THE USE OF A DECISION CRITERIA MATRIX TO DETERMINE GROUNDWATER SAMPLING ANALYTES

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ABSTRACT

Envirocare of Utah, Inc., currently operates an 11e.(2) disposal cell at its South Clive facility, located in the western desert of Utah. This cell is licensed by the Nuclear Regulatory Agency to receive by-products from uranium mill tailing operations throughout the United States. The location of Envirocare's South Clive Facility is ideal for the disposal of 11e.(2) waste material. One of the favorable attributes of the location is that the groundwater is of extremely poor quality (greater than 50,000 mg/L TDS) and is found in a low-yielding aquifer. High TDS waters are found in this area due to the large quantity of evaporite deposits left from the Great Salt Lake and its predecessors. These evaporites are also repositories for metals, which also make the water unsuitable for drinking.

Envirocare's current groundwater monitoring network consists of 12 shallow monitoring wells, which are sampled on a quarterly basis for major cations and anions, metals, volatile and semi-volatile organic compounds, and radiologics. Quarterly analytical results are compared to baselines levels established prior to disposal activities to demonstrate compliance. Arsenic and selenium concentrations in some of the monitoring wells began to increase in the past five years. These increases are directly attributed to increasing groundwater levels caused by enhanced recharge from storm water drainage from the Department of Energy (DOE) Vitro embankment. This storm water drainage has since been diverted to a lined collection pond. As the groundwater elevations increased, residual arsenic and selenium, left in the soil as a precipitate, is re-mobilized.

Although the increases in arsenic and selenium are not the result of cell leakage, Envirocare is responsible for maintaining a compliance monitoring system that will indicate a possible future release. To this end, Envirocare is modifying its current compliance monitoring network to focus on constituents that will indicate a possible release from the cell. Envirocare conducted a sorption coefficient (K_d) study to evaluate the relative mobility of constituents found in the 11e.(2) waste stream. Results of the Kd study were used in a decision criteria matrix to identify those constituents that would be the most likely to be detected, should a release occur. Other factors considered in the decision matrix were mass of constituents in the waste, current concentrations of constituents in the groundwater, and the laboratory analytical detection limits for the constituents. Envirocare anticipates that the study will decrease the current analyte list to a more diagnostic list that will provide a better indication of a release.

INTRODUCTION

Envirocare of Utah, Inc. (Envirocare) operates four waste disposal facilities near Clive, Utah; a Low Activity Radioactive Waste (LARW) unit, a 11e.(2) unit, a Mixed Waste Unit, and a Class A unit. This report addresses the 11e.(2) unit only. The 11e.(2) facility is licensed and permitted to operate under the following laws and rules:

- A materials license to receive, acquire, possess, and transfer byproduct, source, and special nuclear material pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974 (Public Law 93-438), and Title 10, Code of Federal Regulations, Chapter I, Parts 30, 31, 33, 34, 35, 39, 40, and 70. This constitutes Envirocare's 11e.(2) License; License number SMC-1559, which is administered by the Nuclear Regulatory Commission (NRC).
- A Groundwater Quality Discharge Permit (GWQDP) for a Low-Activity Radioactive Waste (LARW) and 11e.(2) waste disposal facility, effective April 5, 1996, pursuant to the Utah Water Quality Act, Title 19, Chapter 5, Utah Code annotated 1953 as amended. Envirocare's GWQDP License number is UGW450005 and is administered by the Utah Division of Radiation Control (DRC).

LOCATION

The Envirocare facility is located in Section 32, T1S, R11W near Clive, Utah, approximately 80 miles west of Salt Lake City, Utah. The entire disposal facility is one square mile in size whereas the 11e.(2) cell occupies approximately 100 acres of the southwest portion of the facility. The 11e.(2) disposal cell receives mine processing wastes (tailings or wastes produced by the extraction or concentration of uranium or thorium ore).

The Department of Energy (DOE) and the Utah Department of Environmental Quality (UDEQ) selected the area in 1984 for the disposal of the VITRO tailings from Salt Lake City, UT. These tailings occupy approximately 85 acres in the north-central portion of Section 32. The DOE and UDEQ selected this facility because it exhibited the most suitable hydrogeological, ecological, and economical characteristics for waste disposal.

One of the primary hydrogeological attributes of the facility is poor groundwater quality and quantity. Based on the Utah Administrative Code (UAC R317-6-3.7), Groundwater beneath the 11e.(2) facility has been classified as a Class IV aquifer because the water has a total dissolved solids (TDS) concentration of greater than 10,000 milligrams per liter (mg/L). The 11e.(2) monitoring wells demonstrate ranges in TDS concentrations from 37,800 to 70,100 mg/L. Groundwater with high TDS makes the location ideal for waste disposal, but makes it difficult to implement a groundwater compliance program.

CURRENT GROUNDWATER MONITORING PROGRAM

Envirocare's 11e.(2) license and GWQDP require compliance monitoring of the shallow, unconfined groundwater. From 1991 to 1994 and prior to waste disposal, Envirocare conducted a monitoring program to establish baselines for the 11e.(2) license and Groundwater Protection Levels (GWPL) for the GWQDP. Table 1 provides a list of monitoring and compliance parameters required for the 11e.(2) license and GWQDP. Baselines and GWPLs were established for each parameter at each well based on the following criteria: for detected parameters – the mean plus two standard deviations; for undetected parameters – the laboratory detection method.

Groundwater samples are collected on a quarterly basis from 12 monitoring wells for the 11e.(2) license and on a semi-annual basis from 15 monitoring wells (the 12 11e.(2) wells and three additional wells) for the GWQDP. Samples are analyzed for the parameters listed in Table 1 and results are submitted on a semi-annual basis. Analytical results are compared to baselines and/or GWPLs to determine if any exceedances have occurred. Should exceedances be observed, Envirocare is required to notify the respective regulatory agency and begin out-of-compliance monitoring.

DESIGN OF 11E.(2) DISPOSAL FACILITY AND GROUNDWATER MOUNDING

During the construction of the VITRO embankment, the upper 10-feet of silty clay was removed from the center portion of the 11e.(2) facility and used in the construction of the clay liner and radon barrier (Figure 1). This borrow area caused the 11e.(2) disposal embankment to be designed as two triangles, with the drainage from the finished VITRO embankment dividing the two triangles. The intent of this design was to allow stormwater from the VITRO embankment to flow to the southwest corner of Section 32 and away from the section. Prior to the completion the drainage system away from the VITRO embankment, heavy snow and rain events in the winter of 1993 created a large pond in the center portion of the 11e.(2) embankment. Unfortunately, the removal of the silty clay in the borrow area exposed a more permeable silty sand beneath it. The ponding water in the center of the 11e.(2) embankment created a large mound in the center of the embankment as evidenced in increasing groundwater elevations in three monitoring wells, GW-36, GW-37, and GW-38, (placed along the diagonal between the two 11e.(2) embankments and shown in Figure 2). Groundwater elevations in these three wells immediately increased by five to eight feet. The VITRO drainage has since be re-routed in a lined ditch that discharges the water southwest of Section 32.

In the spring of 1994, Envirocare began disposal operations in the 11e.(2) facility. The increasing groundwater elevations remobilized residual arsenic, molybdenum, selenium, and other metals. Lake Bonneville, the precursor to present-day Great Salt Lake, left these metals as evaporite deposits. The increasing metals concentrations placed Envirocare's groundwater monitoring network in an out-of-compliance mode. Several observations of the increasing metals concentrations are:

- The metal increases are directly correlated with increasing groundwater elevations as shown in Figure 3;
- The monitoring wells that experienced increasing metals concentrations are located either up gradient or cross gradient from disposal operations;
- The total dissolved solids also increased with water level elevations, suggesting that the mound was re-mobilizing residual desposits;
- Monitoring wells immediately down gradient of disposal operations did not experience an increase in metals concentrations.

Envirocare notified both the NRC and DRC that metals concentrations were rising in site groundwater. Based on the information and analysis performed to date, both agencies and Envirocare are convinced that the increasing metals concentrations are due to rising groundwater elevations. However, the regulatory agencies were not able to agree on how to solve the problem. The purpose of this paper is to describe the steps Envirocare was required to go through in order to return the groundwater-monitoring program back to a compliant mode. Part of this requirement involved the use of a decision criteria matrix in order to demonstrate which parameters would be the best indicators of cell leakage.

Utah Division of Radiation Control Solution

The DRC required that Envirocare continue to monitor groundwater on a quarterly basis and provide a statistical summary of the data. A Comprehensive Groundwater Quality Summary Report was submitted to the DRC October 1999. Based on this summary, the DRC modified the GWPLs for arsenic, molybdenum, uranium, gross beta, and gross alpha.

Nuclear Regulatory Commission Solution

The Code of Federal Regulations (CFR) Part 40, Appendix A of the NRC's regulations would not allow for the changing of baseline concentrations after disposal operations had begun. The NRC proposed that Envirocare establish alternate concentration levels (ACLs), as allowed in Appendix A. Envirocare did not deem this alternative acceptable, because part of the stigma associated with using alternative concentrations is the facility must admit that a release had occurred. It is Envirocare's position that the increasing metals concentrations are not due to a release from the facility and as noted previously, cannot be due to a release.

CFR Part 40, Appendix A, 5B(2) states:

> A constituent becomes a hazardous constituent subject to paragraph 5B(5) only when the constituent meets all three of the following tests:
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> - The constituent is reasonably expected to be in or derived from the byproduct material in the disposal area;

- The constituent has been detected in the ground water in the uppermost aquifer; and
- The constituent is listed in Criterion 13 of this appendix.

Most of the metals that currently exceed the baseline concentrations meet these three criteria, but paragraph 5B(3) continues:

> Even when constituents meet all three tests in paragraph 5B(2) of this criterion, the Commission may exclude a detected constituent from the set of hazardous constituents on a site specific basis if it finds that the constituent is not capable of posing a substantial present or potential hazard to human health or the environment. In deciding whether to exclude constituents, the Commission will consider the following:

- Potential adverse effects on ground-water quality, considering --
  - The physical and chemical characteristics of the waste in the licensed site, including its potential for migration;
  - The hydrogeological characteristics of the facility and surrounding land;
  - (The quantity of ground water and the direction of ground-water flow;
  - The proximity and withdrawal rates of ground-water users;
  - The current and future uses of ground water in the area;
  - The existing quality of ground water, including other sources of contamination and their cumulative impact on the ground-water quality;
  - The potential for health risks caused by human exposure to waste constituents;
  - The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents;
  - The persistence and permanence of the potential adverse effects.

Decision Criteria Matrix

Based on paragraph 5B3), Envirocare proposed to re-evaluate the groundwater monitoring network and monitor only for those constituents that would be diagnostic indicator parameters of a release from the facility. To do this, Envirocare evaluated the following criteria:

- Mass disposed in waste stream;
- Relative mobility or sorption coefficient (Kd); and
- Detectability of the constituent (this included an evaluation of laboratory analytical detection limits as well as constituent concentration in site groundwater)

The analysis consisted of comparing the total ranking of each metal within the three categories described above. For the analysis, the 13 compliance metals were evaluated, which are provided in Table 1. Metals were ranked from 1 to 13 in each category. A total ranking was calculated by multiplying the rankings in all three categories for each metal. The metals with the highest total ranking scores were then identified as potential candidates for a short list of compliance metals for regulatory agencies to consider.

In the mass disposed criteria, the metal with the highest mass disposed received a rank of 13, while the metal with least mass disposed received a rank of 1, with all others ranked accordingly between these values. This approach gave high rankings to those metals that are most representative of waste disposed at Envirocare, with least representative receiving lower rankings.

For the relative mobility criteria, the metal with the lowest K_d received a rank of 13, while the metal with the highest K_d received a rank of 1, with all others ranked accordingly between these values. In this criteria, the ranking was meant to produce high scores for more mobile metals, which would be first to reach a compliance monitoring point if a release from the 11e.(2) facility should ever occur.

When the decision criteria were first introduced, NRC personnel expressed concern that waters with high TDS may influence K_d values. Previous fate and transport modeling exercises used the lowest literature K_d values, which were adequate because they provided conservative results. Because of this concern, Envirocare conducted a K_d study using site soils and groundwater. Sorption coefficients were developed using three different concentrations of spiked solution to demonstrate consistency. Results of the K_d study were submitted to the NRC under a separate document, *Metals Distribution Coefficient Values Relevant to the Envirocare Site.* Results are provided in Table 2 and ranking scores for these criteria were calculated for each metal for their mean, low, and high K_d values.

For the detectability category, the metal with the lowest concentration in groundwater was given a rank of 13, while the metal with the highest concentration in groundwater received a rank of 1, with all others ranked accordingly between these values. This ranking gave a higher score to those metals that are present in Envirocare ground water at low concentrations, and therefore an increase in concentration of one of these metals due to a potential release would be easily detectable.

Table 3 provides the rankings with the relative K_d values for each metal, total mass disposed in the 11e.(2) cell, and the average concentration of each metal in Envirocare ground water. Note that in the K_d category, mean, low, and high site-specific K_ds are reported for each metal. Based on the mean K_d scores, the four highest ranking metals are barium, silver, copper, and lead. Based on the low K_d values, the four highest scoring metals are the same metals as for the mean K_d scores, with successively higher scores for lead, barium, silver, and copper. The high K_d scores demonstrate that silver and barium are again in the top four in the ranking, but cadmium and nickel are ranked third and fourth, as their K_d values do not increase nearly as significantly as lead and copper (although copper was still ranked 6^{th}) did in the high K_d

experiments. Results of adding all three scores (mean, low, and high) suggest that silver, copper, barium, and lead as shown in Figure 4.

To better evaluate the impact of the K_d values on the results, the ranking of all the metals were compared by evaluating where the metals score based on the two fixed categories (mass disposed and average ground-water concentration) versus where they scored when K_d rankings are included. Based on just the mass disposed and average ground water concentrations, the top four metals are silver, copper, barium, and lead. These four metals scored highest in both the mean and low K_d total ranking scores. With the high K_d ranking score, lead and copper move out of the top four rankings. Based on this, the mean and low K_d values have no impact on which metals appear to be the best indicator compounds for compliance monitoring. Use of the higher K_d values remove two of these metals (lead and copper) from the top for total scores. The low and mean concentration K_ds are best representative for evaluating ground water transport (and hence mobility) for all of the compounds except for silver and molybdenum. For these compounds, the full range of K_ds should be considered. Given that silver ranks in the top four for all ranking categories (mass disposed and ground-water concentration; low K_d, mean K_d, and high K_d) and molybdenum does not rank in the top four in any of the ranking categories, the results from the low and mean K_d rankings are best representative for the metals for compliance monitoring.

CONCLUSION

The successful operation of a groundwater compliance monitoring system depends on the ability of the system to detect releases from the disposal facility. Monitoring for the radioactive components (radium, thorium, and uranium) will provide the best indicators for releases from the disposal cell. Envirocare is confident that monitoring for metals in site groundwater is not diagnostic of a release from the facility. However, if metals do need to be monitored for, Envirocare suggests metals monitoring be limited to lead, copper, silver, and barium.