53	4/20/2011	33.6	54	0.836	47.7						
T-54	4/21/2011	3.2	5	1.83	145						
T-54DUP	4/21/2011	2.85	5	1.78	137						
T-55	4/14/2011	4.33	7	1.97	58.6	6.57 U	± 4.9	106	± 12.3	208	± 26.9
T-56	4/21/2011	2.02	3	0.764	20.2						
T-57	4/21/2011	10.5	17	4.47	96.9						
T-57DUP	4/21/2011	10.7	17	4.45	84.1						
T-58	4/21/2011	20.4	33	0.887	13.6						
T-59	4/20/2011	101	164	0.284	150						
T-60	4/20/2011	40.7	66	0.496	59.5						
T-61	4/20/2011	31.7	51	0.46	2.18						
T-62	4/19/2011	157	255	3.06	63.8						

TABLE 1
2011 GROUNDWATER ASSESSMENT DATA SUMMARY
EVALUATION OF POTENTIAL GROUNDWATER REMEDIATION TECHNOLOGIES

Sample Location	Sample Date	Uranium (ug/l)	Uranium (pCi/l)	Fluoride (mg/l)	Nitrate (mg/l)	Gross Alpha (pCi/l)	Gross Beta (pCi/l)	Tc-99 (pCi/l)
T-63	4/21/2011	82.3	133	4.87	31.5			
T-63DUP	4/21/2011	87.1	141	4.9	35			
T-64	4/19/2011	81.5	132	1.1	20.7			
T-65	4/19/2011	130	211	2.66	49.4			
T-66	4/21/2011	123	199	1.85	35.8			
T-67	4/19/2011	149	242	2.7	29.4			
T-68	4/21/2011	119	193	1.37	19.3			
T-69	4/21/2011	47.3	77	0.883	138			
T-69DUP	4/21/2011	47	76	0.896	140			
T-72	4/21/2011	142	230	1.18	25.8			
T-76	4/21/2011	191 J	313 J	2.9	47.8			
T-77	4/21/2011	85.3	138	0.917	5.5			
T-79	4/21/2011	69.5	113	0.937	3.56			
T-84	4/20/2011	45.4	74	0.78	51			
T-85	4/20/2011	26.5	43	1.49	123			
T-86	4/20/2011	16.5	27	1.8	41.1			
T-87	4/20/2011	16.9	27	1.3	109			
T-88	4/20/2011	10.1	16	1.37	52			
T-89	4/20/2011	52.1	84	0.49	72.5			
T-90	4/20/2011	22.4	36	0.737	34.5			

Notes:
Red text indicates undetected value; MDL is shown instead of reported result.
Yellow highlight indicates low spike recovery; result give data review flag of "J"
Uranium activity is a calculated estimate based on an assumed enrichment of 3%.
The DEQ limit for uranium concentration is 110 μg/l.
The NRC limit for uranium activity is 180 pCi/l.

TABLE 2
2009 - 2011 WESTERN AREA NITRATE AND FLUORIDE DATA
EVALUATION OF POTENTIAL GROUNDWATER REMEDIATION TECHNOLOGIES

Sample Location	Fluoride (mg/l)			Nitrate (mg/l)		
	2009	2010	2011	2009	2010	2011
1312	10.4	13.1	9.4	415	299	279
1312DUP	N/A	N/A	12.2	N/A	N/A	287
1313	49.9	27.6	43.1	352	423	464
1319B1	0.4	N/A	0.3	47.4	N/A	85.5
1319B3	0.3	N/A	0.3	89.3	N/A	75.5
1319B4	0.4	N/A	0.4	3.1	N/A	3.6
1319B5	0.3	N/A	0.4	11.9	N/A	6.45
1336A	14.1	10.0	9.8	164	203	283
1337	12.4	2.2	12.7	88.5	12.2	63.7
1340	18.2	15.4	11.2	56.3	27.7	42.9
1341	0.6	0.6	0.6	36.9	32.3	26.8
1346	N/A	10.0	7.1	N/A	520	376
1347	4.4	4.4	4.1	4.6	3.7	5.4
1348	9.8	11.6	9.2	10	7.8	10
1349	N/A	N/A	0.6	N/A	N/A	6
1351	0.9	0.6	0.7	73.8	48.7	58.4
1352	0.4	0.6	0.5	151	64.1	57
1354	0.5	0.4	0.5	366	91.3	63.5
1354DUP	N/A	N/A	0.5	N/A	N/A	61
1356	0.4	0.5	0.3	10	11.9	9.8
1357	0.4	N/A	0.6	42.7	N/A	34.4
1360	1.8	N/A	1.6	12.3	N/A	16.4
MWWA-03	7.6	5.8	4.7	17	30.4	25.7
MWWA-09	5.1	5.4	3.6	33.5	14.3	47.8
T-51	0.4	0.6	0.5	8.6	20.3	16
T-52	2.2	1.9	1.6	23.1	40.6	58
T-53	0.8	1.0	0.8	38.1	36.4	47.7
T-54	2.1	3.0	1.8	317	122	145
T-54DUP	N/A	N/A	1.8	N/A	N/A	137
T-55	2.8	1.7	2.0	99.5	82.8	58.6
T-56	0.7	0.9	0.8	30.8	21.2	20.2
T-57	3.2	4.7	4.5	206	92.2	96.9
T-57DUP	N/A	N/A	4.5	N/A	N/A	84.1
T-58	0.7	1.1	0.9	51.5	14	13.6
T-59	0.3	0.3	0.3	139	123	150
T-60	0.5	0.6	0.5	44.4	43.3	59.5

TABLE 2
2009 - 2011 WESTERN AREA NITRATE AND FLUORIDE DATA
EVALUATION OF POTENTIAL GROUNDWATER REMEDIATION TECHNOLOGIES

Sample Location	Fluoride (mg/l)			Nitrate (mg/l)		
	2009	2010	2011	2009	2010	2011
T-61	0.4	0.5	0.5	6.4	3.4	2.2
T-62	2.6	3.4	3.1	90.2	38.6	63.8
T-63	5.3	4.1	4.9	177	34.2	31.5
T-63DUP	N/A	N/A	4.9	N/A	N/A	35
T-64	2.2	1.1	1.1	24.9	20.9	20.7
T-65	3.1	N/A	2.7	53.8	N/A	49.4
T-66	1.7	N/A	1.9	40.7	N/A	35.8
T-67	2.7	N/A	2.7	23.7	N/A	29.4
T-68	1.3	N/A	1.4	38.5	N/A	19.3
T-69	1.0	1.1	0.9	141	68.2	138
T-69DUP	N/A	N/A	0.9	N/A	N/A	140
T-72	1.1	N/A	1.2	57.4	N/A	25.8
T-76	3.0	N/A	2.9	52.5	N/A	47.8
T-77	1.1	1.2	0.9	9.1	10.6	5.5
T-79	1.0	1.1	0.9	7.4	4.8	3.6
T-84	N/A	N/A	0.8	N/A	N/A	51
T-85	N/A	N/A	1.5	N/A	N/A	123
T-86	N/A	N/A	1.8	N/A	N/A	41.1
T-87	N/A	N/A	1.3	N/A	N/A	109
T-88	N/A	N/A	1.4	N/A	N/A	52
T-89	N/A	N/A	0.5	N/A	N/A	72.5
T-90	N/A	N/A	0.7	N/A	N/A	34.5

Notes: N/A: Not Analyzed

TABLE 3
2009 - 2011 WESTERN AREA URANIUM DATA
EVALUATION OF POTENTIAL GROUNDWATER REMEDIATION TECHNOLOGIES

Sample Location	2009 (pCi/l)	2010 (pCi/l)	2011 (pCi/l)	2011 µg/l
1312	0.0	21.6	28	17.0
1312DUP	N/A	N/A	28	17.3
1313	N/A	36.6	30	18.8
1319B1	N/A	N/A	69	42.8
1319B3	N/A	N/A	40	24.8
1319B4	N/A	N/A	2	1.5
1319B5	N/A	N/A	3	1.9
1336A	35.4	N/A	41	25.3
1337	N/A	2.1	11	7.0
1340	N/A	9.4	13	7.8
1341	N/A	1.3	3	2.1
1346	N/A	4.4	2	1.4
1347	N/A	19.0	30	18.3
1348	N/A	122.0	114	70.1
1349	N/A	N/A	37	22.9
1351	1100.1*	139.8	71	43.5
1352	85.6*	124.5	214	132.0
1354	10.0*	2.4	5	3.0
1354DUP	N/A	N/A	5	2.8
1356	1174.9*	680.4	861	531.0
1357	6.0	N/A	3	1.8
1360	45.6	N/A	27	16.9
MWWA-03	814.9*	728.4	777	479.0
MWWA-09	123.1*	146.2	188	116.0
T-51	N/A	20.3	35	21.5
T-52	N/A	21.2	33	20.6
T-53	N/A	12.5	54	33.6
T-54	N/A	3.1	5	3.2
T-54DUP	N/A	N/A	5	2.9
T-55	N/A	4.1	7	4.3
T-56	N/A	3.0	3	2.0
T-57	N/A	18.1	17	10.5
T-57DUP	N/A	N/A	17	10.7
T-58	33.2	28.4	33	20.4
T-59	N/A	73.6	164	101.0
T-60	N/A	41.2	66	40.7
T-61	N/A	35.5	51	31.7
T-62	81.8	216.4	255	157.0

TABLE 3

2009 - 2011 WESTERN AREA URANIUM DATA

EVALUATION OF POTENTIAL GROUNDWATER REMEDIATION TECHNOLOGIES

Sample Location	2009 (pCi/l)	2010 (pCi/l)	2011 (pCi/l)	2011 µg/l
T-63	70.6*	87.1	133	82.3
T-63DUP	N/A	N/A	141	87.1
T-64	537.3*	86.0	132	81.5
T-65	144.2*	N/A	211	130.0
T-66	70.2*	N/A	199	123.0
T-67	117.0*	N/A	242	149.0
T-68	87.0*	N/A	193	119.0
T-69	30.5*	67.3	77	47.3
T-69DUP	N/A	N/A	76	47.0
T-72	82.1*	N/A	230	142.0
T-76	182.9*	267.5	310 J	191 J
T-77	181.2*	244.8	138	85.3
T-79	134.2*	213.5	113	69.5
T-84	N/A	N/A	74	45.4
T-85	N/A	N/A	43	26.5
T-86	N/A	N/A	27	16.5
T-87	N/A	N/A	27	16.9
T-88	N/A	N/A	16	10.1
T-89	N/A	N/A	84	52.1
T-90	N/A	N/A	36	22.4

Notes: * - Uranium activity is an average of splits.

Uranium activity is a calculated estimate.

TABLE 4
2004 AND 2010 BURIAL AREA #1 URANIUM DATA
EVALUATION OF POTENTIAL ALTERNATIVE GROUNDWATER REMEDIAITON TECHNOLOGIES

Sample Location	2004 Activity (pCi/l)	2010 Activity (pCi/l)	Comment
1314	2	1	
1315R	1,399*	718	Sudden decrease after 2007
1316R	118	109	
TMW-08	2,947*	431	5 analyses from 2005 to 2009 varied from 1,198 to 1,952 pCi/l
TMW-09	4,296*	3,884	
TMW-13	3,384*	1,337	
02W06	2,496*	306	Continual decline between 2004 and 2010
02W08	108*	79	6 analyses between 2004 and 2010 were < 60 pCi/l
02W09	1	2	
02W16	25	8	
02W17	39	14	One anomalous result in 2004 of 932 pCi/l
02W27	153	78	
02W28	300	375	5 analyses between 2004 and 2010 peaked at 1,344 pCi/l
02W32	413	1,449	6 analyses between 2004 and 2010 were < 100 pCi/l
02W35	147*	27	All results except 2004 and 2007 (9 analyses) < 100 pCi/l
02W42	131	156	
02W43	178	130	17 analyses from 2002 to 2010 varied from 80 to 741 pCi/l
02W44	101	190	12 analyses from 2002 to 2010 varied from 7 to 435 pCi/l

* - Represents average of multiple 2004 analyses

TABLE 5
GROUNDWATER REMEDIATION COST ESTIMATES
EVALUATION OF POTENTIAL ALTERNATIVE GROUNDWATER REMEDIATION TECHNOLOGIES

	Component	Component Cost	#1 - No Action		#2 - Extract & Discharge		#3 - Extract, Treat BA #1, Irrigate (8 month)		#4 - Extract and Recharge, Treat BA #1, Irrigate (8 month)		#5 - Extract & Recharge, Treat BA #1 and WA, Discharge		#6 - Extract & Recharge, Treat BA #1 and WA, Irrigate (8 month)		#7 - Extract & Recharge, Treat BA #1 and WA, Irrigate (12 month)		Basis for Cost Estimate
			Federal	State	Federal	State	Federal	State	Federal	State	Federal	State	Federal	State	Federal	State	
					One Year Duration for Finalizing Remedial Design, Contracting, Permitting, and Installation of Components												
Installation & Startup	OPDES Permit	$25,000			$12,500	$12,500					$12,500	$12,500					
	UIC Permit	$10,000															
	Irrigation Permit	$15,000					$5,000	$10,000	$5,000	$10,000				$15,000		$15,000	
	Corps Permit	$10,000					$5,000	$5,000	$5,000	$5,000			$5,000	$5,000	$5,000	$5,000	
	Extraction wells - BA #1	$21,000			$21,000		$21,000		$21,000		$21,000		$21,000		$21,000		6 wells @ $3,500
	Extraction Trench - BA #1	$30,000			$30,000		$30,000		$30,000		$30,000		$30,000		$30,000		200' X 15' X $10/sq.ft.
	Extraction Wells - WA (N only)	$49,000				$49,000		$49,000		$49,000		$49,000		$49,000		$49,000	14 wells @ $3,500
	Extraction Wells - WA (N and U)	$21,000			$10,500	$10,500	$10,500	$10,500	$10,500	$10,500	$10,500	$10,500	$10,500	$10,500	$10,500	$10,500	6 wells @ $3,500
	Extraction Well - Well 1319	$3,500				$3,500		$3,500		$3,500		$3,500		$3,500		$3,500	1 well @ $3,500
	Extraction Wells - UP1, and UP2	$63,000				$63,000		$63,000									18 Wells @ $3,500
	Extraction Wells - WU	$17,500			$8,750	$8,750	$8,750	$8,750									5 Wells @ $3,500
	Injection Wells - WU	$17,500							$17,500		$17,500		$17,500		$17,500		5 wells @ $3,500
	Injection Wells - UP1 and UP2	$63,000								$63,000		$63,000		$63,000		$63,000	11 Wells @ $3,500
	BA #1 Uranium Treatment System	$600,000					$600,000		$600,000		$600,000		$600,000		$600,000		EnergySolutions
	2-acre Impoundment	$150,000			$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000	$75,000			BMcD
	5-acre Impoundment	$300,000													$225,000	$75,000	BMcD
	150-acre Floodplain Irrigation System	$360,000					$120,000	$240,000	$120,000	$240,000			$120,000	$240,000	$120,000	$240,000	BMcD
	Well 1319 Irrigation System	$15,000						$15,000		$15,000				$15,000		$15,000	1-acre sprinkler plus controls
	Piping - BA #1 to Impoundment	$30,000			$30,000		$30,000		$30,000		$30,000		$30,000		$30,000		2,000' @ $15
	Piping - WA to Impoundment	$96,000			$48,000	$48,000	$48,000	$48,000	$48,000	$48,000	$48,000	$48,000	$48,000	$48,000	$48,000	$48,000	6,000 ' @ $15
	Piping - WA Alternate to Impoundment	$39,000									$39,000		$39,000		$39,000		3,900' @ $10
	Piping - WU, UP1, & UP2 to Impoundment	$30,000			$15,000	$15,000	$15,000	$15,000									2,000' @ $15
	Piping - Well 1319 to WU Line	$24,000				$24,000											1,600' @ $15
	Piping - Water Treatment Plant to WU, UP1, & UP2	$75,000							$37,500	$37,500	$37,500	$37,500	$37,500	$37,500	$37,500	$37,500	5,000' @ $15
	Discharge Pipe to River	$25,000			$12,500	$12,500					$12,500	$12,500					1,500' @ $15
	Run Utilities	$50,000			$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	
	NRC License Compliance (annual)	$200,000			$200,000		$200,000		$200,000		$200,000		$200,000		$200,000		Current rate
	NRC Fees (annual)	$250,000			$250,000		$250,000		$250,000		$250,000		$250,000		$250,000		Reduced from 2011
	DEQ Fees (annual)	$10,000			$10,000		$10,000		$10,000		$10,000		$10,000		$10,000		
	Trustee Cost	$100,000			$93,200	$6,800	$93,200	$6,800	$93,200	$6,800	$93,200	$6,800	$93,200	$6,800	$93,200	$6,800	
	HP and QA Program Support	$200,000			$200,000		$200,000		$200,000		$200,000		$200,000		$200,000		Enercon

TABLE 5
GROUNDWATER REMEDIATION COST ESTIMATES
EVALUATION OF POTENTIAL ALTERNATIVE GROUNDWATER REMEDIATION TECHNOLOGIES

	Component	Component Cost	#1 - No Action		#2 - Extract & Discharge		#3 - Extract, Treat BA #1, Irrigate (8 month)		#4 - Extract and Recharge, Treat BA #1, Irrigate (8 month)		#5 - Extract & Recharge, Treat BA #1 and WA, Discharge		#6 - Extract & Recharge, Treat BA #1 and WA, Irrigate (8 month)		#7 - Extract & Recharge, Treat BA #1 and WA, Irrigate (12 month)		Basis for Cost Estimate
			Federal	State	Federal	State	Federal	State	Federal	State	Federal	State	Federal	State	Federal	State	
			Duration - 30 + Years		Remediation - 3 Years		Remediation - 6 Years		Remediation - 6 Years		Remediation - 4 Years		Remediation		Remediation		
					3 Years	2 Years	6 Years	3 Years	6 Years	3 Years	4 Years	2 Years	6 Years	3 Years	5 Years	3 Years	
Annual Cost During Remediation	Recovery System O&M (annual)	$50,000			$100,000	$50,000	$225,000	$75,000	$225,000	$75,000	$150,000	$50,000	$225,000	$75,000	$175,000	$75,000	1/5 time @ $100/hr + $10,000 (equipment)
	Irrigation System O&M (annual)	$50,000					$225,000	$75,000	$225,000	$75,000			$225,000	$75,000	$175,000	$75,000	1/5 time @ $100/hr + $10,000 (equipment)
	BA #1 Treatment System O&M (annual)	$50,000					$300,000		$300,000		$200,000		$300,000		$250,000		1/4 time @ $100/hr
	BA #1 Resin Disposal (annual)	$150,000					$900,000		$900,000		$600,000		$900,000		$750,000		
	WA Resin Disposal (annual)	$75,000									$300,000		$450,000		$375,000		
	Replace Resin & Filters	$30,000					$120,000		$120,000				$120,000		$105,000		$12,500 per resin + filters @ $5,000
	HP & QA Support (8-month)	$120,000					$720,000		$720,000				$720,000				Enercon w/ adjustments
	HP & QA Support (12-month)	$150,000			$450,000						$600,000				$750,000		Enercon w/ adjustments
	Treatment Process Uranium Analysis (8-month))	$31,500					$31,500		$31,500				$31,500				3 samples/week X 35 weeks X $300
	Treatment Process Uranium Analysis (12-month)	$46,800									$187,200				$234,000		3 samples/week X 52 weeks X $300
	NRC License Compliance (annual)	$200,000	$6,000,000		$600,000		$1,200,000		$1,200,000		$800,000		$1,200,000		$1,000,000		Same as Year 1
	NRC Fees (annual)	$250,000	$7,500,000		$750,000		$1,500,000		$1,500,000		$1,000,000		$1,500,000		$1,250,000		Same as Year 1
	DEQ Fees (annual)	$10,000		$300,000		$30,000		$60,000		$60,000		$40,000		$60,000		$50,000	Same as Year 1
	OPDES Permit (annual)	$30,000			$60,000	$30,000					$90,000	$30,000					1 sample/wk X $100, sampler, DMRs
	UIC Permit (annual)	$10,000							$45,000	$15,000	$30,000	$10,000	$45,000	$15,000	$35,000	$15,000	
	Land Application Permit (annual)	$20,000					$60,000	$60,000	$60,000	$60,000			$60,000	$60,000	$50,000	$50,000	
	Corps Permit (annual)	$2,000					$9,000	$3,000	$9,000	$3,000			$9,000	$3,000	$7,000	$3,000	
	Groundwater Monitoring (radiological)	$80,000	$800,000		$80,000		$480,000		$480,000		$320,000		$480,000		$400,000		40 locations/qtr X $500/sample for sampling, shipping, and analysis
	Groundwater Monitoring (chemical)	$56,000	$560,000			$56,000		$168,000		$168,000		$112,000		$168,000		$168,000	40 locations/qtr X $350/sample for sampling, shipping, and analysis
	Trustee Cost	$100,000	$1,500,000				$93,200	$6,800	$93,200	$6,800	$93,200	$6,800	$93,200	$6,800	$93,200	$6,800	

TABLE 5
GROUNDWATER REMEDIATION COST ESTIMATES
EVALUATION OF POTENTIAL ALTERNATIVE GROUNDWATER REMEDIATION TECHNOLOGIES

	Component	Component Cost	#1 - No Action		#2 - Extract & Discharge		#3 - Extract, Treat BA #1, Irrigate (8 month)		#4 - Extract and Recharge, Treat BA #1, Irrigate (8 month)		#5 - Extract & Recharge, Treat BA #1 and WA, Discharge		#6 - Extract & Recharge, Treat BA #1 and WA, Irrigate (8 month)		#7 - Extract & Recharge, Treat BA #1 and WA, Irrigate (12 month)		Basis for Cost Estimate
			Federal	State	Federal	State	Federal	State	Federal	State	Federal	State	Federal	State	Federal	State	
Post-Remediation					Post-Remediation - 3 Years		Post-Remediation - 4 Years		Post-Remediation - 4 Years		Post-Remediation - 3 Years		Post-Remediation - 4 Years		Post-Remediation - 4 Years		
	Post-Remediation Monitoring (radiological)	$80,000			$160,000		$160,000		$160,000		$160,000		$160,000		$160,000		40 locations/qtr X $500/sample for sampling, shipping, and analysis
	Post-Remediation Monitoring (non-radiological)	$56,000				$112,000		$112,000		$112,000		$112,000		$112,000		$112,000	40 locations/qtr X $350/sample for sampling, shipping, and analysis
	OPDES Permit Termination	$20,000			$18,640	$1,360					$18,640	$1,360					
	Irrigation Permit Termination	$5,000					$4,660	$340	$4,660	$340			$4,660	$340	$4,660	$340	
	UIC Permit Termination	$10,000							$9,320	$680	$9,320	$680	$9,320	$680	$9,320	$680	
	Corps Permit Termination	$10,000					$9,320	$680	$9,320	$680			$9,320	$680	$9,320	$680	
	NRC License Compliance (annual)	$200,000			$600,000		$800,000		$800,000		$600,000		$800,000		$800,000		Same as Year 1
	Abandon BA #1 Wells	$132,000			$123,024	$8,976	$123,024	$8,976	$123,024	$8,976	$123,024	$8,976	$123,024	$8,976	$123,024	$8,976	88 Wells X $1,500
	Abandon WA Wells	$90,000			$83,880	$6,120	$83,880	$6,120	$83,880	$6,120	$83,880	$6,120	$83,880	$6,120	$83,880	$6,120	60 Wells X $1,500
	Abandon Plant Area Wells	$36,000			$33,552	$2,448	$33,552	$2,448	$33,552	$2,448	$33,552	$2,448	$33,552	$2,448	$33,552	$2,448	24 Wells X $1,500
	Abandon WU, UP1, UP2 Wells	$72,000			$67,104	$4,896	$67,104	$4,896	$67,104	$4,896	$67,104	$4,896	$67,104	$4,896	$67,104	$4,896	48 Wells X $1,500
	Demob U Treatment System	$10,000					$10,000		$10,000		$10,000		$10,000		$10,000		
	Close 2-Acre Impoundment	$100,000			$93,200	$6,800	$93,200	$6,800	$93,200	$6,800	$93,200	$6,800	$93,200	$6,800			
	Close 5-Acre Impoundment	$200,000													$186,400	$13,600	
	Remove 150-Acre Irrigation System	$30,000					$27,960	$2,040	$27,960	$2,040			$27,960	$2,040	$27,960	$2,040	
	Remove Well 1319 Irrigation System	$2,500						$2,500		$2,500				$2,500		$2,500	
	Remove Piping - BA #1 to Pond	$10,000			$9,320	$680	$9,320	$680	$9,320	$680	$9,320	$680	$9,320	$680	$9,320	$680	2,000' X $5
	Remove Piping - WA to Pond	$32,000			$29,824	$2,176	$29,824	$2,176	$29,824	$2,176	$29,824	$2,176	$29,824	$2,176	$29,824	$2,176	6,400 ' X $5
	Remove Piping - WU & UP2 to Pond	$10,000			$9,320	$680	$9,320	$680	$9,320	$680	$9,320	$680	$9,320	$680	$9,320	$680	2,000' X $5
	Remove Piping - Well 1319 to WU	$8,000			$7,456	$544											1,600' X $5
	Remove Discharge Pipe to River	$7,500			$6,990	$510					$6,990	$510					1,500' X $5
	Remove Utilities	$25,000			$23,300	$1,700	$23,300	$1,700	$23,300	$1,700	$23,300	$1,700	$23,300	$1,700	$23,300	$1,700	
	HP & QA Support (annual)	$150,000			$419,400	$30,600	$559,200	$40,800	$559,200	$40,800	$419,400	$30,600	$559,200	$40,800	$559,200	$40,800	Same as Years 2 ->
	Final Status Survey Plan	$100,000			$100,000		$100,000		$100,000		$100,000		$100,000		$100,000		
	Final Status Survey - 150-Acre Area	$500,000					$500,000		$500,000				$500,000		$500,000		
	Final Status Survey - 2-Acre Pond	$100,000			$100,000		$100,000		$100,000		$100,000		$100,000				
	Final Status Survey - 5-Acre Pond	$200,000													$200,000		
	Post-Remediation Report	$150,000			$139,800	$10,200	$139,800	$10,200	$139,800	$10,200	$139,800	$10,200	$139,800	$10,200	$139,800	$10,200	
	NRC Fees (annual)	$250,000			$750,000		$1,000,000		$1,000,000		$750,000		$1,000,000		$1,000,000		Same as Year 1
	DEQ Fees (annual)	$10,000				$30,000		$40,000		$40,000		$30,000		$40,000		$40,000	Same as Year 1
	License Termination Request	$25,000			$25,000		$25,000		$25,000		$25,000		$25,000		$25,000		
	Trustee Cost	$100,000			$93,200	$6,800	$93,200	$6,800	$93,200	$6,800	$93,200	$6,800	$93,200	$6,800	$93,200	$6,800	
	Installation Cost		$0	$0	$1,028,950	$341,050	$1,736,450	$559,550	$1,767,700	$573,300	$1,699,200	$330,800	$1,806,700	$573,300	$1,956,700	$573,300	
	Annual O&M Cost		$545,333	$10,000	$680,000	$83,000	$977,283	$149,267	$984,783	$154,267	$1,092,600	$124,400	$1,059,783	$154,267	$1,129,840	$147,600	
	Total O&M Cost		$16,360,000	$300,000	$2,040,000	$166,000	$5,863,700	$447,800	$5,908,700	$462,800	$4,370,400	$248,800	$6,358,700	$462,800	$5,649,200	$442,800	
	Closure Cost		$0	$0	$2,893,010	$226,490	$4,001,664	$249,836	$4,010,984	$250,516	$2,904,874	$226,626	$4,010,984	$250,516	$4,204,184	$257,316	
	Total Cost to Each Account		$16,360,000	$300,000	$5,961,960	$733,540	$11,601,814	$1,257,186	$11,687,384	$1,286,616	$8,974,474	$806,226	$12,176,384	$1,286,616	$11,810,084	$1,273,416	
	Total Cost		$16,660,000		$6,695,500		$12,859,000		$12,974,000		$9,780,700		$13,463,000		$13,083,500		

TABLE 6
EVALUATION SUMMARY
EVALUATION OF POTENTIAL ALTERNATIVE GROUNDWATER REMEDIATION TECHNOLOGIES

Alternative		Effectiveness	Regulatory & Public Acceptance	Schedule	Cost	Total
1	No Action	1	1	1	2	5
2	Extract & Discharge	3	2	5	10	20
3	Extract, Treat BA #1, and Irrigate	3	3	2	4	12
4	Extract & Recharge, Treat BA #1, and Irrigate	5	3	2	4	14
5	Extract & Recharge, Treat BA #1 and WA, and Discharge	5	4	5	8	22
6	Extract & Recharge, Treat BA #1 and WA, and Irrigate (8 month)	5	5	2	2	14
7	Extract & Recharge, Treat BA #1 and WA, and Irrigate (12 month)	5	5	3	4	17

FIGURES

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

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Figure 1
"SITE MAP SHOWING REMEDIATION AREAS"

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D-01

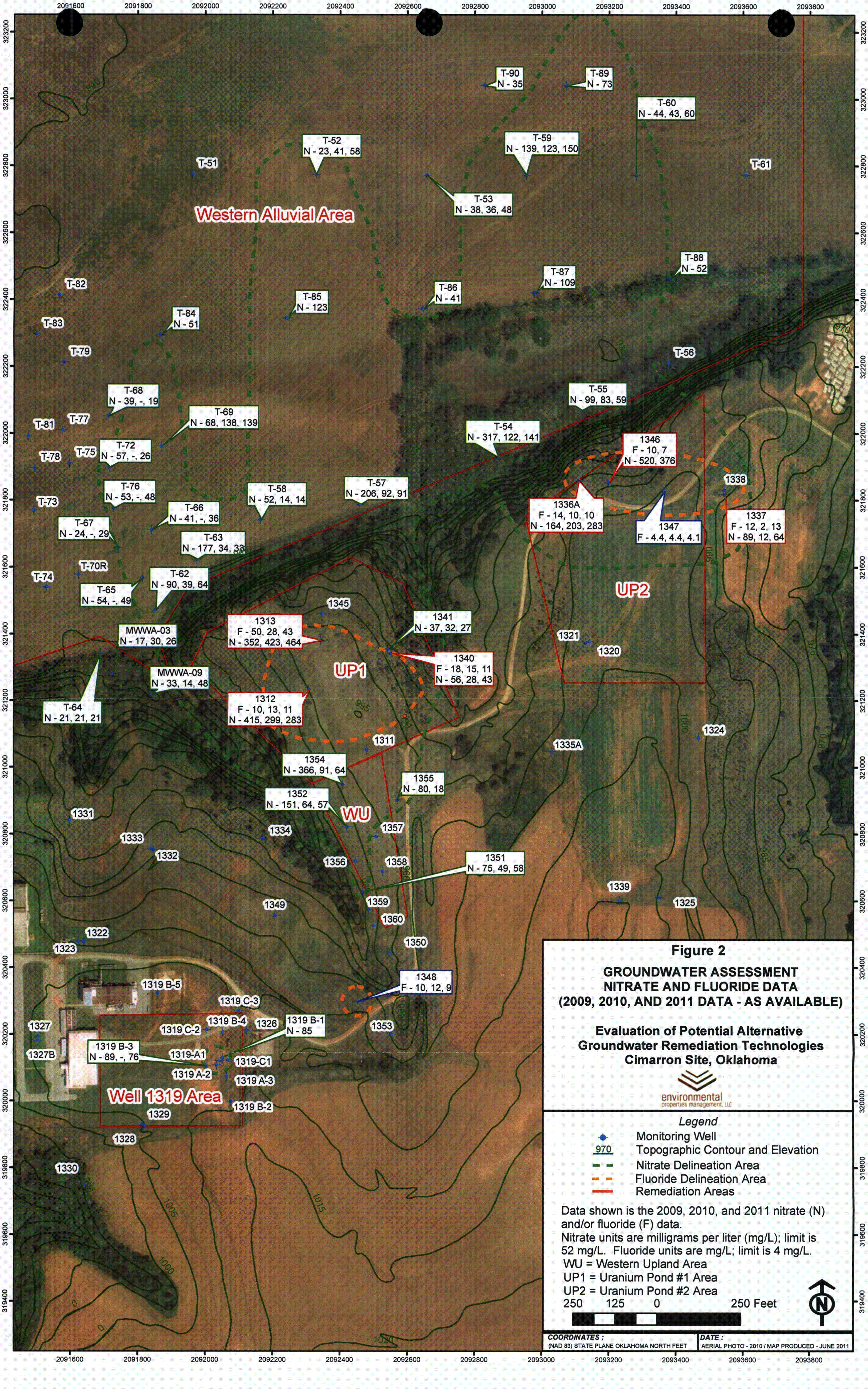
Figure 2
GROUNDWATER ASSESSMENT
NITRATE AND FLUORIDE DATA
(2009, 2010, AND 2011 DATA - AS AVAILABLE)
Evaluation of Potential Alternative
Groundwater Remediation Technologies
Cimarron Site, Oklahoma
environmental properties management, LLC
Legend
Monitoring Well
970 Topographic Contour and Elevation
Nitrate Delineation Area
Fluoride Delineation Area
Remediation Areas
Data shown is the 2009, 2010, and 2011 nitrate (N) and/or fluoride (F) data.
Nitrate units are milligrams per liter (mg/L); limit is 52 mg/L. Fluoride units are mg/L; limit is 4 mg/L.
WU = Western Upland Area
UP1 = Uranium Pond #1 Area
UP2 = Uranium Pond #2 Area
250 125 0 250 Feet
N
COORDINATES : (NAD 83) STATE PLANE OKLAHOMA NORTH FEET
DATE : AERIAL PHOTO - 2010 / MAP PRODUCED - JUNE 2011
Western Alluvial Area
UP1
UP2
WU
Well 1319 Area
T-90 N - 35
T-89 N - 73
T-60 N - 44, 43, 60
T-52 N - 23, 41, 58
T-59 N - 139, 123, 150
T-51
T-61
T-53 N - 38, 36, 48
T-88 N - 52
T-87 N - 109
T-86 N - 41
T-85 N - 123
T-84 N - 51
T-82
T-83
T-79
T-56
T-55 N - 99, 83, 59
T-68 N - 39, -, 19
T-69 N - 68, 138, 139
T-81
T-77
T-72 N - 57, -, 26
T-75
T-78
T-54 N - 317, 122, 141
1346 F - 10, 7 N - 520, 376
1338
T-76 N - 53, -, 48
T-58 N - 52, 14, 14
T-57 N - 206, 92, 91
1336A F - 14, 10, 10 N - 164, 203, 283
1347 F - 4.4, 4.4, 4.1
1337 F - 12, 2, 13 N - 89, 12, 64
T-73
T-66 N - 41, -, 36
T-67 N - 24, -, 29
T-63 N - 177, 34, 33
T-70R
T-74
T-62 N - 90, 39, 64
T-65 N - 54, -, 49
1345
1313 F - 50, 28, 43 N - 352, 423, 464
1341 N - 37, 32, 27
MWWA-03 N - 17, 30, 26
1321
1320
1340 F - 18, 15, 11 N - 56, 28, 43
MWWA-09 N - 33, 14, 48
1312 F - 10, 13, 11 N - 415, 299, 283
T-64 N - 21, 21, 21
1324
1311
1335A
1354 N - 366, 91, 64
1355 N - 80, 18
1352 N - 151, 64, 57
1331
1334
1357
1333
1332
1356
1358
1351 N - 75, 49, 58
1339
1325
1349
1359
1360
1322
1323
1350
1319 B-5
1348 F - 10, 12, 9
1319 C-3
1327
1319 C-2
1319 B-4
1326
1319 B-1 N - 85
1353
1327B
1319 B-3 N - 89, -, 76
1319-A1
1319-C1
1319 A-2
1319 A-3
1319 B-2
1329
1328
1330
2091600 2091800 2092000 2092200 2092400 2092600 2092800 2093000 2093200 2093400 2093600 2093800
323200 323000 322800 322600 322400 322200 322000 321800 321600 321400 321200 321000 320800 320600 320400 320200 320000 319800 319600 319400

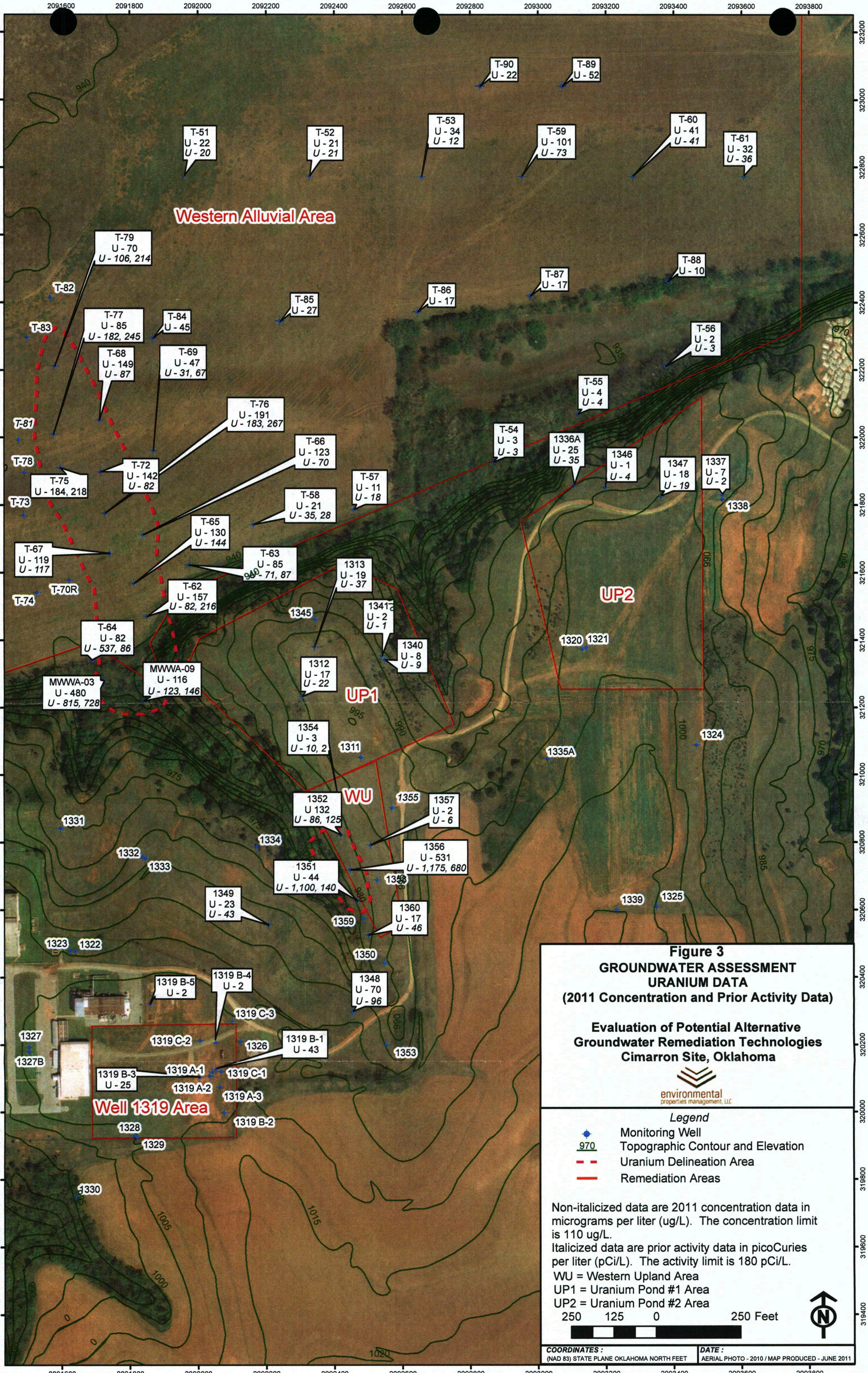
Figure 3
GROUNDWATER ASSESSMENT
URANIUM DATA
(2011 Concentration and Prior Activity Data)
Evaluation of Potential Alternative
Groundwater Remediation Technologies
Cimarron Site, Oklahoma
environmental properties management, LLC
Legend
Monitoring Well
970 Topographic Contour and Elevation
Uranium Delineation Area
Remediation Areas
Non-italicized data are 2011 concentration data in micrograms per liter (ug/L). The concentration limit is 110 ug/L.
Italicized data are prior activity data in picoCuries per liter (pCi/L). The activity limit is 180 pCi/L.
WU = Western Upland Area
UP1 = Uranium Pond #1 Area
UP2 = Uranium Pond #2 Area
250 125 0 250 Feet
COORDINATES : (NAD 83) STATE PLANE OKLAHOMA NORTH FEET
DATE : AERIAL PHOTO - 2010 / MAP PRODUCED - JUNE 2011
Western Alluvial Area
UP1
UP2
WU
Well 1319 Area
T-90 U - 22
T-89 U - 52
T-51 U - 22 U - 20
T-52 U - 21 U - 21
T-53 U - 34 U - 12
T-59 U - 101 U - 73
T-60 U - 41 U - 41
T-61 U - 32 U - 36
T-79 U - 70 U - 106, 214
T-82
T-83
T-77 U - 85 U - 182, 245
T-84 U - 45
T-85 U - 27
T-86 U - 17
T-87 U - 17
T-88 U - 10
T-68 U - 149 U - 87
T-69 U - 47 U - 31, 67
T-56 U - 2 U - 3
T-76 U - 191 U - 183, 267
T-55 U - 4 U - 4
T-81
T-78
T-75 U - 184, 218
T-72 U - 142 U - 82
T-66 U - 123 U - 70
T-54 U - 3 U - 3
1336A U - 25 U - 35
1346 U - 1 U - 4
1347 U - 18 U - 19
1337 U - 7 U - 2
1338
T-73
T-57 U - 11 U - 18
T-58 U - 21 U - 35, 28
T-65 U - 130 U - 144
T-67 U - 119 U - 117
T-63 U - 85 U - 71, 87
T-70R
T-74
1313 U - 19 U - 37
T-62 U - 157 U - 82, 216
1345
1341 U - 2 U - 1
1340 U - 8 U - 9
1320
1321
T-64 U - 82 U - 537, 86
1312 U - 17 U - 22
MWWA-03 U - 480 U - 815, 728
MWWA-09 U - 116 U - 123, 146
1354 U - 3 U - 10, 2
1311
1324
1335A
1355
1352 U 132 U - 86, 125
1357 U - 2 U - 6
1331
1334
1332
1333
1356 U - 531 U - 1,175, 680
1351 U - 44 U - 1,100, 140
1358
1349 U - 23 U - 43
1360 U - 17 U - 46
1359
1339
1325
1323
1322
1350
1348 U - 70 U - 96
1319 B-5 U - 2
1319 B-4 U - 2
1319 C-3
1327
1327B
1319 C-2
1326
1319 B-1 U - 43
1353
1319 B-3 U - 25
1319 A-1
1319 C-1
1319 A-2
1319 A-3
1319 B-2
1328
1329
1330

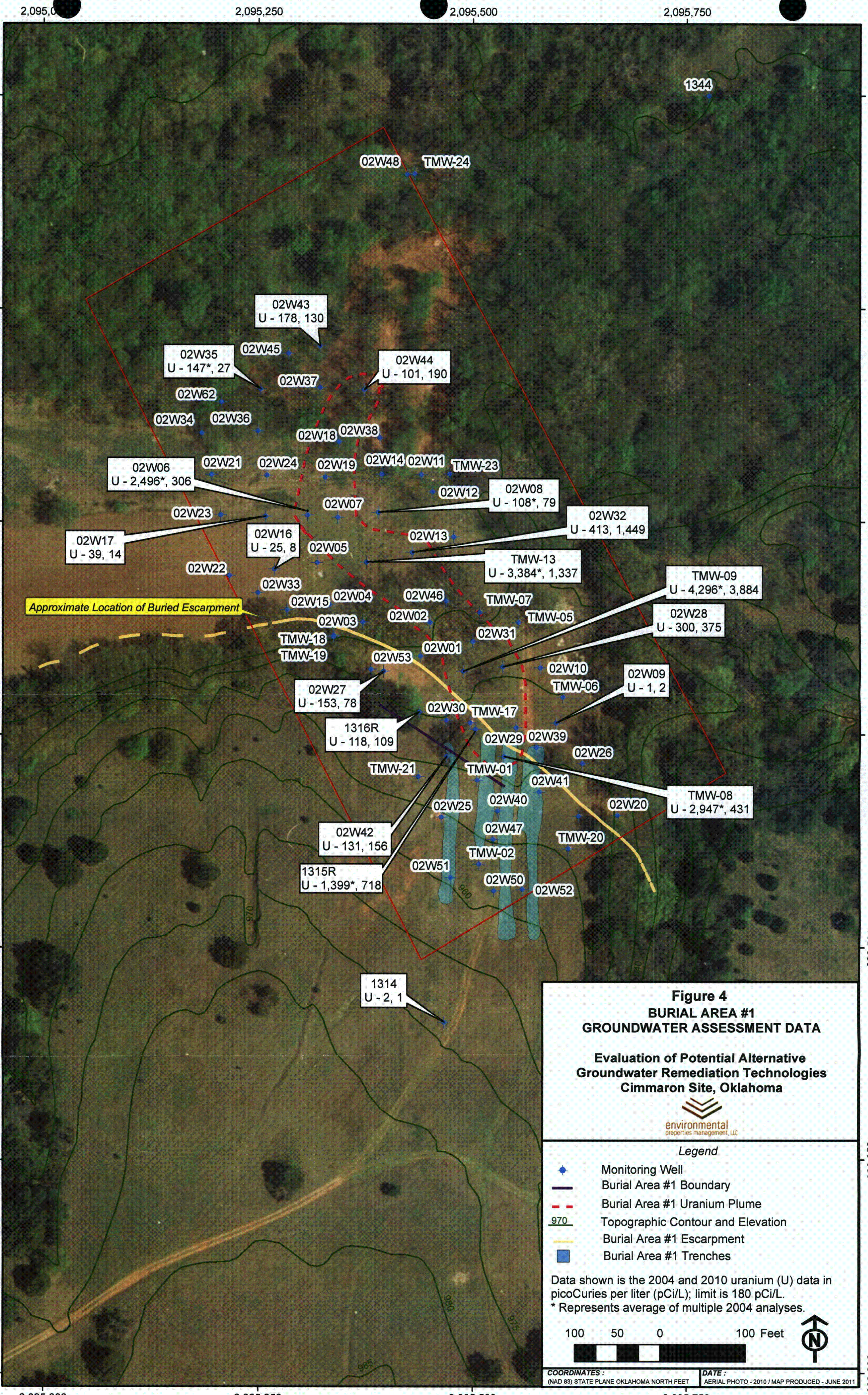
Figure 4
BURIAL AREA #1
GROUNDWATER ASSESSMENT DATA
Evaluation of Potential Alternative
Groundwater Remediation Technologies
Cimmaron Site, Oklahoma
environmental
properties management, LLC
Legend
Monitoring Well
Burial Area #1 Boundary
Burial Area #1 Uranium Plume
970 Topographic Contour and Elevation
Burial Area #1 Escarpment
Burial Area #1 Trenches
Data shown is the 2004 and 2010 uranium (U) data in picoCuries per liter (pCi/L); limit is 180 pCi/L.
* Represents average of multiple 2004 analyses.
100 50 0 100 Feet
N
COORDINATES : (NAD 83) STATE PLANE OKLAHOMA NORTH FEET
DATE : AERIAL PHOTO - 2010 / MAP PRODUCED - JUNE 2011
Approximate Location of Buried Escarpment
02W43 U - 178, 130
02W35 U - 147*, 27
02W44 U - 101, 190
02W06 U - 2,496*, 306
02W08 U - 108*, 79
02W32 U - 413, 1,449
02W17 U - 39, 14
02W16 U - 25, 8
TMW-13 U - 3,384*, 1,337
TMW-09 U - 4,296*, 3,884
02W28 U - 300, 375
02W09 U - 1, 2
02W27 U - 153, 78
1316R U - 118, 109
TMW-08 U - 2,947*, 431
02W42 U - 131, 156
1315R U - 1,399*, 718
1314 U - 2, 1
1344
02W48
TMW-24
02W45
02W37
02W62
02W34
02W36
02W18
02W38
02W21
02W24
02W19
02W14
02W11
TMW-23
02W12
02W07
02W23
02W13
02W05
02W22
02W33
02W15
02W04
02W46
TMW-07
02W02
TMW-05
02W03
02W31
TMW-18
TMW-19
02W01
02W53
02W10
TMW-06
02W30
TMW-17
02W29
02W39
02W26
TMW-21
TMW-01
02W41
02W25
02W40
02W20
02W47
TMW-20
TMW-02
02W51
02W50
02W52
2,095,000
2,095,250
2,095,500
2,095,750
323,500
323,250
323,000
322,750
322,500
322,250
322,000

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Figure 5
"GROUNDWATER REMEDIATION COMPONENTS"

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D-02

APPENDIX A - SOIL BORING LOGS AND MONITOR WELL DIAGRAMS

Drilling Log

Project Name CERT	Project Number	Boring Number T-84
Ground Elevation	Location	Page 1 of 2
Air Monitoring Equipment		Total Footage 28'

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes
HSA	8 1/4"	NA	NA	NA	NA

Drilling Company: Davis Environmental Drilling	Driller(s): Roland Davis
Drilling Rig: CME	Type of Sampler: Continuous to 10'
Date 4-11-11 To 4-11-11	Field Observer(s): Jim Crawford

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
0–5	upper 6" root zone Silty Clay reddish brown firm low plastic moist 2.5' becoming sandy silt with some clay 3.5-4' Wet perched zone silt reddish brown fast dilatency 4' Sand fine grained poorly graded loose yellow orange moist silty			5/5	1000 / 1010		Cuttings Scanned with Ludlum micro R meter - All readings at background thru out boring			PERCHED 3.5'
5–10	Sand becoming fine to coarse grained well graded rd brn No Recovery			2/5						▽
10–14	Description from Auger flights Sand light brown to yellow orange loose saturated			10						At 10', install wood plug in Auger bit

BZ=Breathing Zone BH=Bore Hole S=Sample

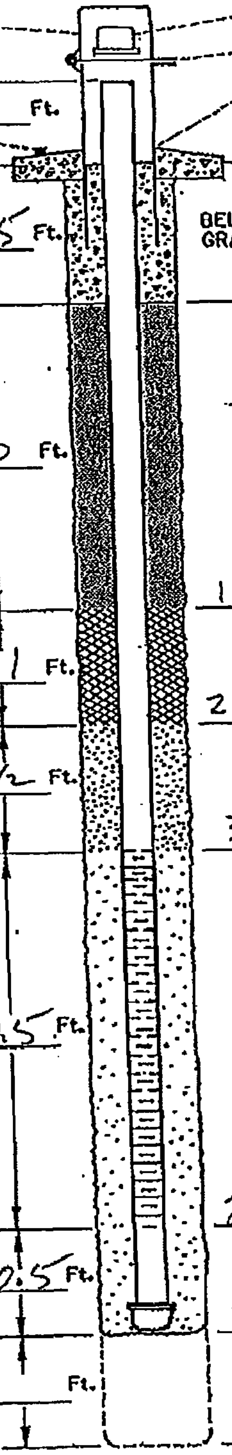
Drilling Log Continuation

	Boring Number T-84
Project Name CERT	Page 2 OF 2
Project Number	Date 4-11-11

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
15				15	1025					
16	Sand fine to coarse grained silty well graded loose some small gravel (max 5mm)									
17										
18										
19										
20				20						
21										
22										
23										
24										
25	Sand fine to very coarse grained silty small gravel. max 1/4"			25	1035					
26										
27	Sandstone vfg brick red						Driller felt a change in drilling at 27'. "crunchy"			
28										
29	Total depth 28'									
30										

BZ=Breathing Zone BH=Bore Hole S=Sample

MONITORING WELL INSTALLATION DIAGRAM



Protective Pipe
Yes [X] No [ ]
Steel [X] PVC [ ]
____ Ft.
Surveying Pin ? Yes [X] No [ ]

Casing Cap Vent ? Yes [ ] No [ ]
Lock ? Yes [ ] No [ ]
Weep Hole ? Yes [ ] No [ ]
Concrete Pad 3 Ft. x 3 Ft. x 4 Inches

	Thickness	DEPTH BELOW GRADE	DEPTH FROM TOP OF CASING
Concrete	1.5 Ft.		
Cement/Bentonite Grout Mix — Yes [ ] No [ ]; 6.5 Gallons Water to 94Lb. Bag Cement & 3-5 Lb. Bentonite Powder; Others:	0 Ft.	1.5	
Bentonite Seal — Pellets [X] Slurry [ ]	1 Ft.	2.5	
Filter Pack Above Screen	1/2 Ft.	3	
Screen (Filter Pack Material)	25 Ft.	27.5	
Dense Phase Sampling Cup	0.5 Ft.	28	
Overdrilled Material Backfill	____ Ft.		

FILTER PACK MATERIAL
Silica Sand [X]
Washed Sand [ ]
Pea Gravel [ ]
Others: ______
Sand Size 20/40

Bottom Plug Yes [X] No [ ]

Overdrilled Material Backfill
Grout [ ] Sand [ ]
Caved Material [ ]
Others: ______

DRILLING INFORMATION:

1. Borehole Diameter= 8 1/4 Inches.
2. Were Drilling Additives Used ? Yes [X] No [ ]
   Revert [ ] Bentonite [ ] Water [X]
   Solid Auger [ ] Hollow Stem Auger [X]
3. Was Outer Steel Casing Used ? Yes [ ] No [X]
   Depth= ______ to ______ Feet.
4. Borehole Diameter for Outer Casing ______ Inches.

WELL CONSTRUCTION INFORMATION:

1. Type of Casing: PVC [X] Galvanized [ ] Teflon [ ]
   Stainless [ ] Other ______
2. Type of Casing Joints: Screw-Couple [X] Glue-Couple [ ] Other ______
3. Type of Well Screen: PVC [X] Galvanized [ ]
   Stainless [ ] Teflon [ ] Other ______
4. Diameter of Casing and Well Screen:
   Casing 2 Inches. Screen 2 Inches.
5. Slot Size of Screen: 10
6. Type of Screen Perforation: Factory Slotted [X]
   Hacksaw [ ] Drilled [ ] Other ______
7. Installed Protector Pipe w/Lock: Yes [X] No [ ]

WELL DEVELOPMENT INFORMATION:

1. How was Well Developed ? Bailing [ ] Pumping [ ]
   Air Surging (Air or Nitrogen) [X] Other ______
2. Time Spent on Well Development ?
   F 60 Minutes/Hours
3. Approximate Water Volume Removed ? 320 Gallons
4. Water Clarity Before Development ? Clear [ ]
   Turbid [ ] Opaque [X]
5. Water Clarity After Development ? Clear [X]
   Turbid [ ] Opaque [ ]
6. Did Water have Odor ? Yes [ ] No [X]
   If Yes, Describe ______
7. Did Water have any Color ? Yes [X] No [ ]
   If Yes, Describe Red

WATER LEVEL INFORMATION:

Water Level Summary (From Top of Casing)

During Drilling ______ Ft. Date ______
Before Development ______ Ft. Date ______
After Development ______ Ft. Date ______

Driller/Firm DAVIS ENVIRONMENTAL Drill Rig Type CME 75 Date Installed 4-11-11

Drill Crew ROLAND DAVIS Well No. T-84 Hydrologist JIM CRAWFORD

Drilling Log

Project Name CERT	Project Number	Boring Number T-85
Ground Elevation	Location	Page 1 OF 2
Air Monitoring Equipment		Total Footage 31.5

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes
HSA	8 1/4"	NA	NA	NA	NA

Drilling Company DAVIS ENVIRONMENTAL	Driller(s) Roland Davis
Drilling Rig CME	Type of Sampler Continuous
Date 4-11-11 To 4-11-11	Field Observer(s) Jim Crawford

Depth (feet)	Description	Class	Blow Count	Recov.	Run/Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
0–5	Silty Clay brown stiff dry becoming firm and moist with depth Silty Sand loose moist red brown 3.5-4' Silt with trace clay wet slow dilotency At 4' Sand yellow brown to yellow orange slightly			5/5	1320 1330		Cuttings scanned with Ludlum micro R meter. All readings at background thru out boring			PERCHED 3.5'
5–10	Silty with few thin clay laminations 6' Sand becoming fine to coarse grained trace very coarse grained wet loose homogeneous No recovery			3/5						▽ (approx. 6')
10–14	Description from auger flights Sand orange brown fine to very coarse grained saturated loose			10						At 10' install wooden plug in auger bit

BZ=Breathing Zone BH=Bore Hole S=Sample

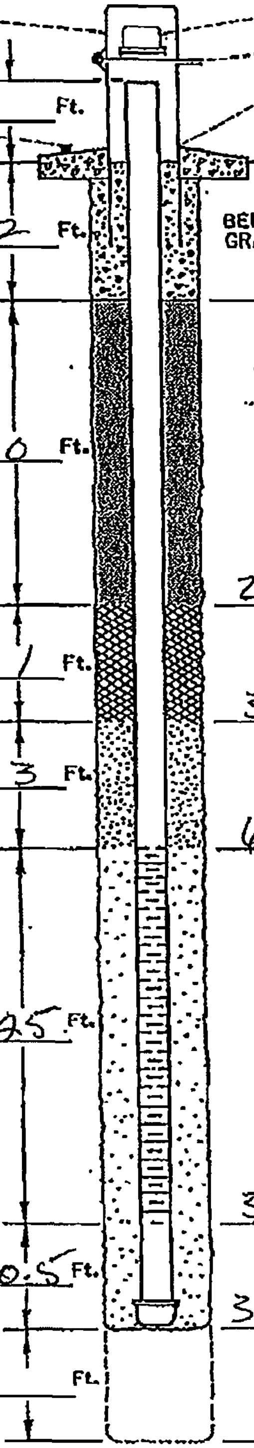
Drilling Log Continuation

Project Name: CERT	Boring Number: T-85
	Page: 2 OF 2
Project Number:	Date: 4-11-11

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
15	Well graded Slightly Silty			15						
16										
17										
18										
19										
20				20	1342					
21	Sand yellowish brown									
22	fine to very coarse well graded Slightly Silty									
23	Saturated Loose									
24										
25				25	1345					
26										FILL AUGERS WITH WATER
27										TO HOLD BACK FLOWING SANDS
28	Sand coarse to very coarse									
29	some small gravel up to 1/2"									
30	Sandstone brick red			30	1353					
31	fine grained				1355					
32	TOTAL DEPTH 31.5'									

BZ=Breathing Zone BH=Bore Hole S=Sample

MONITORING WELL INSTALLATION DIAGRAM



Protective Pipe — Yes ☐ No ☐ — Steel ☐ PVC ☐ — ______ Ft.

Surveying Pin ? Yes ☐ No ☐

Casing Cap Vent ? Yes ☐ No ☐

Lock ? Yes ☐ No ☐

Weep Hole ? Yes ☐ No ☐

Concrete Pad 3 Ft. x 3 Ft. x 4 Inches

Material	Thickness	Depth Below Grade	Depth From Top of Casing
Concrete	2 Ft.		
Cement/Bentonite Grout Mix — Yes ☐ No ☐ — 5.5 Gallons Water to 94Lb. Bag Cement & 3–5 Lb. Bentonite Powder — Other: ______	6 Ft.	2	
Bentonite Seal — Pellets ☒ Slurry ☐	1 Ft.	3	
Filter Pack Above Screen	3 Ft.	6	
FILTER PACK MATERIAL — Silica Sand ☒ Washed Sand ☐ Pea Gravel ☐ Others: ______ Sand Size 20/40	25 Ft.	31	
Dense Phase Sampling Cup Bottom Plug — Yes ☒ No ☐	0.5 Ft.	31.5	
Overdrilled Material Backfill — Grout ☐ Sand ☐ Caved Material ☐ Others: ______	Ft.		

DRILLING INFORMATION:

1. Borehole Diameter= 8 1/4 Inches.
2. Were Drilling Additives Used ? Yes ☒ No ☐
   Revert ☐ Bentonite ☐ Water ☒
   Solid Auger ☐ Hollow Stem Auger ☒
3. Was Outer Steel Casing Used ? Yes ☐ No ☒
   Depth= ______ to ______ Feet.
4. Borehole Diameter for Outer Casing ______ Inches.

WELL CONSTRUCTION INFORMATION:

1. Type of Casing: PVC ☒ Galvanized ☐ Teflon ☐ Stainless ☐ Other ______
2. Type of Casing Joints: Screw–Couple ☒ Glue–Couple ☐ Other ______
3. Type of Well Screen: PVC ☒ Galvanized ☐ Stainless ☐ Teflon ☐ Other ______
4. Diameter of Casing and Well Screen:
   Casing 2 Inches, Screen 2 Inches.
5. Slot Size of Screen: 10
6. Type of Screen Perforation: Factory Slotted ☒ Hacksaw ☐ Drilled ☐ Other ______
7. Installed Protector Pipe w/Lock: Yes ☒ No ☐

WELL DEVELOPMENT INFORMATION:

1. How was Well Developed ? Bailing ☐ Pumping ☐ Air Surging (Air or Nitrogen) ☒ Other ______
2. Time Spent on Well Development ?
   F 60 Minutes/Hours (Minutes circled)
3. Approximate Water Volume Removed ? 300 Gallons
4. Water Clarity Before Development ? Clear ☐ Turbid ☐ Opaque ☒
5. Water Clarity After Development ? Clear ☒ Turbid ☐ Opaque ☐
6. Did Water have Odor ? Yes ☐ No ☒
   If Yes, Describe ______
7. Did Water have any Color ? Yes ☒ No ☐
   If Yes, Describe Red

WATER LEVEL INFORMATION:

Water Level Summary (From Top of Casing)

During Drilling ______ Ft. Date ______

Before Development ______ Ft. Date ______

After Development ______ Ft. Date ______

Driller/Firm DAVIS ENVIRONMENTAL Drill Rig Type CME 75 Date Installed 4-11-11

Drill Crew ROLAND DAVIS Well No. T-85 Hydrologist JIM CRAWFORD

Drilling Log

Project Name: CERT	Project Number:	Boring Number: T-86
Ground Elevation:	Location:	Page: 1 of 2
Air Monitoring Equipment:		Total Footage:

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes
HSA	8 1/4"	NA	NA	NA	NA

Drilling Company: Davis Environmental Drilling	Driller(s): Roland Davis
Drilling Rig: CME	Type of Sampler: Continuous to 10'
Date: 4-11-11 To: 4-11-11	Field Observer(s): Jim Crawford

Depth (feet)	Description	Class	Blow Count	Recov.	Run/Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/Water Levels
0–1	Roots in silty clay Hard dry				1455		Cuttings scanned with Ludlum Micro R meter - All readings at background thru out boring			
1	At 1' Sandy Silt friable									
2–3.5	2' Sand yellow orange fine grained loose friable homogeneous very slightly moist			3.5/5						
3.5–5	No Recovery.									
5				5						
5–6.5	Sand very fine to fine grained silty yellowish orange									▽ (approx. 6')
6.5–7	Sand fine to coarse wet									
7–10	No recovery									
10				10	1506					10' Insert wood plug in auger bit
10–14	Sand fine to coarse grained slightly silty yellowish brown						Cuttings described from auger flights 10' to TD			

BZ=Breathing Zone BH=Bore Hole S=Sample

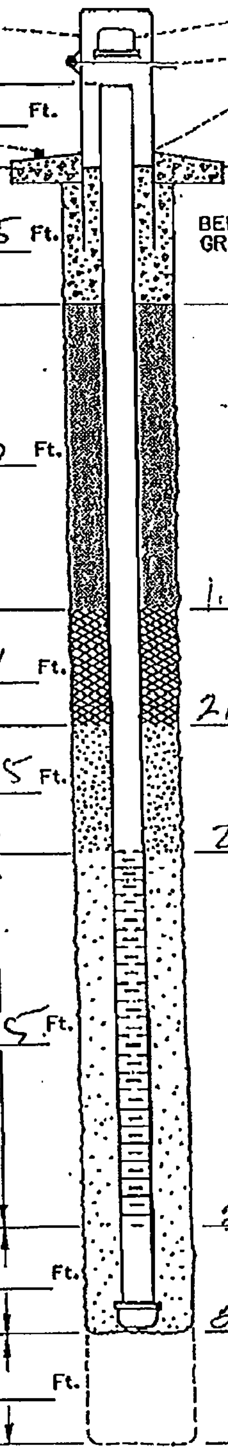
Drilling Log Continuation

Project Name CERT	Boring Number T-86
	Page 2 of 2
Project Number	Date

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
15				15	1511					
16–19	Sand very fine to coarse grained Silty yellowish brown									
20				20						
21–24	Sand yellowish brown very fine to coarse w/ tr some very coarse or small gravel (to 1/4")									Add water in auger to hold back sands
25				25	1520					
26–27										
27.5	SANDSTONE - RED Fine Grained									T/ Bedrock 27'
28	Total Depth 27.5'									
29–30										

BZ=Breathing Zone BH=Bore Hole S=Sample

MONITORING WELL INSTALLATION DIAGRAM



Protective Pipe
Yes ☐ No ☐
Steel ☐ PVC ☐
______ Ft.
Surveying Pin ? Yes ☐ No ☐

Casing Cap Vent ? Yes ☐ No ☐
Lock ? Yes ☐ No ☐
Weep Hole ? Yes ☐ No ☐
Concrete Pad 3 Ft. x 3 Ft. x 4 Inches

		DEPTH BELOW GRADE	DEPTH FROM TOP OF CASING
Concrete	1.5 Ft.		
Cement/Bentonite Grout Mix Yes ☐ No ☐ 5.5 Gallons Water to 94Lb. Bag Cement & 3-5 Lb. Bentonite Powder Others: ______	0 Ft.	1.5	
Bentonite Seal Pellets ☒ Slurry ☐	1 Ft.	2.5	
Filter Pack Above Screen	.5 Ft.	2	
FILTER PACK MATERIAL Silica Sand ☒ Washed Sand ☐ Pea Gravel ☐ Others: ______ Sand Size 20/40	25 Ft.	27	
Dense Phase Sampling Cup Bottom Plug Yes ☒ No ☐	______ Ft.	27.5	
Overdrilled Material Backfill Grout ☐ Sand ☐ Caved Material ☐ Others: ______	______ Ft.		

DRILLING INFORMATION:

1. Borehole Diameter= 8 1/4 Inches.
2. Were Drilling Additives Used ? Yes ☒ No ☐
   Revert ☐ Bentonite ☐ Water ☒
   Solid Auger ☐ Hollow Stem Auger ☒
3. Was Outer Steel Casing Used ? Yes ☐ No ☒
   Depth= ______ to ______ Feet.
4. Borehole Diameter for Outer Casing ______ Inches.

WELL CONSTRUCTION INFORMATION:

1. Type of Casing: PVC ☒ Galvanized ☐ Teflon ☐
   Stainless ☐ Other ______
2. Type of Casing Joints: Screw-Couple ☒ Glue-Couple ☐ Other ______
3. Type of Well Screen: PVC ☒ Galvanized ☐
   Stainless ☐ Teflon ☐ Other ______
4. Diameter of Casing and Well Screen:
   Casing 2 Inches. Screen 2 Inches.
5. Slot Size of Screen: 10
6. Type of Screen Perforation: Factory Slotted ☒
   Hacksaw ☐ Drilled ☐ Other ______
7. Installed Protector Pipe w/Locks: Yes ☒ No ☐

WELL DEVELOPMENT INFORMATION:

1. How was Well Developed ? Bailing ☐ Pumping ☐
   Air Surging (Air or Nitrogen) ☐ Other ______
2. Time Spent on Well Development ?
   70 (Minutes)/Hours
3. Approximate Water Volume Removed ? 400 Gallons
4. Water Clarity Before Development ? Clear ☐
   Turbid ☐ Opaque ☒
5. Water Clarity After Development ? Clear ☒
   Turbid ☐ Opaque ☐
6. Did Water have Odor ? Yes ☐ No ☒
   If Yes, Describe ______
7. Did Water have any Color ? Yes ☒ No ☐
   If Yes, Describe Red

WATER LEVEL INFORMATION:

Water Level Summary (From Top of Casing)

During Drilling ______ Ft. Date ______
Before Development ______ Ft. Date ______
After Development ______ Ft. Date ______

Driller/Firm DAVIS ENVIRONMENTAL Drill Rig Type CME Date Installed 4-11-11
Drill Crew ROLAND DAVIS Well No. T-84 Hydrologist JIM CRAWFORD

Drilling Log

Project Name: CERT	Project Number:	Boring Number: T-87
Ground Elevation:	Location:	Page: 1 of 2
Air Monitoring Equipment:		Total Footage: 29.5'

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes
HSA	8 1/4"	NA	NA	NA	NA

Drilling Company: Davis Environmental Drilling	Driller(s): Roland Davis
Drilling Rig: CME 75	Type of Sampler: Continuous to 10'
Date: 4-12-11 To: 4-12-11	Field Observer(s): Jim Crawford

Depth (feet)	Description	Class	Blow Count	Recov.	Run/Time	Sample Desig.	PID (ppm) BZ / BH / S	Remarks/Water Levels
0–1.5	Roots Silty clay hard dry 5YR 3/4 dark reddish brown				0800		Cuttings scanned with Ludlum Micro R meter - All readings at background thru out boring.	
1.5–2.5	Sandy silt firm 5YR 5/8 Red			4/5				
2.5–4.5	Sand fine grained poorly graded moist 7.5YR 6/4 reddish yellow							
4.5–5	No Recovery			5				
5–6.5	Sand fine-medium grained some coarse loose saturated homogenous 7.5YR 5/6 strong brown							▽ (~6.3)
6.5–10	No recovery			1.5/5				
10				10	0808			
10–14	Sand fine to coarse grained silty loose saturated 5YR 4/6 strong brown						Cuttings described from Auger flights 10' to TD	install wood plug in Auger bit

BZ=Breathing Zone BH=Bore Hole S=Sample

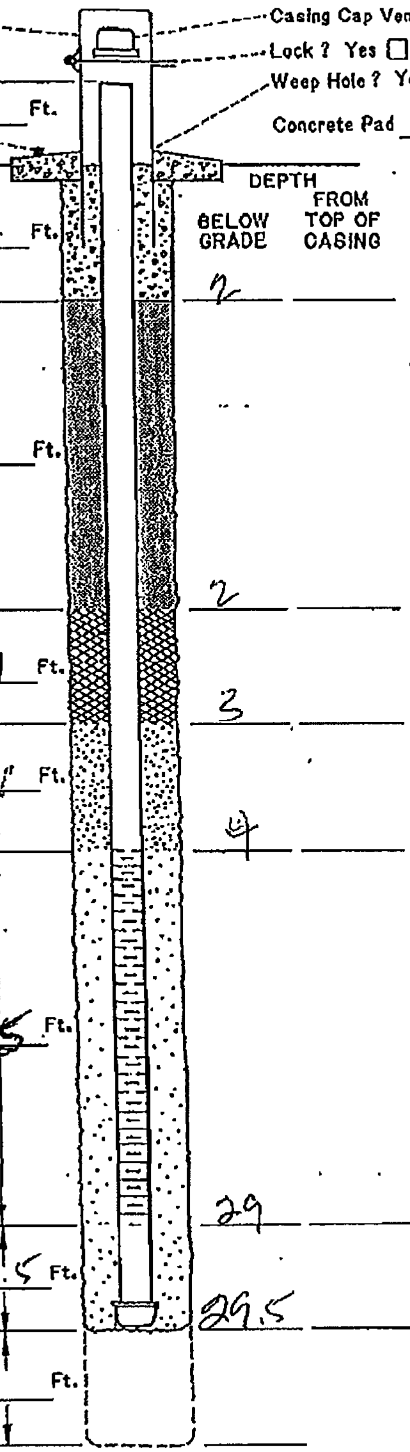
Drilling Log Continuation

	Boring Number T-87
Project Name CERT	Page 2 of 2
Project Number	Date 4-12-11

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
15				15						
16–18	Sand fine to coarse grained saturated loose homogeneous 5YR 5/4 reddish brown silty									
20				20						
22–24	Sand fine to very coarse grained silty small gravel 1/8" to 1/4" 5YR 4/6 yellowish red									
25				25						
27–28	Sand fine to very coarse grained yellowish red some small gravel									
30	Sandstone fine grained 2.5YR 4/8 Red total depth 29.5'									Top of bedrock 29.5'

BZ=Breathing Zone BH=Bore Hole S=Sample

MONITORING WELL INSTALLATION DIAGRAM



Protective Pipe — Yes [X] No [ ]
Steel [X] PVC [ ]
Surveying Pin ? ______ Ft.
Yes [X] No [ ]

Casing Cap Vent ? Yes [ ] No [ ]
Lock ? Yes [ ] No [ ]
Weep Hole ? Yes [ ] No [ ]
Concrete Pad 3 Ft. x 3 Ft. x 4 Inches

Concrete 2 Ft.

Cement/Bentonite Grout Mix
Yes [ ] No [ ]
5.5 Gallons Water to 94Lb. Bag Cement & 3-5 Lb. Bentonite Powder ______ Ft.
Others ______

Bentonite Seal 1 Ft.
Pellets [ ] Slurry [ ]

Filter Pack Above Screen 1 Ft.

FILTER PACK MATERIAL
Silica Sand [X]
Washed Sand [ ] 25 Ft.
Pea Gravel [ ]
Others: ______
Sand Size 20/40

Dense Phase Sampling Cup 0.5 Ft.
Bottom Plug
Yes [X] No [ ]

Overdrilled Material Backfill ______ Ft.
Grout [ ] Sand [ ]
Caved Material [ ]
Others: ______

DRILLING INFORMATION:

1. Borehole Diameter= 8 1/4 Inches.
2. Were Drilling Additives Used ? Yes [X] No [ ]
   Revert [ ] Bentonite [ ] Water [X]
   Solid Auger [ ] Hollow Stem Auger [ ]
3. Was Outer Steel Casing Used ? Yes [ ] No [X]
   Depth= ______ to ______ Feet.
4. Borehole Diameter for Outer Casing ______ Inches.

WELL CONSTRUCTION INFORMATION:

1. Type of Casing: PVC [X] Galvanized [ ] Teflon [ ]
   Stainless [ ] Other ______
2. Type of Casing Joints: Screw—Couple [X] Glue—Couple [ ] Other ______
3. Type of Well Screen: PVC [X] Galvanized [ ]
   Stainless [ ] Teflon [ ] Other ______
4. Diameter of Casing and Well Screen:
   Casing 2 Inches, Screen 2 Inches.
5. Slot Size of Screen: 10
6. Type of Screen Perforation: Factory Slotted [X]
   Hacksaw [ ] Drilled [ ] Other ______
7. Installed Protector Pipe w/Lock: Yes [X] No [ ]

WELL DEVELOPMENT INFORMATION:

1. How was Well Developed ? Bailing [ ] Pumping [ ]
   Air Surging (Air or Nitrogen) [X] Other ______
2. Time Spent on Well Development ?
   ______ 70 Minutes/Hours
3. Approximate Water Volume Removed ? 120 Gallons
4. Water Clarity Before Development ? Clear [ ]
   Turbid [ ] Opaque [X]
5. Water Clarity After Development ? Clear [X]
   Turbid [ ] Opaque [ ]
6. Did Water have Odor ? Yes [ ] No [X]
   If Yes, Describe ______
7. Did Water have any Color ? Yes [X] No [ ]
   If Yes, Describe Red

WATER LEVEL INFORMATION:

Water Level Summary (From Top of Casing)

During Drilling ______ Ft. Date ______
Before Development ______ Ft. Date ______
After Development ______ Ft. Date ______

Driller/Firm Davis Environmental Drill Rig Type CME 75 Date Installed 4-12-11

Drill Crew Roland Davis Well No. T-87 Hydrologist Jim Crawford

Drilling Log

Project Name: CERT	Project Number:	Boring Number: T-88
Ground Elevation:	Location:	Page: 1 of 2
Air Monitoring Equipment:		Total Footage: 28'

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes
HSA	8 1/4"	NA	NA	NA	NA

Drilling Company: Davis Environmental Drilling	Driller(s): Roland Davis
Drilling Rig: CME 75	Type of Sampler: Continuous to 10'
Date: 4-12-11 To: 4-12-11	Field Observer(s): Jim Crawford

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
0–2.5	Roots Silty Clay firm to hard dry low plastic 5YR 3/4 dark reddish brown			4.5/5	0950		Cuttings scanned with Ludlum Micro R meter. All readings at background thru out boring.			
2.5–4	Silt with clay very slight moist firm 5YR 5/8 yellow red									
4–4.5	Sand fg dry with 3" clay lens									
4.5–5	No Recovery			5						
5–7.5	Sand fine grained wet loose very slightly clayey soft 5YR 5/6 yellow red			1/5						
7.5–10	No Recovery			10						
10–14	Cuttings described from auger flights 10' to TD Sand fine to coarse grained silty 5YR 5/6 yellow red									Install wood plug in bit

BZ=Breathing Zone BH=Bore Hole S=Sample

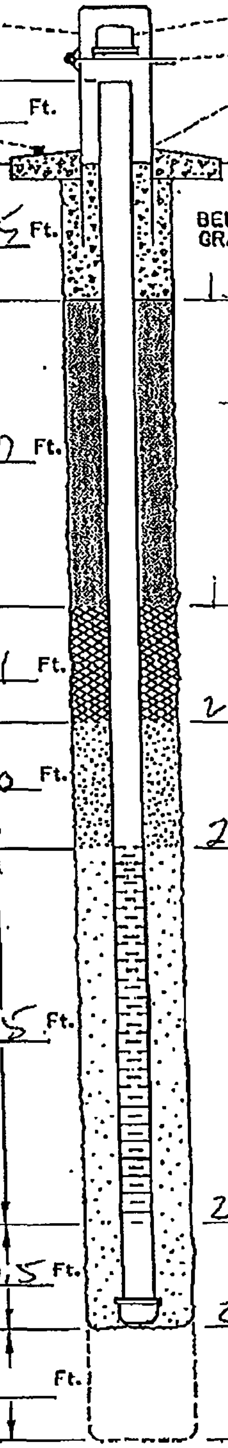
Drilling Log Continuation

..	Boring Number T-88
Project Name CERT	Page 2 of 2
Project Number	Date 4-12-11

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
15				15						
16	Sand fine to very coarse grained									
17	Silty Saturated									
18	5YR 5/4 yellowish red									
19										
20				20						
21										
22	Sand fine to very coarse grained Silty loose Saturated									
23	5YR 4/4 yellowish red									
24										
25				25						
26	Sand fine to very coarse grained with some									
27	small gravel									Drills like gravel
28	T/Bedrock 28'									
29	Mudstone 5YR 4/4 reddish brown									
30										

BZ=Breathing Zone BH=Bore Hole S=Sample

MONITORING WELL INSTALLATION DIAGRAM



Protective Pipe Yes [X] No [ ]
Steel [X] PVC [ ]
______ Ft.
Surveying Pin ? Yes [X] No [ ]

Casing Cap Vent ? Yes [ ] No [ ]
Lock ? Yes [X] No [ ]
Weep Hole ? Yes [ ] No [ ]
Concrete Pad 3 Ft. x 3 Ft. x 4 Inches

Concrete 1.5 Ft.

Cement/Bentonite Grout Mix
Yes [ ] No [X]
5.5 Gallons Water to 94Lb. Bag Cement & 3-5 Lb. Bentonite Powder 0 Ft.
Others ______

Bentonite Seal 1 Ft.
Pellets [X] Slurry [ ]

Filter Pack Above Screen 0 Ft.

FILTER PACK MATERIAL
Silica Sand [X]
Washed Sand [ ] 25 Ft.
Pea Gravel [ ]
Others ______
Sand Size 20/40

Dense Phase Sampling Cup 0.5 Ft.
Bottom Plug Yes [X] No [ ]

Overdrilled Material Backfill ______ Ft.
Grout [ ] Sand [ ]
Caved Material [ ]
Others ______

DEPTH BELOW GRADE	DEPTH FROM TOP OF CASING
1.5	
1.5	
2.5	
2.5	
27.5	
28	

DRILLING INFORMATION:

1. Borehole Diameter= 8 1/4 Inches.
2. Were Drilling Additives Used ? Yes [X] No [ ]
   Revert [ ] Bentonite [ ] Water [X]
   Solid Auger [ ] Hollow Stem Auger [X]
3. Was Outer Steel Casing Used ? Yes [ ] No [X]
   Depth= ______ to ______ Feet.
4. Borehole Diameter for Outer Casing ______ Inches.

WELL CONSTRUCTION INFORMATION:

1. Type of Casing: PVC [X] Galvanized [ ] Teflon [ ] Stainless [ ] Other ______
2. Type of Casing Joints: Screw-Couple [X] Glue-Couple [ ] Other ______
3. Type of Well Screen: PVC [X] Galvanized [ ] Stainless [ ] Teflon [ ] Other ______
4. Diameter of Casing and Well Screen: Casing 2 Inches, Screen 2 Inches.
5. Slot Size of Screen: 10
6. Type of Screen Perforation: Factory Slotted [X] Hacksaw [ ] Drilled [ ] Other ______
7. Installed Protector Pipe w/Lock: Yes [X] No [ ]

WELL DEVELOPMENT INFORMATION:

1. How was Well Developed ? Bailing [ ] Pumping [ ] Air Surging (Air or Nitrogen) [X] Other ______
2. Time Spent on Well Development ? F 75 Minutes/Hours
3. Approximate Water Volume Removed ? 400 Gallons
4. Water Clarity Before Development ? Clear [ ] Turbid [ ] Opaque [X]
5. Water Clarity After Development ? Clear [X] Turbid [ ] Opaque [ ]
6. Did Water have Odor ? Yes [ ] No [X]
   If Yes, Describe ______
7. Did Water have any Color ? Yes [X] No [ ]
   If Yes, Describe Red

WATER LEVEL INFORMATION:

Water Level Summary (From Top of Casing)

During Drilling ______ Ft. Date ______
Before Development ______ Ft. Date ______
After Development ______ Ft. Date ______

Driller/Firm DAVIS Environmental Drill Rig Type CME 75 Date Installed 4-12-11
Drill Crew Roland Davis Well No. T-88 Hydrologist Jim Crawford

Drilling Log

Project Name CERT	Project Number	Boring Number T-89
Ground Elevation	Location	Page 1 of 2
Air Monitoring Equipment		Total Footage

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes
HSA	8 1/4"	NA	NA	NA	NA

Drilling Company: DAVIS ENVIRONMENTAL DRILLING	Driller(s): Roland Davis
Drilling Rig: CME 75	Type of Sampler: Continuous (to 10')
Date 4-12-11 To 4-12-11	Field Observer(s): JIM CRAWFORD

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
0–2	Roots Silty CLAY FIRM DRY DARK BROWN 7.5 YR 3/4				1325		Cuttings scanned with Ludlum Micro R meter - All readings at background thru out boring.			
	SILT BECOMING SLIGHTLY CLAYEY WITH DEPTH VERY SLIGHTLY MOIST 5YR 4/6 YELLOW RED			4/5						
3	Sand fine grained poorly sorted dry loose homogeneous 5YR 5/6 to 6/4 Strong brown to lite brown									
4	No Recovery			5						
5	Sand fine grained becoming fine to medium grained with depth 7.5 YR 5/4 Brown Silty									▽ (approx. 6.2')
7	No Recovery									
10	Sample described from Auger flights 10' - TD. Sand fine to very coarse grained Silty well graded loose Saturated 5YR 4/6 Strong brown				1335					Add wooden plug to Auger bit

BZ=Breathing Zone BH=Bore Hole S=Sample

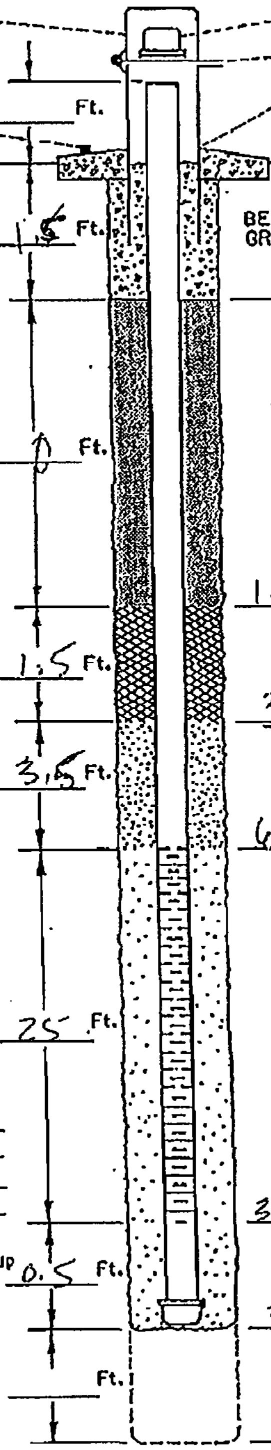
Drilling Log Continuation

	Boring Number T-88
Project Name CERT	Page 2 of 2
Project Number	Date 4-1

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	BH	S	Remarks/ Water Levels
15				15						
16–18	Sand fine to very coarse grained silty traces small gravel (1/4") 7.5YR 4/4 Brown Saturated									
19, 20				20						
21–23	Sand fine to very coarse grained very silty loose saturated 7.5YR 4/4 Brown									
24, 25				25						
26–28	Sand fine to very coarse grained silty small gravel to 1/2"									
29, 30				30						
31–32	Top of bedrock 30.5' Sandstone fine grained 2.5YR 4/8 Red						Total depth 32'			

BZ=Breathing Zone BH=Bore Hole S=Sample

MONITORING WELL INSTALLATION DIAGRAM



Protective Pipe — Yes ☒ No ☐ — Steel ☒ PVC ☐ — ____ Ft.

Surveying Pin ? Yes ☒ No ☐

Casing Cap Vent ? Yes ☐ No ☐

Lock ? Yes ☐ No ☐

Weep Hole ? Yes ☐ No ☐

Concrete Pad 3 Ft. x 3 Ft. x 4 Inches

	Ft.	DEPTH BELOW GRADE	DEPTH FROM TOP OF CASING
Concrete	1.5		
Cement/Bentonite Grout Mix — Yes ☐ No ☐ — 5.5 Gallons Water to 94Lb. Bag Cement & 3-5 Lb. Bentonite Powder — Others:	0	1.5	
Bentonite Seal — Pellets ☒ Slurry ☐	1.5	3	
Filter Pack Above Screen	3.5	6.5	
FILTER PACK MATERIAL — Silica Sand ☒ Washed Sand ☐ Pea Gravel ☐ Others: — Sand Size 20/40	25	31.5	
Dense Phase Sampling Cup — Bottom Plug Yes ☒ No ☐	0.5	32	
Overdrilled Material Backfill — Grout ☐ Sand ☐ Caved Material ☐ Other:			

DRILLING INFORMATION:

1. Borehole Diameter= 8 1/4 Inches.
2. Were Drilling Additives Used ? Yes ☒ No ☐
   Revert ☐ Bentonite ☐ Water ☒
   Solid Auger ☐ Hollow Stem Auger ☒
3. Was Outer Steel Casing Used ? Yes ☐ No ☒
   Depth= ____ to ____ Feet.
4. Borehole Diameter for Outer Casing ____ Inches.

WELL CONSTRUCTION INFORMATION:

1. Type of Casing: PVC ☒ Galvanized ☐ Teflon ☐ Stainless ☐ Other ____
2. Type of Casing Joints: Screw-Couple ☒ Glue-Couple ☐ Other ____
3. Type of Well Screen: PVC ☒ Galvanized ☐ Stainless ☐ Teflon ☐ Other ____
4. Diameter of Casing and Well Screen:
   Casing 2 Inches, Screen 2 Inches.
5. Slot Size of Screen: 10
6. Type of Screen Perforation: Factory Slotted ☒ Hacksaw ☐ Drilled ☐ Other ____
7. Installed Protector Pipe w/Lock: Yes ☒ No ☐

WELL DEVELOPMENT INFORMATION:

1. How was Well Developed ? Bailing ☐ Pumping ☐ Air Surging (Air or Nitrogen) ☒ Other ____
2. Time Spent on Well Development ?
   120 Minutes/Hours
3. Approximate Water Volume Removed ? 500 Gallons
4. Water Clarity Before Development ? Clear ☐ Turbid ☐ Opaque ☒
5. Water Clarity After Development ? Clear ☒ Turbid ☐ Opaque ☐
6. Did Water have Odor ? Yes ☐ No ☒
   If Yes, Describe ____
7. Did Water have any Color ? Yes ☒ No ☐
   If Yes, Describe Red

WATER LEVEL INFORMATION:

Water Level Summary (From Top of Casing)

During Drilling ____ Ft. Date ____

Before Development ____ Ft. Date ____

After Development ____ Ft. Date ____

Driller/Firm Davis Environmental Drill Rig Type CME-75 Date Installed 4-12-11

Drill Crew Roland Davis Well No. T-89 Hydrologist Jim Crawford

Drilling Log

Project Name CERT	Project Number	Boring Number T-90
Ground Elevation	Location	Page 1 of 2
Air Monitoring Equipment		Total Footage 29'

Drilling Type	Hole Size	Overburden Footage	Bedrock Footage	No. of Samples	No. of Core Boxes
HSA	8 1/4"	NA	NA	NA	NA

Drilling Company: Davis Environmental Drilling	Driller(s): Roland Davis
Drilling Rig: CME 75	Type of Sampler: Continuous (to 10')
Date 4-12-11 To 4-12-11	Field Observer(s): Jim Crawford

Depth (feet)	Description	Class	Blow Count	Recov.	Run/Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
0–2	Roots SILT - FIRM DRY 5YR 4/4 REDDISH BROWN				1455		Cuttings scanned with Ludlum micro R meter - All readings at background thru out boring.			
2–3	SAND FINE grained Poorly graded becoming slightly moist 5YR5/6 YELLOWISH RED			3/5						
3–5	NO RECOVERY			5						
5–7	SAND fine to medium grained LOOSE CLEAN WELL GRADED BECOMING WET 7.5YR 5/4 BROWN			1.5/5						▽ (7)
7–10	No RECOVERY			10						
10–14	Cuttings described from Auger flights 10' to TD. SAND FINE to COARSE SATURATED LOOSE WELL GRADED 7.5YR 4/6 strong brown									Installe wood Plug in AUGER Bit

BZ=Breathing Zone BH=Bore Hole S=Sample

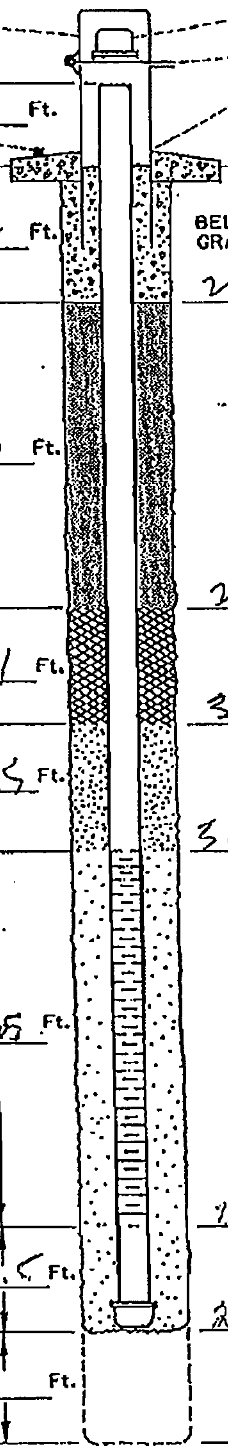
Drilling Log Continuation

Project Name	CERT
Project Number	
Boring Number	T-90
Page	2 OF 2
Date	4-12-11

Depth (feet)	Description	Class	Blow Count	Recov.	Run/ Time	Sample Desig.	PID (ppm) BZ	PID (ppm) BH	PID (ppm) S	Remarks/ Water Levels
15				15						
16										
17	SAND VERY FINE TO									
18	COARSE SOME VERY COARSE SATURATED									
19	WELL GRADED SILTY									
20	7.5YR 4/6 STRONG brown			20	1515					
21										
22										
23										
24										
25	Sand fine to very COARSE LOOSE SILTY			25						
26	7.5 YR 4/4 STRONG BROWN									
27										
28										
29	SANDSTONE BRICK RED 2.5YR 4/8									
30	Total depth 29'									

BZ=Breathing Zone BH=Bore Hole S=Sample

MONITORING WELL INSTALLATION DIAGRAM



Protective Pipe — Yes [X] No [ ]

Steel [X] PVC [ ]

_____ Ft.

Surveying Pin ? Yes [X] No [ ]

Casing Cap Vent ? Yes [ ] No [ ]

Lock ? Yes [ ] No [ ]

Weep Hole ? Yes [ ] No [ ]

Concrete Pad 3 Ft. x 3 Ft. x 4 Inches

	Ft.	DEPTH BELOW GRADE	DEPTH FROM TOP OF CASING
Concrete	2	2	
Cement/Bentonite Grout Mix — Yes [ ] No [ ]; 5.5 Gallons Water to 94Lb. Bag Cement & 3-5 Lb. Bentonite Powder; Other:	0	2	
Bentonite Seal — Pellets [X] Slurry [ ]	1	3	
Filter Pack Above Screen	0.5	3.5	
FILTER PACK MATERIAL — Silica Sand [X] Washed Sand [ ] Pea Gravel [ ] Others: ____ Sand Size 20/40	25	28.5	
Dense Phase Sampling Cup Bottom Plug — Yes [X] No [ ]	0.5	29	
Overdrilled Material Backfill — Grout [ ] Sand [ ] Caved Material [ ] Other:			

DRILLING INFORMATION:

1. Borehole Diameter= 8 1/4 Inches.
2. Were Drilling Additives Used ? Yes [X] No [ ]
   Revert [ ] Bentonite [ ] Water [X]
   Solid Auger [ ] Hollow Stem Auger [X]
3. Was Outer Steel Casing Used ? Yes [ ] No [X]
   Depth= ______ to ______ Feet.
4. Borehole Diameter for Outer Casing ______ Inches.

WELL CONSTRUCTION INFORMATION:

1. Type of Casing: PVC [X] Galvanized [ ] Teflon [ ]
   Stainless [ ] Other ______
2. Type of Casing Joints: Screw-Couple [X] Glue-Couple [ ] Other ______
3. Type of Well Screen: PVC [X] Galvanized [ ]
   Stainless [ ] Teflon [ ] Other ______
4. Diameter of Casing and Well Screen:
   Casing 2 Inches, Screen 2 Inches.
5. Slot Size of Screen: 10
6. Type of Screen Perforation: Factory Slotted [X]
   Hacksaw [ ] Drilled [ ] Other ______
7. Installed Protector Pipe w/Locks: Yes [X] No [ ]

WELL DEVELOPMENT INFORMATION:

1. How was Well Developed ? Bailing [ ] Pumping [ ]
   Air Surging (Air or Nitrogen) [X] Other ______
2. Time Spent on Well Development ?
   ~~F~~ 100 Minutes/Hours
3. Approximate Water Volume Removed ? 600 Gallons
4. Water Clarity Before Development ? Clear [ ]
   Turbid [ ] Opaque [X]
5. Water Clarity After Development ? Clear [X]
   Turbid [ ] Opaque [ ]
6. Did Water have Odor ? Yes [ ] No [X]
   If Yes, Describe ______
7. Did Water have any Color ? Yes [X] No [ ]
   If Yes, Describe Red

WATER LEVEL INFORMATION:

Water Level Summary (From Top of Casing)

During Drilling ______ Ft. Date ______

Before Development ______ Ft. Date ______

After Development ______ Ft. Date ______

Driller/Firm DAVIS ENVIRONMENTAL Drill Rig Type CME 75 Date Installed 4-12-11

Drill Crew ROLAND DAVIS Well No. T-90 Hydrologist JIM CRAWFORD