Response to RAIs

Responses Related to NRC Comments Regarding the Highland Uranium Mine and Millsite Request for Amendment to Radioactive Materials License UA-1139 Application to Amend Existing Alternate Concentration Limit

Prepared On Behalf Of:

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Prepared For:

U.S. Nuclear Regulatory Commission

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RESPONSES TO NRCs REQUEST FOR ADDITIONAL INFORMATION

On May 10, 2011, ExxonMobil Environmental Services Company (EMES) submitted a request to the U.S. Nuclear Regulatory Commission (NRC) to amend source materials license SUA-1139, which covers the licensed material at the Highland Uranium Operations (Highland), located near Douglas, Wyoming. The license amendment request (LAR) included requests for expansion of the long-term surveillance boundary (LTSB) and establishment of new and revised alternate concentration limits (ACLs) with associated point of compliance (POC) and point of exposure (POE) locations.

On May 29, 2012, EMES received a Request for Additional Information (RAIs) from NRC staff. The RAIs were organized based on the Safety Evaluation Report (SER) section that was being prepared by NRC staff in support of the LAR. Additional RAIs were received on June 25, 2012 to support the Environmental Assessment (EA) portion of the LAR review. On July 8, 2012, EMES received additional RAIs that were in accordance with environmental protection regulations in 10 CFR Part 51, and were focused on Proposed Actions, Land Use, and comments received by NRC from the U.S. Fish & Wildlife Service (FWS) regarding potential impacts to migratory birds.

The NRC and EMES met on August 14, 2012 to discuss the RAIs and provide EMES the opportunity to have a technical discussion with NRC staff and get clarification of what NRC required to finish their review of the LAR. During that meeting, NRC staff requested that additional data be collected for EMES to completely address all of NRCs concerns that formed the bases of the RAIs. At the August meeting, EMES agreed to reassess the conceptual and numerical groundwater flow model for the site. That reassessment will include additional data collection on water level and water quality within the primary Ore Body Sandstone (OBSS) units in the vicinity of the existing pit lake and Tailing Impoundment from newly installed monitoring wells. EMES also agreed to collect additional data to evaluate a potential secondary source term to the east of the tailings impoundment, and to support the evaluation of potential impacts to migratory birds.

As agreed to in the August 14, 2012 meeting, EMES has prepared the following responses to the RAIs to facilitate NRC's review of the LAR. Because additional data gathering is required to completely address all the RAIs, this is a partial response. Following the additional data acquisition to fill identified data gaps, a final response to the outstanding RAIs will be completed and submitted to the NRC. A work plan **(Attachment H1)** for the hydrogeochemical investigations, that outlines the proposed well locations, target geologic units and depths, and data collection activities for these new monitoring wells and soil borings has been prepared and is included with the responses to the RAIs for NRC's review and comment.

NRC Staff RAI - Geo1 Provide additional information regarding the location of all "known" boreholes (wells and investigation boreholes) on the site and neighboring mine sites used to develop the geologic framework model discussed in the LAR (EMES 2011, Section 1.2.2.6). In addition, clarify whether the geologic framework model (EMES, 2011, Section 1.2.2.6) changed any previously assumed hydrostratigraphic conceptualizations that are used as inputs to other models. The licensee must also state whether the 3-dimensional (3D) geologic framework model provided any additional or new insights or a change in the understanding of the lateral extent and continuity of the strata in the LTSB. If so, these insights should be clearly described in the LAR. Additionally, the impact of these insights on the hydrogeological and geochemical processes should be discussed.

RESPONSE: **Table Geo1-1** presents the primary data input to the geologic model. The geologic model requires estimates of the elevation of the bottom of each modeled stratigraphic unit, which were developed based on a review of available geologic logs for each boring. In some instances, previous interpretations of unit depths were used in the model. All geologic borings used to develop the model are shown on **Figure Geo1-1**.

The geologic model was developed primarily as a tool to visualize the nature and extent of known geologic and hydrostratigraphic units in relation to the Tailings Impoundment, the pit backfill and the current open pit. The objective of model development was to visualize in three dimensions potential migration pathways from the Impoundment, but complexities in converting older topographic maps representing the complex sequence of pit development and backfill topography limited the model's usefulness for three-dimensional visualization. Model development was based on existing data and did not change any previously assumed hydrostratigraphic conceptualizations, and the model was not used to develop additional or new insights in the lateral extent and continuity of the geologic strata at the site.

It should be noted that the model was used to develop the two dimensional cross sections presented in Figures 1-9 through 1-12 in the LAR.

NRC Staff RAI - Geo2 Provide northing and easting information in LAR Figure 1-8 (EMES, 2011).

RESPONSE: Northing and easting information for the monitoring wells shown on Figure 1-8 were provided both in Appendix C and in Table 1-4 of the ACL Application, and are summarized in **Table Geo2-1**.

NRC Staff RAI - Geo3 Provide the location of the boreholes and well data in Figures 1-9 through 1-12 in the LAR (EMES, 2011).

RESPONSE: The cross sections presented in LAR Figures 1-9 through 1-12 represent output from the Mine Visualization Software (MVS) model. All information used to develop the MVS model is presented in **Table Geo1-1**.

NRC Staff RAI - H1 Clarify the current conceptualization of the regional groundwater flow.

RESPONSE: As discussed at the meeting with NRC on August 14, 2012, and in the DRAFT Action Items provided by NRC after the meeting, EMES has agreed to reassess the conceptual and numerical groundwater flow model for the site. This will include additional data collection on water level and water quality within the primary OBSS units in the vicinity of the existing pit lake and Tailing Impoundment from newly-installed monitoring wells. A work plan **(Attachment H1)** is included with this submittal that outlines proposed well locations, target geologic units and depths, and data collection activities for these new monitoring wells for NRC's review and comment.

Data from the wells, along with any publically-available hydrogeologic data related to neighboring ISR sites will be used to review and update, as appropriate, the site conceptual groundwater flow model related to long-term conditions at the pit lake. After reviewing the data EMES will evaluate the need for developing an updated groundwater flow model for the system to assess long-term groundwater conditions on the basis of newly-acquired data and any updated assessments of the site conceptual model.

NRC Staff RAI - H2 Provide technical bases for excluding explicit effects of in situ recovery (ISR) or oil and gas exploration operations in the flow analyses.

RESPONSE: As discussed in the Draft Action Items from the August 14, 2012 meeting, EMES will work with neighboring ISR producers to identify and review publically-available data related to regional groundwater conditions in the OBSS units affecting the Highland Pit Lake. In addition, EMES will review publically available documents pertinent to assessing potential impacts of oil and gas exploration and production. These data will be summarized and used, to the extent practical, in the assessment of regional groundwater flow conditions and the potential development of an updated groundwater flow model, as discussed above in the response to RAI H1.

NRC Staff RAI - H3 Explain the inconsistencies in the well data provided in Highland Groundwater and Surface Data (EMES, 2011, Appendix C).

RESPONSE: Historical field sheets were reviewed to confirm questionable entries and locate missing data entries for water level data. Responses to individual NRC Staff comments in the data table and corrected data, if any, are listed in **Table 1**, Attachment H3. In addition, missing data from years 2002-2005 were added to the table. The final revised data is found in **Table 2**, Attachment H3.

See **Attachment H3** for detail.

NRC Staff RAI - H4 Clarify the technical basis for estimating conditions under which Pit Lake waters may discharge to Box Creek.

<u>RESPONSE</u>: Discharge from the Pit Lake to Box Creek is not possible based on the assessment that the Box Creek area is a zone of recharge to the OBSS units and the fact that the pit lake will act as a long-term regional hydrogeologic sink for available groundwater.

As noted in the response to RAI H1, EMES will collect additional data related to the OBSS units and use these data to update the site conceptual groundwater flow model. A work plan will be provided to NRC prior to well installation that outlines the proposed well locations, target geologic units and depths, and data collection activities for these new monitoring wells for NRC's review and comment.

NRC Staff RAI - H5 Clarify the technical basis for the boundary conditions used in groundwater modeling.

<u>RESPONSE</u>: Appendix A was provided to characterize the evolution of model development and model assumptions for models developed in support of transport assessments since the early 1970s. Long-term data collection and analyses related to the current assessment have identified uncertainties in assumptions used in all previous modeling efforts, and are not limited to the most recent modeling.

EMES will collect additional water level and water quality data both from additional monitoring wells to be installed at the site and from publically-available regional data. These data will be reviewed and used to update the site conceptual model. Newly collected data and the updated site conceptual model will form the basis for updated assessments and potentially an updated groundwater flow model that will supersede results and assumptions made during development of the Tetra Tech (2007) model.

NRC Staff RAI - H6 Clarify the influence of drainages east of the tailings basin on groundwater flow paths, geochemistry, and radionuclide transport.

<u>RESPONSE</u>: Our review of drainages east of the tailings sub-basin suggest they act as recharge areas to regional groundwater flow and do not represent a significant migration pathway. EMES will review any additional publically-available regional groundwater data, and include a detailed review of the potential influence of regional OBSS outcrops on groundwater flow and long-term behavior of the Highland Pit Lake in the updated site conceptual model.

NRC Staff RAI - H7 Address the inconsistency related to Figure 19 and related text in Tetra Tech (2007).

<u>RESPONSE</u>: The Tetra Tech (2007) report contains two references to a Figure 19, both in Section 3.7 that correctly references the provided figure, and again in Section 4.1 that references a figure that was not provided in the report. As stated in the response to RAI H5, newly collected data and the updated site conceptual model will form the basis for updated assessments and potentially an updated groundwater flow model that will supersede results and assumptions made during development of the Tetra Tech (2007) model.

NRC Staff RAI - H8 Clarify the location and status of an unnamed well described by Dames & Moore (1980, Plate 6).

<u>RESPONSE</u>: EMES reviewed available historical information and was unable to identify the source of the information provided in the Dames & Moore report. EMES will re-assess potential pre-mining water level conditions as part of the updated site conceptual model, and provide more detailed justification of assumed conditions as part of that work.

NRC Staff RAI - H9 Provide a technical basis for considering the Pit Lake hydrology and Southeast Drainage independently

<u>RESPONSE</u>: The conceptual model identifies the southeast drainage as a likely source of recharge to groundwater flow in the underlying OBSS units. Surface runoff provides a highly-localized flow system related to the surface drainage that provides both flow within the drainage and potentially recharge to the OBSS.

As noted in the response to RAI H1, EMES will collect additional data related to the OBSS units and use these data to update the site conceptual groundwater flow model. A work plan will be provided to NRC prior to well installation that outlines the proposed well locations, target geologic units and depths, and data collection activities for these new monitoring wells for NRC's review and comment.

NRC Staff RAI - H10 Clarify the technical basis for the choice of wells as calibration targets in Tetra Tech (2007).

NRC Staff RAI - H11 Provide technical basis for the multipliers used in the sensitivity analysis on the groundwater model (Tetra Tech, 2007). In addition, clarify how Tetra Tech (2007) performed the sensitivity analysis for the recharge parameter.

NRC Staff RAI - H12 Provide technical bases for not evaluating uncertainty or variability of the input parameters in Tetra Tech (2007).

NRC Staff RAI - H13 Justify why reservoirs, diversion channels, or low-flow channels constructed during mining operations were not included in the groundwater model (Tetra Tech, 2007) that was used to represent the Pit Lake hydrology.

NRC Staff RAI - H14 Clarify the extent that the data collected since 2003 validate results from the groundwater model (Tetra Tech, 2007) used to describe the Pit Lake hydrology.

RESPONSE to RAIs H10, H11, H12, H13, and H14: The response to RAIs H10, H11, H12, H13, and H14 all of which are focused on the groundwater model produced by Tetra Tech (2007) is the same. As noted in the response to RAI-H5, EMES will collect additional water level and water quality data both from additional monitoring wells to be installed at the site and from publically- available regional data. These data will be reviewed and used to update the site conceptual model. Newly collected data and the updated site conceptual model will form the basis for updated assessments and potentially an updated groundwater flow model that will supersede results and assumptions made during development of the Tetra Tech (2007) model.

NRC Staff RAI - H15 Provide technical justification for not evaluating a potential flow pathway north of the tailings dam.

RESPONSE: EMES recognizes that water elevation data and geological information indicate that the flow direction in the Tailings Dam Sandstone (TDSS) is in the downdip direction north of the tailings impoundment. In addition, groundwater monitoring data indicate chloride and sulfate have likely been transported to the north of the tailings impoundment as they are present at concentrations above background in Wells 176, 179, and 183.

The technical justification for not fully evaluating a potential flow path to the north is based on historical publications and current data that indicate potentially-hazardous constituents (selenium and uranium) are unlikely to be transported to the north due to prevailing redox conditions to the north. The conceptual geochemical site model discussed in Section 1.3 of the LAR and shown schematically in **Figure H15-1**, indicates limited transport of these elements under reducing conditions due to the formation of solid phase precipitates. Early investigations of the Highland sandstone units and the roll-front deposits found reducing conditions to the north of the tailings impoundment as shown in **Figure H15-2**. Chemical data from monitoring wells on the Site, including dissolved iron support the findings of these early investigators and the geochemical conceptual model. The presence of dissolved iron at circumneutral pH indicates the presence of ferrous iron and reducing conditions (*e.g.* Eh < 100 mV). Iron and uranium concentrations at selected TDSS wells are presented in **Figure H15-3**. These data show elevated iron concentrations (*e.g.* reducing conditions) in wells to the north of the tailings impoundment and corresponding to low uranium concentrations. Selenium concentrations in wells to the north are also very low or non-detectable.

As noted in the response to RAI-H5, EMES will collect additional water level and water quality data both from additional monitoring wells to be installed at the site and from publically-available regional data. In addition, soil chemical data will also be collected from well cores. These data will be reviewed and used to update the site conceptual models and verify the presence of reducing conditions to the north of the tailings. Newly collected data and the updated site conceptual model will form the basis for updated assessments and potentially an updated groundwater flow model that will supersede results and assumptions made during development of the Tetra Tech (2007) model.

NRC Staff RAI - H16 Provide technical justification for the assumption that the conditions in the Southeast Drainage for the future long-term conditions are similar to the current conditions.

<u>RESPONSE</u>: Groundwater and surface water flow in the Southeast Drainage have been affected by the closure of the Tailing Impoundment. The Impoundment has been closed for approximately 28 years, and conditions have reached a new equilibrium related to groundwater underflow, surface recharge, and surface flows based on the current surface area of the drainage and the closed condition of the Impoundment.

As noted in the response to RAI H1, EMES will collect additional data related to the OBSS units and use these data to update the site conceptual groundwater flow model. A work plan is included with this submittal **(Attachment H1)** that outlines the proposed well locations, target geologic units and depths, and data collection activities for these new monitoring wells for NRC's review and comment.

NRC Staff RAI - H17 Clarify the calculations and conclusions of the verification analysis of the estimated groundwater flux from the GHB in Tetra Tech (2007).

<u>RESPONSE</u>: As noted in the response to RAI-H5, EMES will collect additional water level and water quality data both from additional monitoring wells to be installed at the site and from publically-available regional data. These data will be reviewed and used to update the site conceptual model. Newly collected data and the updated site conceptual model will form the basis for updated assessments and potentially an updated groundwater flow model that will supersede results and assumptions made during development of the Tetra Tech (2007) model.

NRC Staff RAI - GC-1: Provide data and assumptions associated with modeling of surface reactions involving the sorption and desorption of uranium, selenium, nickel, and chromium. The data should include: (i) the reactions postulated; (ii) the equilibrium constants assumed and the basis for those constants; and (iii) the MINTEQ database used in the calculations.

RESPONSE: The Minteq.v4 database was used for all modeling calculations and this database is provided on the accompanying disk (**Attachment GC-1-1**). Minteq.v4 was introduced into Version 2.11 of PHREEQC and was translated from the updated Version 4.02 of MINTEQA2. The Minteq.v4 database was appended with uranyl surface complexation constants originally determined by Hsi and Langmuir (1985) which are also provided in Dzombak and Morel (1990) (**Table GC-1-1**). Equilibrium expressions for selenium, nickel, and chromium are provided in the Minteq.v4 database and were also taken from Dzombak and Morel (1990) (**Table GC-1-1**).

In the development of these surface complexation constants, Dzombak and Morel (1990) developed a parameter extraction procedure and a generalized two-layer surface complexation model for analysis of sorption data from a variety of sources. All original experimental sorption data are presented in Dzombak and Morel (1990) along with the results of the equilibrium calculations for each data set. Sorption constants were extracted from equilibrium, single-solute sorption data, and the best overall estimates for the constants were determined via a weighted average of the results.

Additional model assumptions include the properties of the adsorbing surface assumed to consist of hydrous ferric oxide (HFO). Hydrous iron oxides are some of the most dominant sorbents in nature because of their tendency to be finely-dispersed and to coat other particles. The surface complexation modeling for uranium, nickel, selenium, and chromium assumed that the aquifer contains 0.1% HFO with a surface area of 600 m^2/g (Dzombak and Morel, 1990). Surface site densities were also divided into Type 1 and Type 2 sites: Type 2 sites (Hfo_w) are the total reactive sites available for sorption as determined from observed sorption maxima with an assumed site density of 0.2 mol/mol Fe. Type 1 sites (Hfo_s) correspond to a smaller set of high-affinity binding sites with an assumed site density of 0.005 mol/mol Fe. The assumed HFO surface area and surface site densities are the best estimates for these parameters developed through a comprehensive literature review and evaluation (Dzombak and Morel, 1990).

NRC Staff RAI - GC-2: Provide additional justification for selection of Well MFG-1 as the point of compliance well for the Southeast Drainage area.

RESPONSE: Well MFG-1 is located at the toe of the tailings impoundment embankment and at the head of the Southeast Drainage where historic tailings seepage emanated as springs and created surface flow. Well MFG-1 is proposed as the POC well at the southeast side of the tailings and northwest of the Southeast Drainage because the well is screened in the uppermost aquifer at the center of the drainage through which the tailings seepage enters the Southeast Drainage groundwater system. The specific location and screened interval of MFG-1 is consistent with the criteria for a POC defined by the NRC as the intersection of a vertical plane with the uppermost aquifer at the hydraulically downgradient limit of the impoundment (NRC, 2003). Therefore, Well

MFG-1 meets the NRC objective in selecting a POC that will provide the earliest practicable warning if the impoundment is releasing hazardous constituents to groundwater (NRC, 2003).

Groundwater quality in MFG-1 currently meets the Groundwater Protection Limit (GPL) for all of the hazardous constituents, with the exception of uranium. However, groundwater from wells screened in the Southeast Drainage regolith downgradient of MFG-1 contain selenium (Well BBL-2) and radium-226+228 (Well BBL-3) at concentrations above those in MFG-1 and at levels exceeding GPLs. These observations are interpreted as isolated occurrences of residual subsurface contamination that become diluted and attenuated to levels below GPLs with further migration toward Well Tt-7 and the southern POE. Nevertheless, the NRC has requested that additional justification and technical basis be provided to demonstrate that MFG-1 is an appropriate monitoring point for hazardous constituents in the Southeast Drainage.

The NRC has suggested there may be secondary source areas for contaminants located within the sediments and alluvium of the Southeast Drainage. Therefore, EMES has prepared a hydrologic and geochemical work plan (**Attachment H1**) for NRC review and approval that presents specific data collection activities designed to: (1) identify the location and extent of potential secondary subsurface contaminant sources and (2) improve our understanding of the distribution and mobility of hazardous constituents in Southeast Drainage. The results from this investigation will provide additional data that can be used as a basis to better support appropriate POC location(s) in the Southeast Drainage.

NRC Staff RAI - GC-3: Provide the technical bases for the statement "Groundwater uranium concentrations at Well MFG-1... are not anticipated to increase as tailings seepage rates continue to decline (Section 2.2.3.2)" (EMES, 2011, p. 4-4).

RESPONSE: EMES has proposed an alternate concentration limit of 0.7 mg/L for uranium at Well MFG-1 for the Southeast Drainage. The NRC has noted historical fluctuations in uranium concentration at Well MFG-1 and has requested that EMES provide a technical basis to describe the previous uranium concentration changes at MFG-1 and demonstrate that uranium concentrations will not increase and exceed the proposed ACL.

The trend-plot for uranium at MFG-1 has been updated to include all data through the first quarter of 2012 and is presented on **Figure GC-3-1**. The data show that in 2006 and 2007, there were large downward fluctuations in uranium concentration compared to initial concentrations, but uranium never increased during this period. Since 2008, uranium concentrations at MFG-1 have remained fairly stable between 0.344 mg/L and 0.395 mg/L and do not appear to be increasing or decreasing (**Figure GC-3-1**).

A detailed data analysis was performed using the Minitab® (Release 14) software package to determine if there is a statistically-significant trend of increasing or decreasing uranium in Well MFG-1. The statistical data set included all MFG-1 uranium concentration measurements collected through the first quarter of 2012 (**Table GC-3-1**). The uranium concentration data from MFG-1 were first tested for statistical outliers using box-plots, and identified outliers were removed before trend analysis. The boxplot on **Figure GC-3-2** shows that the variable uranium concentrations measured in 2006 and 2007 are statistical outliers, and the revised MFG-1 uranium trend plot (with outliers removed) is also shown on **Figure GC-3-2**.

Once the statistical outliers were removed from the data set, the distribution was analyzed using probability plots. The data followed a normal distribution and therefore were tested for trend using regression analysis of concentration on time (**Figure GC-3-3**). The trend analysis tests the null hypothesis (Ho = 0) that there is no trend, or more specifically, that the slope is not significantly different from zero. The p-value for the regression slope was 0.506; therefore Ho was not rejected, and thus not significant, indicating there is no upward or downward statistical trend in the MFG-1 uranium concentration data. Therefore, the concentration of Uranium in MFG-1 is historically constant.

NRC Staff RAI - GC-4: Provide the technical bases for the variations in water temperature and solute concentrations reported in data for Wells 129 and 128.

RESPONSE: Upon review of Highland groundwater monitoring data supplied by EMES, the NRC has noted large seasonal temperature variations in OBSS Wells 128 and 129. Although similar seasonal temperature variations have been observed in the adjacent TDSS Well 120, seasonal variations in nearby TDS Wells 176 and 179 are much smaller. The NRC suggests that air temperatures are not the cause of the large temperature variations and further state that solute concentration data from Wells 128 and129 appear to be strongly correlated with temperature. Therefore, the NRC has specifically requested that EMES provide the technical bases to explain these variations in temperature and concentration data at Wells 128 & 129.

Temperature Variation

The historic temperature data through 2010 for OBSS Wells 128 & 129 and nearby TDSS Wells 120, 176, and 179 are shown on **Figure GC-4-1**. The larger seasonal temperature variations in OBSS Wells 128 & 129 and TDSS Well 120 compared to TDSS Wells 176 & 179 are apparent. Groundwater temperatures are lower in winter and warmer in summer in all wells (**Figure GC-4-1**), which is consistent with seasonal warming and cooling at the surface. The exchange of heat between the sun, earth, and atmosphere ultimately controls the temperature of the earth's surface and shallow groundwater. In shallow groundwater, seasonal variations related to surface temperatures can be on the order of 5 to 10°C or more (Nelson, 2002). In groundwater deeper than 50 to 75 feet, however, seasonal changes are generally less than 1°C (Heath, 1989).

The OBSS Wells 128 & 129 and TDSS Wells 120, 176, and 179 have screen depths ranging between 140 feet and 216 feet bgs and theoretically should not undergo the large temperature variations observed. As such, there is no relationship between the well depth and degree of temperature variation (*i.e.*, both low and high variation observed at greatest depths, **Figure GC-4-1**). Therefore, it was hypothesized that temperature variations in the deep groundwater samples can only be related to the very limited amount of recharge in these wells, combined with adaptive sampling procedures that produce large variations in temperature between seasonal sampling events. To evaluate this hypothesis, EMES requested detailed information regarding sampling procedures and well recharge rates from Pronghorn Pump LLC (Glenrock, WY). Pronghorn is responsible for routine sampling of site monitoring wells and their detailed response is provided in **Attachment GC-4-1**. The information supplied by Pronghorn indicates that wells with the largest temperature variations (Wells 120, 128, and 129) require 3 months to recover and only produce between 1 and 2 gallons of water. Therefore, EMES concludes that the large temperature variations in Wells 128 and 129 are a result of extended recovery times coupled with low recovery volumes such that seasonal temperature changes are detectable even in deep wells when they contain very small volumes of stagnant groundwater.

Variation in Solute Concentrations

The NRC also noted variation in solute concentrations and possible correlations between solute concentration and temperature in OBSS Wells 128 and 129. A primary consideration of any groundwater monitoring program is the selection of monitoring wells that will yield samples that accurately represent the water chemistry of the hydrogeologic system targeted for study. The large temperature variations discussed above in deep wells in which such seasonal fluctuations should not be observed and the very low yield from these wells indicates that any data collected from these wells should be interpreted with great caution. The U.S. Geological Survey in its "National Field Manual for the Collection of Water-Quality Data" (USGS, 2006) recommend not sampling any well that has not recovered to within 90% of its static water level within a 24-hr period and has less than one borehole volume of water removed during purging. The total volume of water that can be pumped from Wells 128 and 129 are 2.0 and 1.25 gallons, respectively and it takes them approximately 3 months to recover. EMES believes that fluctuations in solute concentration is related to water stagnation within the well bore and that solute concentrations measured are not representative of the aquifer of interest. In summary, the OBSS Wells 128 and 129 are prone to large seasonal fluctuations in temperature due to their extended recovery times and low recovery volumes which renders the wells essentially dry. Wells 128 and 129 cannot be properly purged prior to sampling (**Attachment GC-4-1**) and with extended recovery time only produces a small volume of stagnant water that is subject to surface atmospheric effects, such as evaporation and condensation of water within the well casing, causing large fluctuations in both temperature and solute concentrations. Additional wells installed as described in the work plan **(Attachment H1)** included with this submittal will help to further evaluate groundwater conditions to the north of the tailings impoundment in the OBSS.

NRC Staff RAI - GC-5: Provide the technical bases for excluding a proposed point of compliance well located in the OBSS north of the tailings impoundment.

RESPONSE: The NRC has noted that elevated concentrations of hazardous constituents in OBSS Well 129 indicate likely transport of constituents to the north and off site within the OBSS. Therefore, the NRC is requesting a technical basis for excluding additional monitoring or POC wells in the OBSS to the north.

Point of compliance wells are designated for the uppermost aquifer based on NRC guidelines (NRC, 2003). Well 176 is screened within the TDSS and serves as the current POC well for the northern boundary of the impoundment. Well 176 contains elevated concentrations of chloride and sulfate, with hazardous constituent concentrations generally below site GPLs. However, radium-226+228 activities have historically fluctuated above and below the GPL of 5 pCi/L (EMES, 2011). The current TDSS seepage front to the north as delineated by chloride in Wells 176, 179, and 181 is similar to that observed in 1996 (EMES, 2011). Although chloride has increased in Wells 179 and 183, the concentrations of hazardous constituents are below GPLs in TDSS Wells 179, 181, and 183. Measured solute concentrations in Well 129 fluctuate considerably, including the concentration of selenium, which has on occasion exceeded the MCL. However, as discussed above in response to RAI-GC-4, these fluctuations are believed to be due to extended well recovery times and low recovery volumes which renders wells 128 and 129 essentially dry and therefore not representative of aquifer conditions.

No additional POC wells were proposed for the north in the LAR primarily because a POC has already been established according to license conditions, and because the current conceptual model indicates that water within the OBSS and TDSS flows toward the pit. However, to address NRC concerns regarding potential contaminant transport within the OBSS to the north, additional hydrologic and geochemical data will be collected. EMES has prepared a work plan **(Attachment H1)** for NRC review and approval that presents specific data collection activities designed to: (1) better define the extent of potential indicator and hazardous constituent concentrations in the OBSS and TDSS to the north of the impoundment, and (2) collect additional hydrologic data. Newly collected data and the updated site conceptual model will form the basis for updated assessments and potentially an updated groundwater flow model.

NRC Staff RAI - HAZ1: Provide the bases for the characterization of the alluvial floodplain as ephemeral and that water quality is affected by biological fouling by giardia and fecal coliform bacteria.

RESPONSE: The bases for characterizing the alluvial floodplain along North Fork Box Creek (NFBC) as ephemeral and that water quality is affected by biological fouling is based on knowledge of the site and surface water data collected over the last several years. The NFBC flows as a continuous stream only during a very short time, if at all, during the spring runoff. At other times of the year the only water in NFBC is found in isolated pools as seem in **Figure HAZ-1-1**.

Additional support comes from the surface water sampling of NFBC that was initiated in August 2008. Surface water samples are collected twice a year, in spring and late summer, from six locations along NFBC (**Figure HAZ-1-2**). The locations selected for sampling are located at sites along NFBC where water tends to pool after flow has ceased. Between pools NFBC is dry except for a short time in early spring. While sample locations were selected at pools, only sample locations BC-4 and BC-6 have been sampled during every sampling event. Sample location BC-1 and BC-3 were dry on one occasion and BC-2 and BC-5 were dry on five and four of the nine total sampling events, respectively.

During third quarter sampling in 2012, in addition to the standard water quality parameters that are measured, samples were collected at BC-4 and BC-6 (all other locations were dry) for microbiological analysis for total and fecal coliform bacteria. Both samples were found to contain total coliform bacteria and *Escherichia coli* (fecal coliform) and were classified by the laboratory as unsafe.

NRC Staff RAI - HAZ2: Provide technical bases for the statements made in the LAR (EMES, 2011, Section 2.3.1) about potential future human water uses in the Southeast Drainage watershed that "...all other uses would continue to be protective..." ...and that "once it enters the North Fork Box Creek groundwater system, remains available for all appropriate uses," and "...resource of the region is in no way impaired."

RESPONSE: The historic and current land use in the areas surrounding the Highland Site is open grazing of livestock (primarily sheep and cattle). The nearest residences are located about 5 miles from the site and thus there is not current use of the shallow groundwater in the area as a drinking water source for human consumption.

EMES has purchased or is in the process of purchasing lands in the Southeast Drainage and adjoining areas for inclusion in the LTSB thereby eliminating the potential for development of the shallow groundwater system in the Southeast Drainage as a source of drinking water in the future. The institutional control of the groundwater resource and elimination of the groundwater as a drinking water source for human consumption will provide protection of human health.

The shallow groundwater system in the Southeast Drainage would continue to discharge to NFBC and be available for consumption by livestock, which is the historical and current use of the groundwater resource. The concentration of uranium in the shallow groundwater in the Southeast Drainage discharging to NFBC, as monitored at well Tt-7, is slightly above the current drinking water Maximum Contaminant Level (MCL) of 0.03 mg/L. The average concentration of uranium measured since 2008 at well Tt-7, which is a short distance from NFBC (**Figure HAZ2-1**), is 0.047 mg/L. Wyoming no longer has a water quality standard for uranium for livestock watering. However, in the past the livestock standard for uranium was 5.0 mg/L, which is about two orders of magnitude greater than the average concentration measured at Tt-7. Therefore, the limited shallow groundwater in the Southeast Drainage discharging to NFBC does not pose a risk to livestock and remains available for this historic/current use and future use.

NRC Staff RAI - HAZ3: Clarify whether the bases for the proposed ACL for Well 175 included consideration of ecological hazards, and if so, provide the information or references that support the no environmental hazard determination for the proposed Well 175 ACL.

RESPONSE: The proposed ACL for Well 175 at the western edge of the tailings impoundment, while not explicitly stated in the text in Section 1.5.2, did take into consideration ecological hazards. The no environmental hazard determination was based on the *"Final Highland Pit Lake-Specific*

Ecological Risk Assessment" (ERA - Attachment 3 of LAR) and evaluation of the mass flux of uranium from Well 175 to the Highland Pit Lake.

A phased approach was used in the Highland Pit Lake ERA to assess risks from selenium and uranium to pit lake biota via several exposure pathways. Terrestrial plants, aquatic biota, birds, and mammals were assessed as potential receptors. The methods for assessing ecological risk and conclusions of the assessment presented in Attachment 3 of the LAR are summarized in Section 2.3.5 of the LAR. For the risk analysis, measured selenium and uranium concentrations were compared with toxicity reference values (TRVs). TRVs represent known levels of effects for specific exposure ranges based upon dose-response studies conducted primarily in the laboratory. Estimating effects based on exposure involves comparing measured selenium and uranium concentrations with the media specific TRVs. Results are expressed as a Hazard Quotient (HQ) (EPA, 1997) where:

Hazard Quotient (HQ) = Exposure Point Concentration (EPC) ÷ TRV

The phased approach included a very conservative screening level assessment using maximum chemical concentrations and the most conservative TRV, followed by a less conservative, but more realistic, baseline evaluation of exposure and effects using the 95th percentile upper confidence limits (UCLs) as the exposure point concentration and the less conservative TRV that is still protective of individual receptors or, in all cases, receptor populations. After the baseline assessment, only one exposure pathway for uranium (benthic invertebrate tissue) yielded an HQ (HO = 1.6) that suggested a small potential for adverse effects.

While a risk analysis may indicate a potential for adverse effects based on numerical comparisons, it is important to interpret the significance of the risk analysis within the context of the physical and biological characteristics of the Pit Lake. This final step in the assessment evaluates the significance of selenium and uranium concentrations in biota with respect to the type and amounts of habitat, biological productivity, and recorded use of the Pit Lake by wildlife. These physical and biological attributes of the Pit Lake determine the potential magnitude and significance of food chain transport of selenium and uranium to aquatic and terrestrial consumers.

Highland Pit Lake provides minimal habitat and primary and secondary biological productivity to maintain a significant permanent aquatic plant and animal community or to host migrant species that frequent the lake primarily during summer months. This is primarily due to the general configuration of the lake which has very steep banks with a very small shallow water zone conducive to establishment of an aquatic biological community.

Integrating habitat and biomass estimates into the interpretation of the chemical data, including food availability and frequency of use of the lake by migratory species, leads to the conclusion that risks to resident and migratory biota at Highland Pit Lake are very low.

The Highland Pit Lake currently contains an estimated 3.9×10^9 gallons of water with a uranium concentration of about 3.3 mg/L, which equates to a uranium mass of about 49,000 kg. The average uranium concentration at Well 175 over the past four quarters of sampling is about 0.037 mg/L. Well 175 is located in a narrow strip of land between the western edge of the tailings impoundment and the eastern edge of backfill Pit 2. Current discharge from the tailings impoundment to the TDSS and to the pit lake has diminished to very low levels and long-term discharges are predicted to be less than 5 gpm. If it is assumed that most of the long-term discharge from the tailings (*i.e.* 4 gpm) goes to the backfill and to the pit lake and the uranium concentration in the discharge is equivalent to the current uranium concentration measured at Well 175, the mass loading of uranium to the pit lake is about 0.001% of the mass presently in the lake. If the concentration were to increase to the 3.0 mg/L level of the proposed ACL the mass loading to the lake would be about 0.06% of the current uranium mass. This small increase in uranium mass is not expected to significantly increase the very low risk to ecological receptors.

The proposed ACL for Well 175 is based on the modeled equilibrium concentration of uranium from tailings seepage in the neutralized TDSS aquifer (discussed in Section 2.1.2.6 in the LAR) and represents a concentration that is below the current uranium concentrations at the POE and not likely to be exceeded. While the proposed ACL was based on a modeled concentration, consideration was given to the risk assessment that concluded that water quality of the Highland Pit Lake does not pose a risk to ecological receptors and the small long-term mass loading from the tailings to the pit lake will not alter that conclusion.

As discussed in the Draft Action Items from the August 14, 2012 meeting, EMES agreed to submit a work plan for NRC review to collect additional data to assess potential risks to migratory birds and validate the conclusions reached in the 2010 ERA and in response to the NRC RAI.

NRC Staff RAI - HAZ4: Provide the basis for the statement that the proposed ACL for Well MFG-1 in the Southeast Drainage is protective for humans.

<u>RESPONSE</u>: The LAR in Section 4.2 states;

> *"An ACL of 0.7 mg/L for uranium is proposed for Well MFG-1 (Table 4-1). This proposed ACL is equal to one half the risk-based concentration of 1.4 mg/L, which is protective of human health and the environment at the POE (Section 2.3.5)."*

The NRC staff has requested clarification of this statement to ensure that the bases for the proposed ACL are clearly stated to allow staff to complete the review of the proposed ACL. EMES agrees that the statement lacks clarity for defining the bases of the proposed ACL.

With institutional controls in place, the actual point of exposure in the Southeast Drainage is NFBC, which as discussed under HAZ2 is not a human drinking water source. Therefore, institutional controls that eliminate access to the limited groundwater in the Southeast Drainage as a drinking water source and provide protection of human health.

As discussed in Section 2.3.5, neither EPA nor the State of Wyoming have promulgated standards for uranium for ecological receptors (*e.g.* aquatic life, wildlife or livestock). Wyoming previously had a uranium standard of 5.0 mg/L for livestock and 1.4 mg/L for aquatic life (WDEQ, 2005); however, these standards were recently rescinded. Colorado has the following uranium standards for support of aquatic life (CDPHE, 2009).

Acute = e(1.1021[ln(hardness)] + 2.7088)
Chronic = e(1.1021[ln(hardness)] + 2.2382)

These equations are valid for hardness (as mg/L $CaCO_3$) of 400 mg/L or below. The hardness of NFBC exceeds 400 mg/L. Using a hardness value of 400 mg/L in the equations above, the protective acute exposure uranium concentration is 11.1 mg/L and the chronic protective chronic exposure uranium concentration is 6.9 mg/L. The Wyoming rescinded uranium aquatic standard of 1.4 mg/L is considered a conservative Risk-Based Concentration (RBC) and protective for ecological exposures. This is supported by the information and analysis presented in the Highland Pit Lake Ecological Risk Assessment (Attachment 3 in the LAR).

The proposed ACL of 0.7 mg/L at Well MFG-1 is based on the following:

- It is equal to one half the previous state of Wyoming RBC of 1.4 mg/L that was protective of aquatic life and approximately 16 and 10 times lower than uranium standards in the neighbouring state of Colorado for acute and chronic exposure, respectively;
- The *"Final Highland Pit Lake-Specific Ecological Risk Assessment"* (ERA - Attachment 3 of LAR) that supports the previous Wyoming standard of 1.4 mg/L as protective;
- The proposed ACL is approximately two times the average concentration of uranium measured at MFG-1 since 2008, and the concentration of uranium at MFG-1 is not expected to increase to levels above 0.7 mg/L as discussed under GC-3;
- Data collected from wells installed in the Southeast Drainage beginning in about 2006 show that uranium concentrations decrease as flow moves down the drainage to NFBC. Average uranium concentrations at Tt-7, approximately 0.05 mg/L, are just above the EPA MCL.
- Institutional controls (as part of the Long-term Custodianship) eliminate access to the shallow groundwater system and will provide protection of human health.

NRC Staff RAI - CA1: Provide additional information or bases for not evaluating corrective actions for the uranium exceedance at Well 175.

RESPONSE: EMES has determined that the Highland Pit Lake contains 11e.(2) byproduct material and therefore has proposed to extend the LTSB to include the pit lake. Well 175 is located in a small strip of land positioned between the western edge of the tailings impoundment and east of the backfilled Pit 2 and the pit lake and would be included within the expanded LTSB as shown on the Site Map (Figure CA 1-1). The groundwater flow in the TDSS in the vicinity of Well 175 is moving downdip to the west and reports to the backfill and eventually to the pit lake.

On August 15, 1989, Exxon submitted a revised groundwater corrective action plan (CAP) to the NRC (ECMC, 1989b). The CAP approved by NRC on August 18, 1989 via License Amendment No. 32, consisted of pumping five existing wells (Wells 114, 117, 175, 177 and 178) which were completed in the TDSS in the area of highest COC concentrations, and evaporating the recovered water in lined ponds on a non-reclaimed portion of the tailings impoundment.

Exxon began operating the NRC approved CAP in November of 1989. NRC approved discontinuing pumping from Well 114 in 1990 since the well was unproductive. Suspension of winter operation was approved in 1994 (License Amendment No. 44). In 1998, Exxon submitted an ACL application for POC Wells 125, 175 and 177 with a demonstration that continued pumping was no longer practicable. In May 1999, via License Amendment No. 49, NRC approved the proposed ACLs and cessation of CAP pumping. Via License Amendment 49, the NRC concurred that there remained no practicable corrective actions for mitigating groundwater impacts from 11e.(2) byproduct material in the TDSS.

Because groundwater in the vicinity of Well 175 is expected to report to the pit lake, and as discussed under HAZ3 the uranium concentration measured at Well 175 is approximately 2 orders of magnitude lower than the uranium concentration downgradient in the pit lake, evaluation of a corrective action at this location is considered to be inappropriate and unnecessary. Corrective actions for the pit lake were evaluated in the LAR and the costs of those corrective actions were used as a basis for the As Low As Reasonably Achievable (ALARA) demonstration that was provided in Section 3.3 of the LAR.

NRC Staff RAI - CA2: Provide the reference for the 2009 survey of land prices that supports the licensee's corrective action assessment.

RESPONSE: The 2009survey of land prices used to support the corrective action assessment was provided in Exhibit 7 of Appendix E of the LAR.

NRC Staff RAI - PA-1: Provide additional characteristics of the area enclosed within the current and proposed long-term surveillance and monitoring (LTSM) boundaries.

RESPONSE: The original LTSM boundary is 465.5 acres. The New LTSM boundary is 1,773 acres. A parcel of 167 acres has been previously purchased on the southeast corner of site which will be added to the LTSM boundary. Prior to acquisition, the land was used for livestock grazing. Currently, the previous land owner is allowed to continue grazing that area.

The future purchases of four separate parcels owned by Cameco Resources and the Fowler Ranch Partnership are currently being negotiated to accommodate the expansion of the new LTSM boundary. The Cameco Resources property consists of two parcels; one of 18.09 acres and the other of 7.81 acres. Both parcels are within the current mine permit area. Prior to mining, the land was used for livestock grazing. The Fowler Ranch Partnership property consists of two parcels; one of 122.57 acres and the other of 81.48 acres. Both parcels are within the current mine permit area. Prior to mining, the land was used for livestock grazing. In all, 1,307.5 acres are being added to the LTSM boundary.

NRC Staff RAI - LU-1: Clarify the current land subsurface ownership status and the land within the proposed long-term care boundary at the Highland site.

<u>**RESPONSE**</u>: Subsurface rights within the newly-proposed LTSM boundary are controlled by a variety of stakeholders, both public and private, including: U.S. Department of the Interior, ExxonMobil, Highland Uranium Project, Saaberg-Interplan Uran GMBH, Box Creek Mineral Limited Partnership and the State of Wyoming. A number of minor stakeholders control subsurface rights for the Fowler Ranch Partnership parcel which is being negotiated for purchase by ExxonMobil. These minor stakeholders include: Mary Livingston-Weston (50%) and Donald Reeder, Dan Reeder, Una Paules and Shirley Clouse (50%) for oil and gas only and Ruth Lundberg (25%), Rachel Gasbarre (25%), Barbara Warner (12.5%), Janis Richards (12.5%), Karen Gasbarre (12.5%) and Debra Lundberg (12.5%) for all other minerals. A map of subsurface mineral rights at the Highland Site is being created and will be provided under separate cover.

NRC Staff RAI - LU-2: Confirm site features and the location of nearest residence(s) from the Highland site.

<u>**RESPONSE**</u>: Private residences within a 10-mile radius of Highland Site are those listed below. It is not known if these are the location of the living area (house) or general street address for the greater ranch (specifically for the Hornbuckle Ranch and Reynolds Ranch). Year-round residence is not suspected on at least one of the ranches.

1. Fowler Ranch Partnership (2.65 miles from the approximate center of the LTSB)
   Highland Loop Road
   Douglas, WY. 82633
   Converse County Parcel # 00133655

2. Boner Bros. Partnership (4.25 miles from the approximate center of the LTSB)
   Highland Loop Road
   Douglas, WY. 82633
   Converse County Parcel # 00165962

3. Vollman Ranches (5.11 miles from the approximate center of the LTSB)
   28 Highland Loop Road
   Douglas, WY. 82633
   Converse County Parcel # 00131907

4. Reynolds Ranches, Inc. (8.80 miles from the approximate center of the LTSB)
   712 Willow Creek Road
   Douglas, WY. 82633
   Converse County Parcel # 00023328

5. Hornbuckle Ranch (11.97 miles from the approximate center of the LTSB)
   1558 Ross Road
   Douglass, WY. 82633
   Converse County Parcel # 00003452

Source: Converse County Assessor's Office

A map showing these locations is included on **Figure LU-2**.

NRC Staff RAI - RAI: Impact of Pit Lake on Migratory Birds

RESPONSE: After reviewing the "Final Highland Pit Lake-Specific Ecological Risk Assessment" (ERA - Attachment 3 of LAR), the U.S. Fish & Wildlife Service (FWS) concluded that the report did not adequately support the conclusion of insignificant effects to migratory birds. The FWS contends that the ERA overlooks or excludes a number of important factors that may have an impact on the conclusions of that study.

As discussed in the Draft Action Items from the August 14, 2012 meeting, EMES agreed to submit a work plan for NRC review to collect additional data to assess potential risks to migratory birds and validate the conclusions reached in the 2010 ERA and in response to the NRC RAI.

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SUPPLEMENTAL INFORMATION

TABLES

FIGURES

ATTACHMENTS

TABLES

Table Geo 1-1 - Geologic Data Input for MVS Model

Well or Boring Designation	Northing	Easting	Ground Surface Elevation (ft amsl)	Bottom Elevation of Alluvial Unit (ft amsl)	Bottom Elevation of Fowler Sandstones (ft amsl)	Bottom Elevation of Tailing Dam Sandstone (ft amsl)	Bottom Elevation of Tailing Dam Shale (ft amsl)	Bottom Elevation of 50 Sandstone Unit (ft amsl)	Bottom Elevation of 45 Shale Unit (ft amsl)	Bottom Elevation of 40 Sandstone Unit (ft amsl)	Bottom Elevation of 35 Shale Unit (ft amsl)	Bottom Elevation of 30 Sandstone Unit (ft amsl)	Bottom Elevation of 25 Shale Unit (ft amsl)	Bottom Elevation of 20 Sandstone Unit (ft amsl)
DW-47	4768097.4	456951.9	5238.6	5215	5159	5078	5053	4998	4980	4935	4895	4881	4852	4837
DW-46	4767993.6	457352.7	5235.5	5217	5160	5083	5061	5004	4988	4948	4907	4892	4863	4849
TDM_XXXVII	4768276.2	458184.2	5127.5	NM	NM	4959.5	NA	NA	NA	NA	NA	NA	NA	NA
TDM_XXXVII	4768276.2	458184.2	5127.5	5220	5162	5093	5072	5024	5002	4968	4930	4915	4887	4870
TDMXXXVIII	4768210.4	458629.5	5202.6	5222	5163	5099	5078	5032	5010	4979	4942	4926	4897	4882
TDM_XLIV	4768063.3	459374.5	5274	5225	5164	5111	5088	5049	5024	4998	4962	4947	4917	4902
MFG-3	4768139.7	460353.3	5113.08	5110.58	NM	NM	5098.08	5061.58	5038.08	5021.08	4984.08	4970.08	4943	4926
MFG-1	4768134.3	460342.3	5115.827	5112.327	NM	NM	5102.827	5064.827	NA	NA	NA	NA	NA	NA
MFG-2	4768137.0	460347.8	5114.744	5111.244	NM	NM	5101.744	5063.744	5041.744	5022.744	NA	NA	NA	NA
TDM_XXXII	4768067.1	460517.2	5109.98	5105	NM	NM	NM	5071	5044	5028	4992	4974	4948	4932
BBL-1	4768040.6	460603.4	5092.4	5053.9	NM	NM	NM	NM	NM	5027.4	4987.4	4965.9	NA	NA
BBL-2	4767975.7	460630.7	5091.03	5054.53	NM	NM	NM	NM	NM	NA	NA	NA	NA	NA
BBL-3	4767868.1	460779.3	5085.56	5055.56	NM	NM	NM	NM	5041.06	NA	NA	NA	NA	NA
TDM_XXXIV	4769212.1	457983.1	5301	5272	5098	5032	5024	4975	4956	4949	4918	4873	4862	4852
DW-18	4769188.7	457947.4	5273.1	5268	5100.1	5032.1	5014.1	4976.1	4960.1	4939.1	4920.1	4874.1	4862.1	4853.1
TDM_XXXV	4768830.2	458303.5	5270.4	5233	5110	5053	5024	4988	4973	4953	4935	4891	4868	4854
DW-41	4767626.2	458212.1	5227.1	NM	5134.1	5105.1	5045.1	5019.1	5009.1	4982.1	4969.1	4927.1	4885.1	4863.1
DW-35	4768939.3	456956.6	5311.3	NM	5116.3	5061.3	5011.3	4976.3	4961.3	4931.3	4911.3	4881.3	4811.3	NA
RM-1	4769492.6	456039.4	5342.1	NM	5008.1	NA	NA	NA	NA	NA	NA	NA	NA	NA
RM-2	4769058.7	456321.8	5289.9	NM	5070.9	NA	NA	NA	NA	NA	NA	NA	NA	NA
RM-3	4768742.0	456527.2	5256.2	NM	5074.2	NA	NA	NA	NA	NA	NA	NA	NA	NA
RM-4	4767265.0	457987.1	5156.8	NM	5121.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
TDM_XL	4769662.3	456655.5	5378.3	5354.3	5060.3	NA	NA	NA	NA	NA	NA	NA	NA	NA
TDM_VIII	4768058.4	459820.6	5250	NM	5152	5128	NA	NA	NA	NA	NA	NA	NA	NA
TDM_XXIII	4767903.2	460262.1	5181.27	5171.27	NM	NA	NA	NA	NA	NA	NA	NA	NA	NA
TDM_C	4767969.4	460235.0	5176	5164	NM	5143	5121.5	NA	NA	NA	NA	NA	NA	NA
TDM_XXIV	4767900.6	460293.0	5180.37	5170.37	NM	5142.37	5119.37	NA	NA	NA	NA	NA	NA	NA
TDM_VI	4768184.8	460317.8	5125	5105	NM	NM	NM	5079.5	5063.5	NA	NA	NA	NA	NA
TDM_E	4768254.0	460133.0	5170.37	NM	NM	5140.37	5115.37	NA	NA	NA	NA	NA	NA	NA
TDM_IV	4768153.0	460234.0	5150	NM	NM	NM	NM	5085	5067	NA	NA	NA	NA	NA
TDM_III	4768338.6	460371.5	5148	5125	NM	5116	NA	NA	NA	NA	NA	NA	NA	NA
TDM_II	4768542.8	460344.4	5173	5125	NM	5116	NA	NA	NA	NA	NA	NA	NA	NA
TDM_V	4768553.5	460488.6	5144	NM	NM	5104	5079	NA	NA	NA	NA	NA	NA	NA
TDM_XXV	4768480.0	460529.6	5161.87	5143.87	NM	NA	NA	NA	NA	NA	NA	NA	NA	NA
TDM_XXVI	4768774.0	460364.4	5169.4	5149.4	NM	5117.4	NA	NA	NA	NA	NA	NA	NA	NA
TDM_D	4768737.5	460237.6	5177	5147	NM	5107	NA	NA	NA	NA	NA	NA	NA	NA
TDM_VII	4768893.5	460238.8	5183.69	5166.69	5142.69	5093.69	NA	NA	NA	NA	NA	NA	NA	NA
TDM_I	4768971.0	460278.3	5193	NM	5148	5110	NA	NA	NA	NA	NA	NA	NA	NA
TDM_XXVIII	4769119.5	460261.7	5201.3	5171.3	5146.3	5123.3	NA	NA	NA	NA	NA	NA	NA	NA
TDM_XXVII	4769117.3	460261.5	5201.07	5171.07	5156.07	short	NA	NA	NA	NA	NA	NA	NA	NA
TDM_XXIX	4769124.7	460260.6	5201.8	5171.8	5146.8	5102.8	5070.8	5056.8	NA	NA	NA	NA	NA	NA
TDM_XLVII	4769387.4	460038.4	5236.3	5189.3	5138.3	5097.3	5077.3	NA	NA	NA	NA	NA	NA	NA
TDM_XLVIII	4769777.4	460060.5	5238.7	5196.7	5103.7	5086.7	5068.7	NA	NA	NA	NA	NA	NA	NA
TDM_XLV	4769339.5	459642.2	5293.7	5222.7	5122.7	5074.7	5056.7	NA	NA	NA	NA	NA	NA	NA
TDM_XLII	4769193.2	459635.8	5252.8	5231.8	5129.8	5097.8	5041.8	NA	NA	NA	NA	NA	NA	NA
TDM_XXI	4769025.7	459595.2	5237.4	NM	5145.4	5094.4	NA	NA	NA	NA	NA	NA	NA	NA
TDM_XX	4769027.3	459600.8	5235.55	NM	5143.55	5092.55	5062.55	5034.55	5029.55	5000.55	NA	NA	NA	NA
TDM_XXX	4769017.2	459595.2	5237.4	NM	5145.4	5094.4	5064.4	NA	NA	NA	NA	NA	NA	NA
TDM_XIX	4769019.4	459589.4	5237.5	NM	5145.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
TDM_XLIX	4769386.1	459185.2	5299.8	5261.8	5109.8	5082.8	5062.8	NA	NA	NA	NA	NA	NA	NA
TDM_XII	4768204.3	459496.6	5262.68	NM	5163.68	5117.68	5112.08	NA	NA	NA	NA	NA	NA	NA
TDM_XLIII	4768169.8	459460.1	5262	5221	5159	5121	5110	NA	NA	NA	NA	NA	NA	NA
TDM_IX	4768609.5	459001.1	5240.3	NM	5141.3	5096.3	5065.3	NA	NA	NA	NA	NA	NA	NA
TDM_XLI	4768588.2	458967.3	5257.6	5167.6	5141.6	5084.6	5057.6	NA	NA	NA	NA	NA	NA	NA
TDM_XI	4768615.5	458995.2	5241.84	NM	5142.84	5097.84	5066.84	5033.34	5021.84	NA	NA	NA	NA	NA
Tt-1	4768674.9	460948.2	5164.42	5135.42	5133.42	5120.42	5093.42	5071.92	5064.42	NA	NA	NA	NA	NA
Tt-2	4768522.3	460544.1	5140.11	5106.11	NM	NM	NM	5065.11	5055.11	NA	NA	NA	NA	NA
Tt-3	4768110.0	460986.5	5100.41	5038.91	NM	NM	NM	NM	NM	5020.41	NA	NA	NA	NA
Tt-4	4767381.1	461153.1	5061.65	5061.65	NM	NM	NM	NM	NM	5029.65	NA	NA	NA	NA
Tt-5	4767282.1	461169.8	5057.95	5048.95	NM	NM	NM	NM	NM	5033.95	NA	NA	NA	NA
Tt-6	4767308.7	461272.5	5056.22	5048.22	NM	NM	NM	NM	NM	5030.22	NA	NA	NA	NA
Tt-7	4767422.5	461290.4	5055.22	5038.72	NM	NM	NM	NM	NM	5023.72	NA	NA	NA	NA
Tt-8	4768025.4	460619.0	5091.81	5058.81	NM	NM	NM	NM	NM	NA	NA	NA	NA	NA
53-09_E-E'	4770522.5	458442.2	5389.41	NM	NM	5030	4997	4965	4945	NM	4926	4874	4857	4838
49-09_E-E'	4770389.2	458442.0	5390.54	NM	NM	5035	4997	4975	4953	NM	4935	4871	4860	4833
45-09_E-E'	4770254.0	458441.7	5380.7	NM	NM	5036	5000	4975	4955	4948	4919	4871	4857	4835
41-08_E-E'	4770118.5	458441.4	5370.35	NM	NM	5031	4997	4960	4953	NM	4913	4868	4842	4835
37-08_E-E'	4769986.4	458441.2	5357.2	NM	NM	5032	5000	4975	4960	4947	4909	4863	4847	NM

Table Geo 1-1 - Geologic Data Input for MVS Model

Well or Boring Designation	Northing	Easting	Ground Surface Elevation (ft amsl)	Bottom Elevation of Alluvial Unit (ft amsl)	Bottom Elevation of Fowler Sandstones (ft amsl)	Bottom Elevation of Tailing Dam Sandstone (ft amsl)	Bottom Elevation of Tailing Dam Shale (ft amsl)	Bottom Elevation of 50 Sandstone Unit (ft amsl)	Bottom Elevation of 45 Shale Unit (ft amsl)	Bottom Elevation of 40 Sandstone Unit (ft amsl)	Bottom Elevation of 35 Shale Unit (ft amsl)	Bottom Elevation of 30 Sandstone Unit (ft amsl)	Bottom Elevation of 25 Shale Unit (ft amsl)	Bottom Elevation of 20 Sandstone Unit (ft amsl)
33-08_E-E'	4769851.6	458440.9	5317.59	NM	NM	5040	5010	4987	4960	4943	4928	4870	4857	4849
28-08_E-E'	4769681.0	458440.5	5290.55	NM	NM	5046	5008	4974	4963	4938	4927	4877	4854	NM
23-09_E-E'	4769512.0	458440.2	5301.9	NM	NM	5035	5011	4979	4960	4935	4923	4882	4858	NM
17-35_D-D'	4771169.5	457678.8	5409.72	NM	NM	5006	4969	4946	4900	NM	4869	4842	4837	4817
13-35_D-D'	4770988.6	457673.9	5437.99	NM	NM	5011	4971	4950	4897	4886	4878	4847	4838	4822
09-35_D-D'	4770808.3	457673.5	5411.29	NM	NM	5013	4971	4934	4906	4897	4867	4833	4825	4812
05-35_D-D'	4770634.2	457673.2	5403.29	NM	NM	5013	4976	4935	4895	4873	4861	4844	4827	4816
01-35_D-D'	4770460.3	457672.8	5384.51	NM	NM	5005	4967	4948	4896	4866	4859	4846	4833	4820
53-36_D-D'	4770282.7	457672.5	5328.91	NM	NM	5002	4971	4950	4894	4865	4857	4843	4835	4825
50-35_D-D'	4770108.8	457672.1	5344.49	NM	NM	5023	4976	4955	4917	4898	4881	4864	4840	4837
35-15_C-C'	4769919.3	456849.6	5331.81	NM	NM	5038	5013	4977	4968	4943	4928	4881	4861	4847
35-09_C-C'	4769915.9	457067.3	5377.69	NM	NM	5037	5009	4981	4967	4934	4921	4871	4850	pinch
35-06_C-C'	4769912.4	457290.3	5325.2	NM	NM	5029	5005	4972	4955	4921	4912	4859	4848	4837
35-01_C-C'	4769908.9	457509.1	5358.12	NM	NM	5027	5005	4967	4954	4921	4911	4854	4846	4830
35-50_C-C'	4769905.4	457733.6	5312.23	NM	NM	5026	5000	4963	4952	4920	4914	4859	4831	4826
35-42_C-C'	4769901.9	457952.2	5290.48	NM	NM	5018	4982	4947	4936	4926	4906	4858	4831	4816
35-34_C-C'	4769898.4	458172.9	5293.66	NM	NM	5024	4986	4951	4935	4927	4884	4863	4823	4810
35-26_C-C'	4769894.9	458395.1	5328.36	NM	NM	5007	4985	4956	4935	NM	4905	4858	4815	4801
35-18_C-C'	4769891.4	458615.5	5358.23	NM	NM	5017	4987	4941	NM	4926	4897	4859	4808	NA
35-9.25C-C	4769884.5	458836.5	5364.38	NM	NM	5009	4982	4940	4926	4911	4886	4842	4812	NA
51-28_B-B'	4770362.6	457258.4	5394.9	NM	NM	5002	4970	4937	4897	4877	4850	NM	4824	4817
51.5-32B-B	4770359.8	457416.2	5360.24	NM	NM	5001	4968	4938	4899	4876	4856	4841	4823	4816
51-37_B-B'	4770356.8	457577.4	5345.65	NM	NM	5008	4978	4943	4920	4880	4870	4854	4838	NM
51-44_B-B'	4770352.7	457799.4	5355.47	NM	NM	5017	4978	4954	4942	4912	4881	4862	4842	NM
51-48_B-B'	4770349.8	457956.6	5369.1	NM	NM	5022	4987	4952	4941	4932	4908	4858	4839	4831
51-52_B-B'	4770346.8	458120.8	5400.46	NM	NM	5031	4990	4959	4929	4921	4911	4852	4839	4830
51-04_B-B'	4770343.9	458277.9	5376.32	NM	NM	5034	4998	4976	4935	4915	NM	4851	4843	4829
51-08_B-B'	4770340.9	458441.5	5386.21	NM	NM	5034	4996	4971	4935	4922	NM	4868	4850	4830
51-12_B-B'	4770338.0	458604.0	5374.91	NM	NM	5031	4997	4973	4953	4945	4923	4868	4856	4832
51-17_B-B'	4770335.0	458762.9	5366.26	NM	NM	5040	5000	4979	4950	NM	4926	4874	4863	4841
7-02_A-A'	4770770.3	456788.9	5401.64	NM	NM	4986	4951	4893	4869	4857	4851	4817	4800	NM
7-06_A-A'	4770768.0	456897.9	5401.74	NM	NM	4983	4944	4906	4868	4854	4840	4822	4801	NM
7-10_A-A'	4770765.7	457007.2	5404.34	NM	NM	4985	4956	4916	4878	4863	4843	4808	4802	NM
7-14_A-A'	4770763.4	457117.8	5402.01	NM	NM	4987	4953	4924	4881	4862	4842	4823	4803	NM
6-18_A-A'	4770761.1	457227.4	5413.78	NM	NM	4992	4961	4925	4882	4862	4851	4826	4806	4800
7.6-21_A-A	4770758.7	457340.3	5417.55	NM	NM	4988	4959	4936	4885	4863	4849	4828	4811	4798
7.6-23_A-A	4770756.4	457450.4	5418.31	NM	NM	4981	4964	4935	4886	4860	4848	4831	4813	4800
7-28_A-A'	4770754.1	457560.5	5409.91	NM	NM	5004	4968	4937	4889	4865	NM	4838	4816	NM
7-32_A-A'	4770751.8	457669.9	5402.46	NM	NM	5013	4974	4951	4896	4876	4872	4841	4825	NM
7-35_A-A'	4770749.5	457778.6	5396.88	NM	NM	5016	4978	4954	4916	4903	4874	4844	4832	4818
7-38_A-A'	4770747.1	457893.7	5394.22	NM	NM	5017	4978	4942	4918	4911	4875	4851	4833	4818
8-42_A-A'	4770744.7	458006.4	5391.96	NM	NM	5018	4983	4942	4921	4916	4895	4854	4832	4822
15-05_W-E	4769272.4	453336.1	5500 *	5223	5165	NM	5092	4983	4948	4921	4896	4794	NA	NA
15-09_W-E	4769266.9	453460.0	5500 *	5227	5172	5157	5046	5001	4943	4925	4892	4805	4758	4725
15-13_W-E	4769265.8	453588.6	5500 *	5259	5158	5155	5047	4999	4951	4931	4893	4816	NA	NA
15-17_W-E	4769268.6	453708.6	5500 *	5271	5178	5155	5027	5007	4958	4930	4898	4814	NA	NA
15-21_W-E	4769268.7	453824.5	5500 *	5283	5190	5063	5026	5012	4954	4925	4898	4811	NA	NA
15-25_W-E	4769264.6	453945.8	5500 *	5324	5101	5072	5028	5013	4953	4925	4892	4840	NA	NA
15-29_W-E	4769263.4	454074.3	5500 *	5274	5102	5074	5014	4988	4946	4931	4900	4844	4831	NA
15-33_W-E	4769259.5	454192.7	5500 *	5263	5125	5082	5013	4979	4940	pinch	4904	4843	4835	NA
15-37_W-E	4769256.9	454310.9	5500 *	5239	5138	5108	5021	4984	4940	pinch	4909	4851	NA	NA
04.35-17SN	4768949.9	453706.1	5500 *	5311	5183	5155	5034	5014	4956	4924	4898	4815	4793	NA
07-17_S-N	4769027.2	453705.7	5500 *	5284	5191	5156	5027	5014	4950	4920	4890	4810	4788	NA
09-17_S-N	4769086.6	453709.4	5500 *	5284	5176	5156	5034	5005	4952	4920	4892	4808	NA	NA
12-17_S-N	4769178.5	453709.6	5500 *	5282	5193	5153	5044	5004	4956	4922	4894	4805	NA	NA
14-17_S-N	4769238.8	453708.0	5500 *	5271	5190	5151	5026	5004	4956	4927	4896	4809	NA	NA
16-17_S-N	4769299.3	453709.2	5500 *	5280	5187	5155	5025	5008	4951	4926	4891	4812	NA	NA
20-18_S-N	4769421.4	453774.3	5500 *	5280	5162	5147	5020	4996	4938	4921	4879	4826	4746	4717
24-17_S-N	4769532.0	453710.0	5500 *	5275	5157	5141	5014	4993	4927	4917	4879	4828	NA	NA
26-17_S-N	4769592.0	453711.4	5500 *	5268	5156	5141	5014	4966	4932	4915	4874	4837	NA	NA

NM = unit not mapped in original boring log
NA = unit elevation not available as well or boring did not penetrate to this depth
* - elevation estimated to allow model to display deeper units

Table Geo 2-1. Northing and Easting Information for the Monitoring Wells Shown on LAR Figure 1-8

Well Number	Well Name	Location Information	
		Northing	Easting
015	TDM DR	76026.2	114074.3
47	DW-18	77474.1	106659.5
112	TDM VII	76565.0	114151.4
114	TDM IX	75580.4	110120.0
116	TDM XI	75600.1	110101.1
117	TDM XII	74253.4	111749.5
120	TDM XXI	76950.8	112068.3
125	TDM XXVI	76128.9	114593.9
127	TDM XXVIII	77262.0	114254.8
128	TDM XXIX	77279.6	114251.1
129	TDM XXX	76922.2	112068.1
131	RM-1	78457.7	100396.1
132	RM-2	77035.0	101325.6
133	RM-3	76000.8	102000.1
134	RM-4	71158.3	106800.2
136	DW-41	72348.0	107537.9
141	DW-46	73583.8	104714.6
142	DW-47	73886.1	103399.0
144	DW-35	76693.8	103409.5
148	TDM XXXII	73813.8	115094.8
150	TDM XXXIV	77550.9	106776.3
151	TDM XXXV	76308.3	107831.5
152	TDM XXXVI	73125.6	112602.0
170	TDM XXXVII	74481.2	107441.9
171	TDM XXXVIII	74268.1	108904.3
172	EM-5	78815.0	107535.1
173	TDM XXXIX	72931.3	109911.7
174	TDM XL	79017.0	102402.1
175	TDM XLI	75518.6	110009.7
176	TDM XLII	77503.7	112195.8
177	TDM XLIII	74138.5	111630.7
178	TDM XLIV	73787.9	111351.6
179	TDM XLV	77978.0	112219.5
180	TDM XLVI	75439.8	109728.7
181	TDM XLVII	78139.9	113512.9
182	TDM XLVIII	79420.0	113590.0
183	TDM XLIX	78129.1	110719.4
NA	MFG-1	874029.5	414525.6
NA	MFG-2	874038.3	414543.5
NA	MFG-3	874047.3	414561.7
NA	BBL-1	873723.4	415383.1
NA	BBL-2	873510.6	415471.2
NA	BBL-3	873158.7	415961.4
NA	BBL-4	871969.4	417072.4
TT-1	TT-1	875807.4	416510.5
TT-2	TT-2	875304.2	415185.3
TT-3	TT-3	873953.9	416639.9
TT-4	TT-4	871562.8	417191.5
TT-5	TT-5	871238.1	417247.1
TT-6	TT-6	871325.9	417583.7
TT-7	TT-7	871699.6	417642.0
TT-8	TT-8	873673.8	415434.6

[1] *The legal location of the wells is unknown.*

[2] *The datum for the MFG wells is WGS 84; the datum for the BBL wells is NAD83. The datum for the other wells is unknown.*

Table GC-1-1: Thermodynamic Adsorption Data for Uranium, Selenium, Nickel, and Chromium (from Minteq.v4)

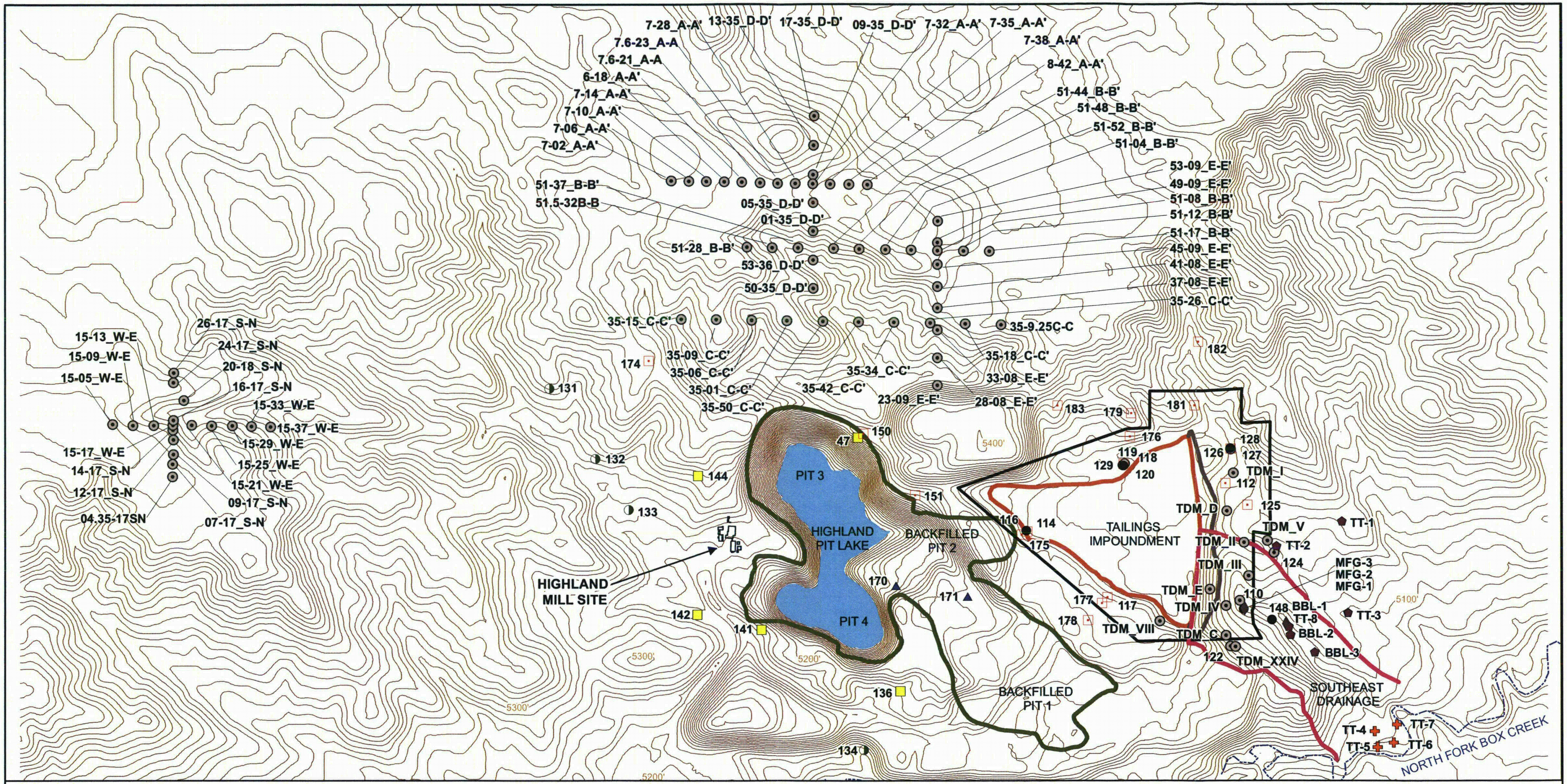
Reaction	Log K
$Hfo\_sOH + UO_2^{+2} = Hfo\_sOHUO_2^{+2}$	5.2
$Hfo\_wOH + UO_2^{+2} = Hfo\_wOUO_2^{+} + H^{+}$	2.8
$Hfo\_sOH + SeO_4^{-2} + H^{+} = Hfo\_sSeO_4^{-} + H_2O$	7.73
$Hfo\_wOH + SeO_4^{-2} + H^{+} = Hfo\_wSeO_4^{-} + H_2O$	7.73
$Hfo\_sOH + SeO_4^{-2} = Hfo\_sOHSeO_4^{-2}$	0.80
$Hfo\_wOH + SeO_4^{-2} = Hfo\_wOHSeO_4^{-2}$	0.80
$Hfo\_sOH + HSeO_3^{-} = Hfo\_sSeO_3^{-} + H_2O$	4.29
$Hfo\_wOH + HSeO_3^{-} = Hfo\_wSeO_3^{-} + H_2O$	4.29
$Hfo\_sOH + HSeO_3^{-} = Hfo\_sOHSeO_3^{-2} + H^{+}$	-3.23
$Hfo\_wOH + HSeO_3^{-} = Hfo\_wOHSeO_3^{-2} + H^{+}$	-3.23
$Hfo\_sOH + Ni^{+2} = Hfo\_sONi^{+} + H^{+}$	0.37
$Hfo\_wOH + Ni^{+2} = Hfo\_wONi^{+} + H^{+}$	-2.5
$Hfo\_sOH + CrO_4^{-2} + H^{+} = Hfo\_sCrO_4^{-} + H_2O$	10.85
$Hfo\_wOH + CrO_4^{-2} + H^{+} = Hfo\_wCrO_4^{-} + H_2O$	10.85
$Hfo\_sOH + CrO_4^{-2} = Hfo\_sOHCrO_4^{-2}$	3.9
$Hfo\_wOH + CrO_4^{-2} = Hfo\_wOHCrO_4^{-2}$	3.9

Table GC-3-1: MFG-1 Uranium Concentration Data and Descriptive Statistics from Minitab®.

Date	Uranium (mg/L) 1
2/24/2005	0.362
10/3/2005	0.372
3/14/2006	0.358
8/18/2006	**0.146**
3/22/2007	**0.298**
8/15/2007	**0.133**
3/17/2008	0.355
4/30/2008	0.395
8/21/2008	0.344
12/11/2008	0.364
2/23/2009	0.358
6/16/2009	0.362
8/19/2009	0.352
11/16/2009	0.388
3/3/2010	0.358
6/8/2010	0.367
8/19/2010	0.371
10/11/2010	0.367
3/22/2011	0.384
6/23/2011	0.383
9/19/2011	0.373
12/6/2011	0.350
3/21/2012	0.368
Descriptive Statistics	
Distribution	**Normal**
N	20
Mean	0.367
StDev	0.013
Median	0.366
Minimum	0.344
95% UPL	0.395

[1] *Values in bold indicate statistical outliers.*

FIGURES



LEGEND

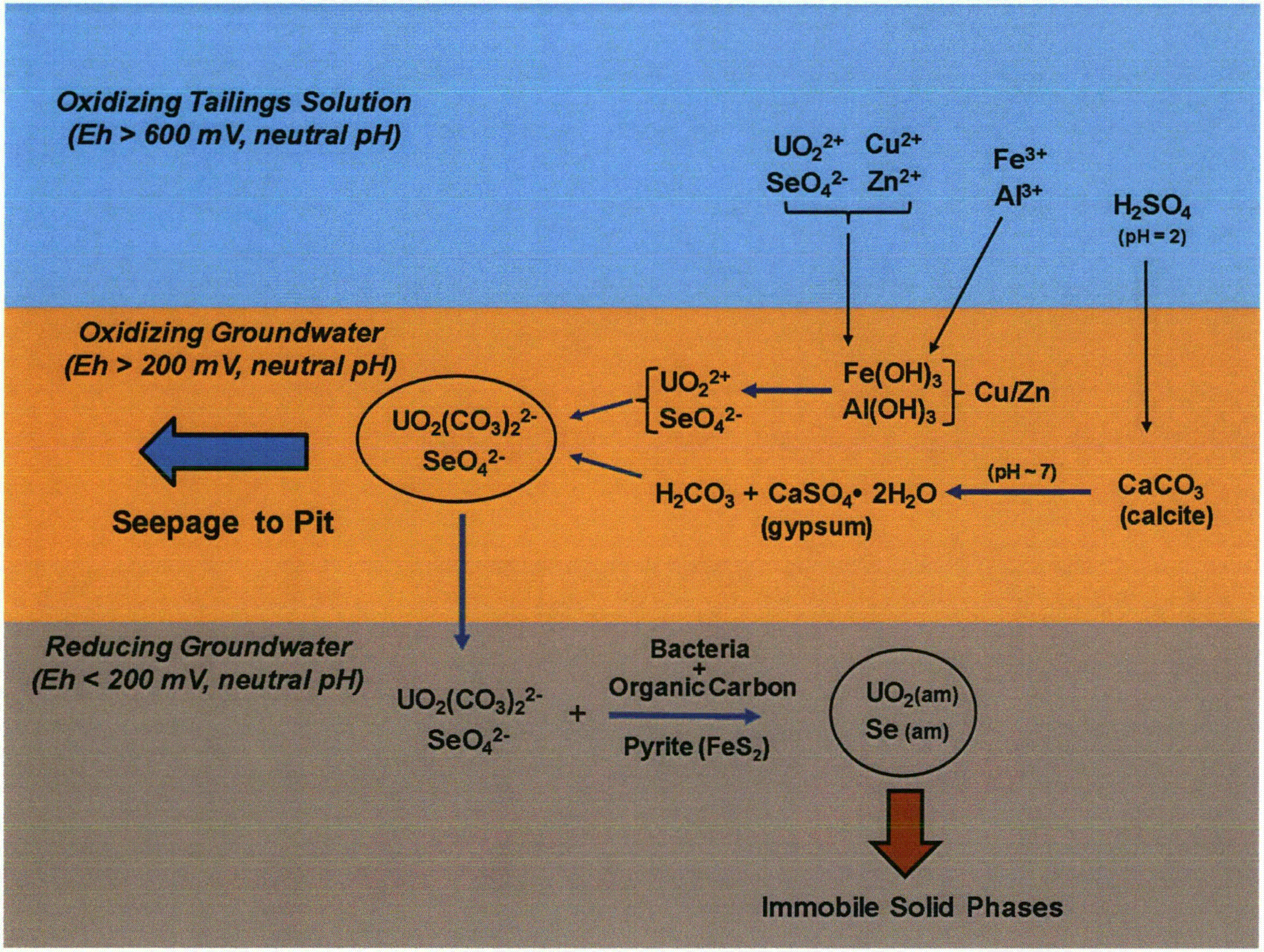
- DEWATERING WELLS OPEN TO ALL LITHOLOGIC UNITS
- WELLS SCREENED IN NORTH FORK BOX CREEK ALLUVIUM
- HYDRAULICALLY ISOLATED WELLS SCREENED IN TDSS
- WELLS SCREENED IN TDSS
- WELLS SCREENED IN 50SS
- WELLS SCREENED IN BACKFILL
- WELLS SCREENED IN REGOLITH
- WELLS SCREENED IN OTHER FORMATIONS
- OTHER WELL AND BORING LOCATION
- SOUTHEAST DRAINAGE AREA
- CREEK
- EXTENT OF MINING
- EXTENT OF TAILINGS
- TAILINGS DAM
- EXISTING LONG-TERM SURVEILLANCE BOUNDARY
- 10 FT ELEVATION CONTOURS

0 1,000 2,000 FEET

CLIENT	ExxonMobil Environmental Services
PROJECT	HIGHLAND MINE & MILL SITE
TITLE	LOCATION OF WELLS AND BORINGS USED IN THE MVS MODEL

amec

DRAWN BY	KMW	CHECKED BY	JW
FILENAME	677520026	DATE	11/28/12
FIGURE No.	GEO1-1		



HIGHLAND MINE & MILL SITE	ExxonMobil Environmental Services			
CONCEPTUAL SITE MODEL	amec	PROJECT No. 677520028	DATE 11/15/12	
		FIGURE No.	H15-1	

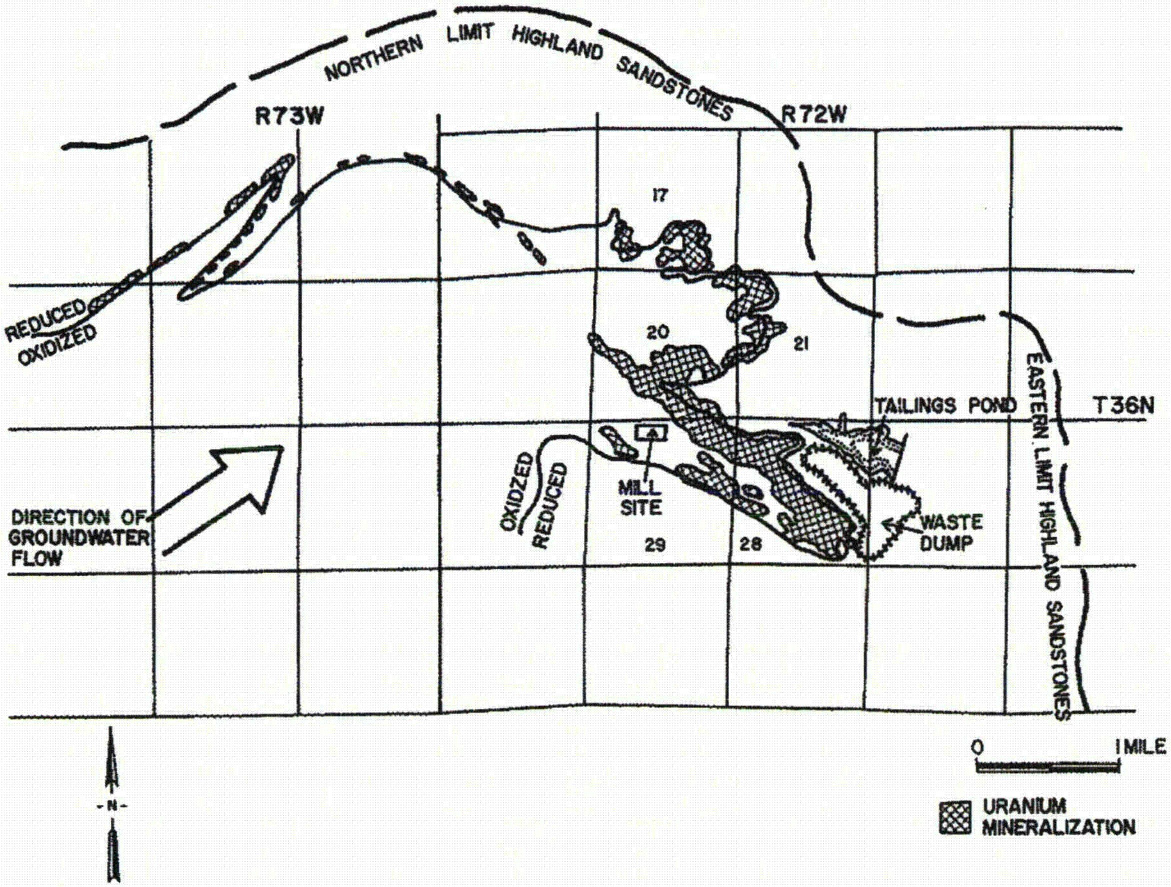
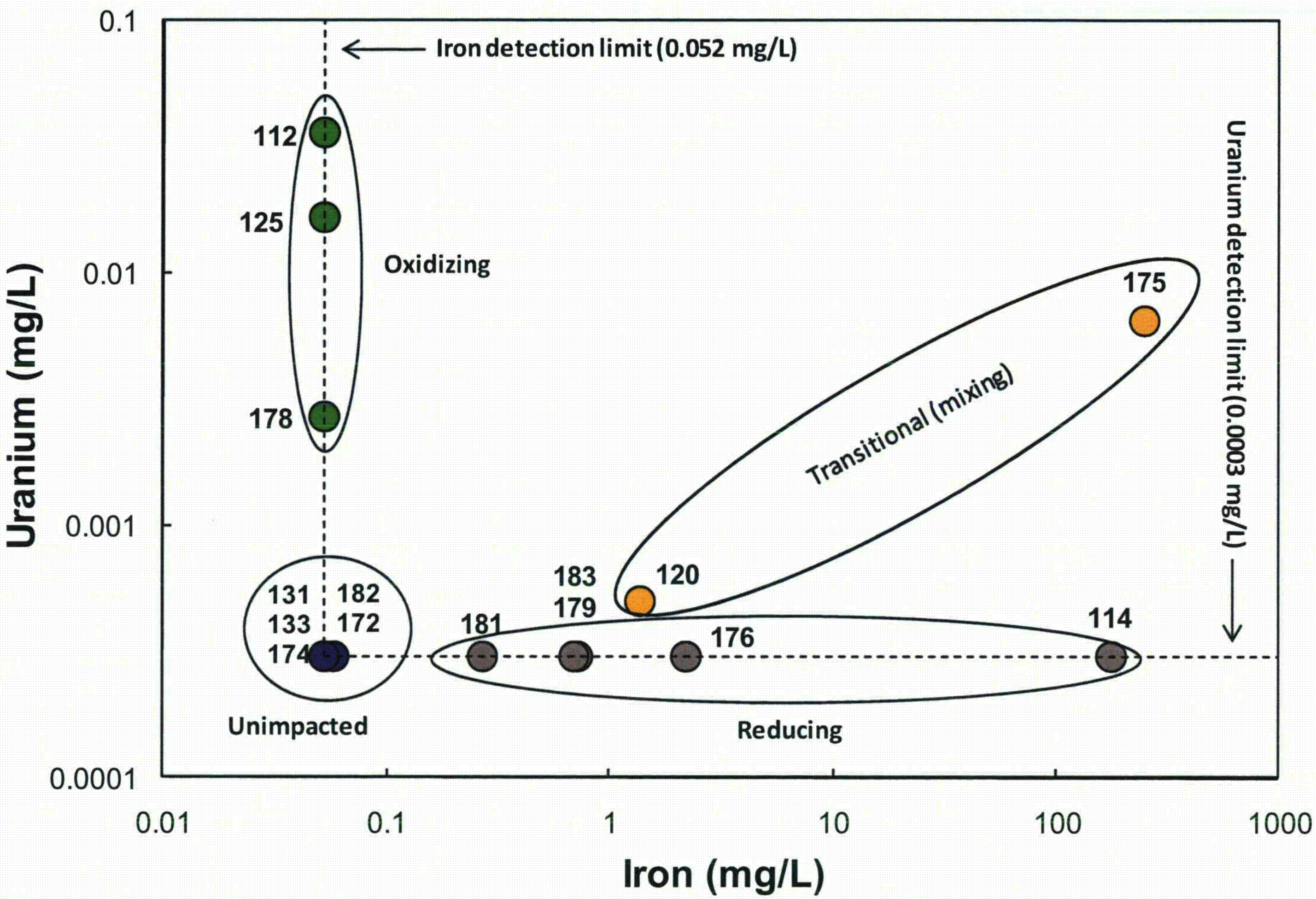
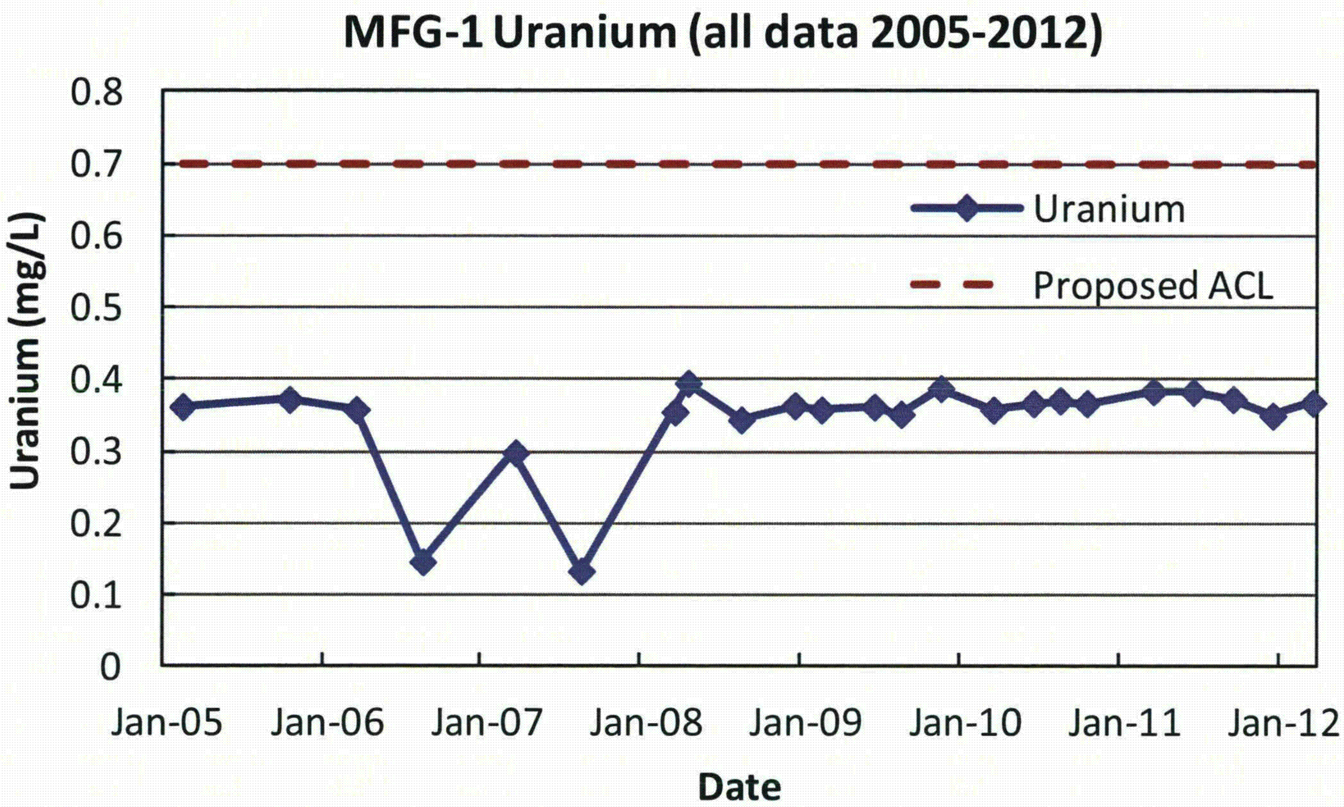


FIG. 8. Geological summary map of Highland Area showing relationship of uranium mineralization, limit of Highland sandstone unit, oxidation-reduction boundary and groundwater flow path.

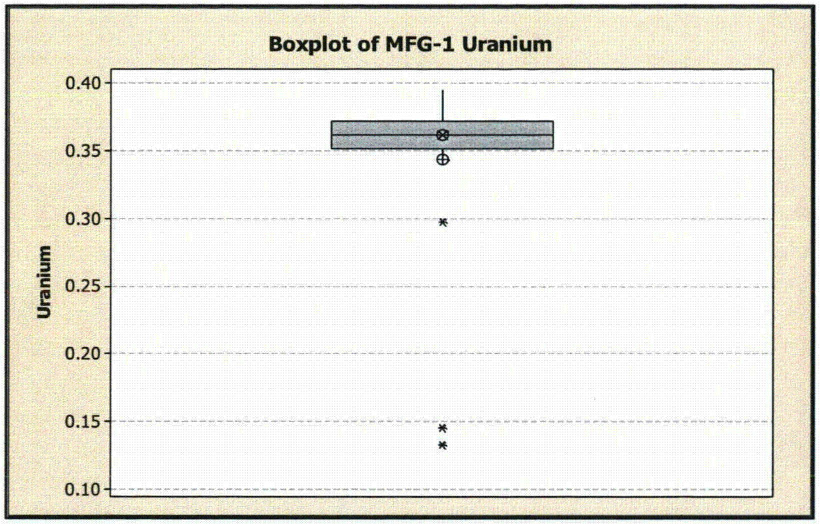
HIGHLAND MINE & MILL SITE	ExxonMobil Environmental Services		
Geological Summary Map of the Highland Area Including Delineation of Redox Boundary (from Dahl and Hagmaier, 1974)	amec	PROJECT No. 677520026	DATE 11/15/12
		FIGURE No.	H15-2

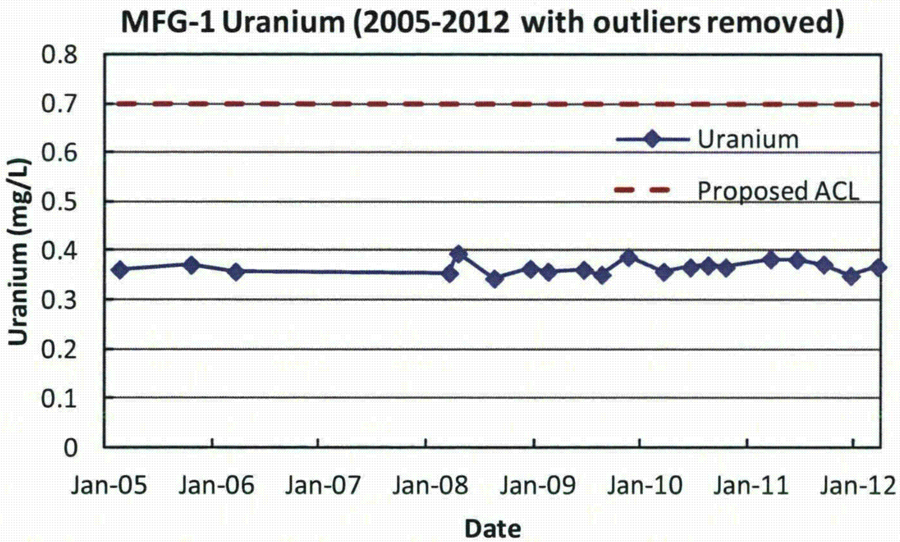


HIGHLAND MINE & MILL SITE	ExxonMobil Environmental Services	
IRON AND URANIUM CONCENTRATIONS IN SELECTED TDSS WELLS	amec	PROJECT No. 677520029 / DATE 11/15/12 / FIGURE No. H15-3

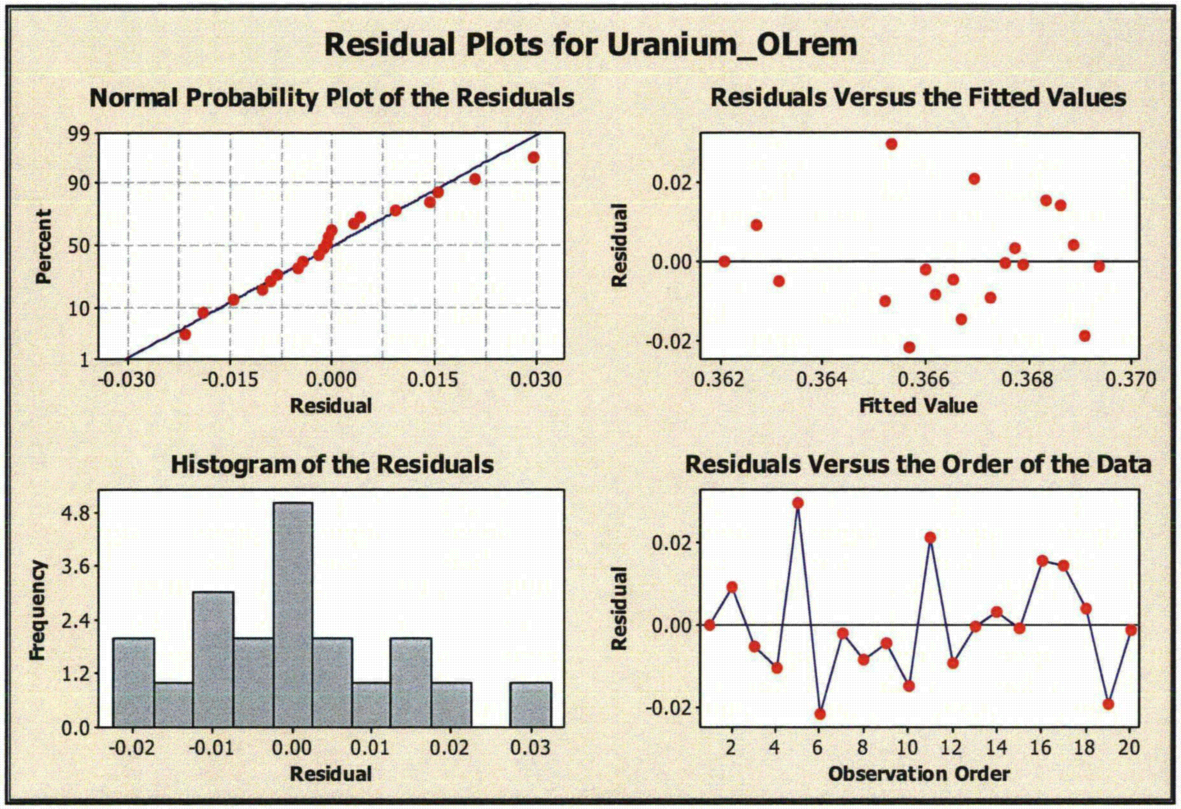


HIGHLAND MINE & MILL SITE	ExxonMobil Environmental Services		
Uranium Trends in Proposed POC Monitoring Well MFG-1	amec	PROJECT No. 677520026	DATE 11/15/12
		FIGURE No. GC-3-1	





HIGHLAND MINE & MILL SITE	ExxonMobil Environmental Services	
Uranium Boxplot Showing Statistical Outliers and Revised MFG-1 Trend Plot With Outliers Removed	amec	PROJECT No. 677520026 DATE 11/15/12
		FIGURE No. GC-3-2



Analysis of Variance					
Source	**DF**	**SS**	**MS**	**F**	**P**
Regression	1	8.31E-05	8.31E-05	0.46	0.506
ResidualError	18	0.00325	0.000181		
Total	19	0.003333			

HIGHLAND MINE & MILL SITE

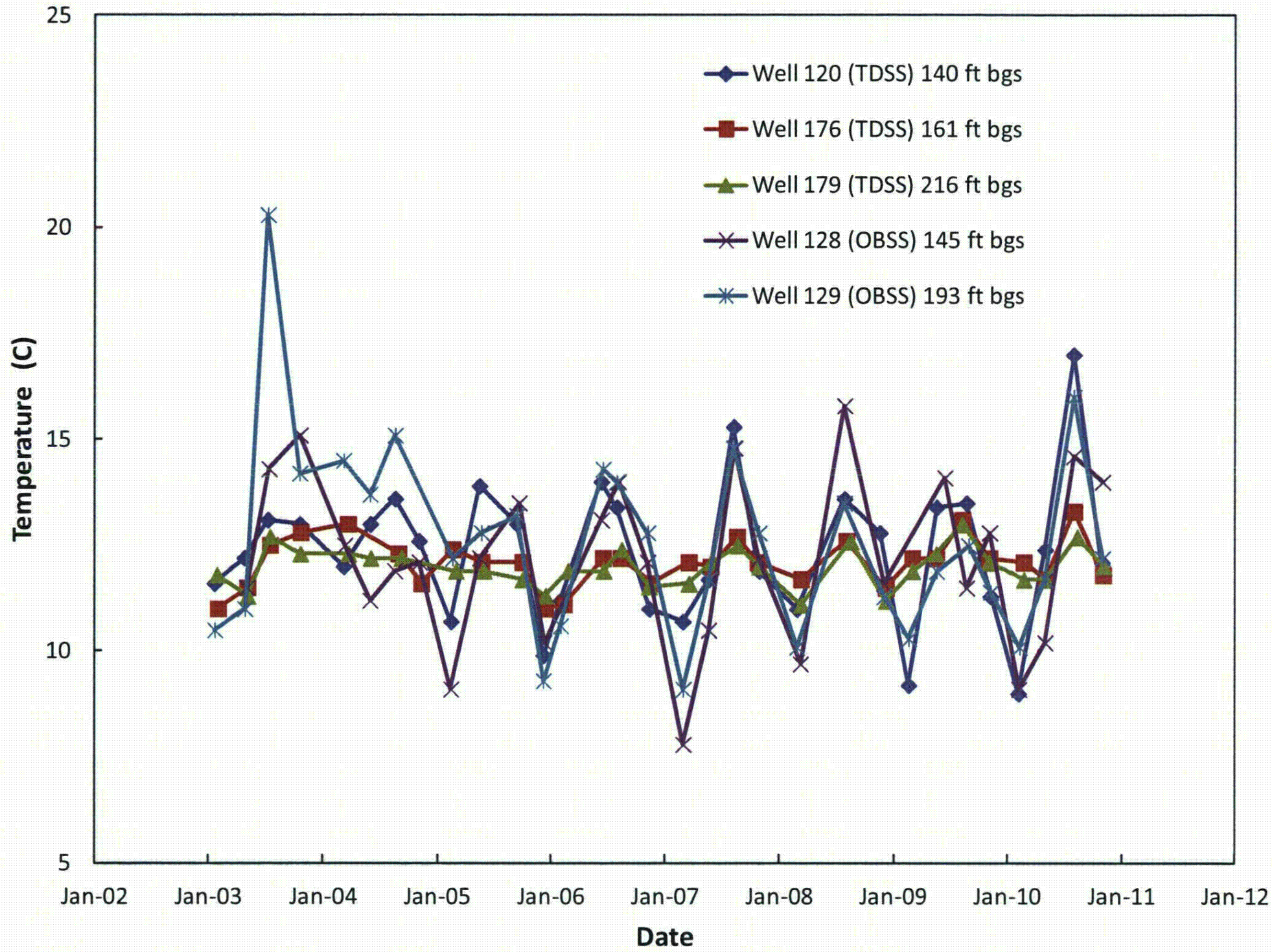
ExxonMobil
Environmental Services

Statistical Trend Analysis Results for Uranium in MFG-1 from Minitab (Outliers Removed)

amec

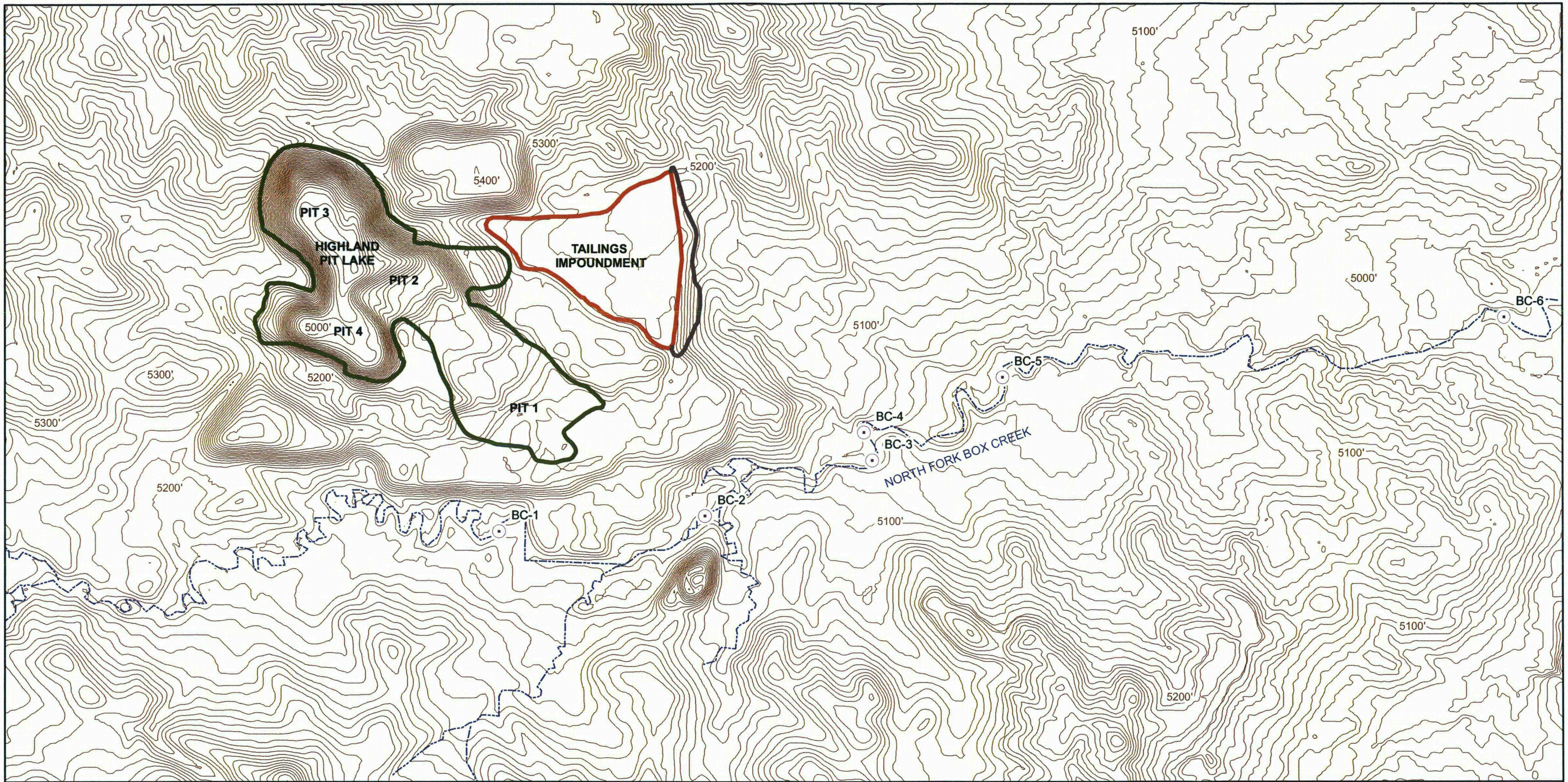
PROJECT No. 677520026 DATE 11/15/12

FIGURE No. GC-3-3



HIGHLAND MINE & MILL SITE	ExxonMobil Environmental Services		
Temperature Variation in Selected TDSS and OBSS Monitoring Wells (depth bgs refers to bottom of well screen)	amec	PROJECT No. 677520026	DATE 11/15/12
		FIGURE No. GC-4-1	

HIGHLAND MINE & MILL SITE	ExxonMobil Environmental Services		
Photograph of North Fork Box Creek Near Sample Location BC-4 Showing Ephemeral Nature of Creek	amec	PROJECT No. 677520026	DATE 11/15/12
		FIGURE No.	HAZ1-1



LEGEND

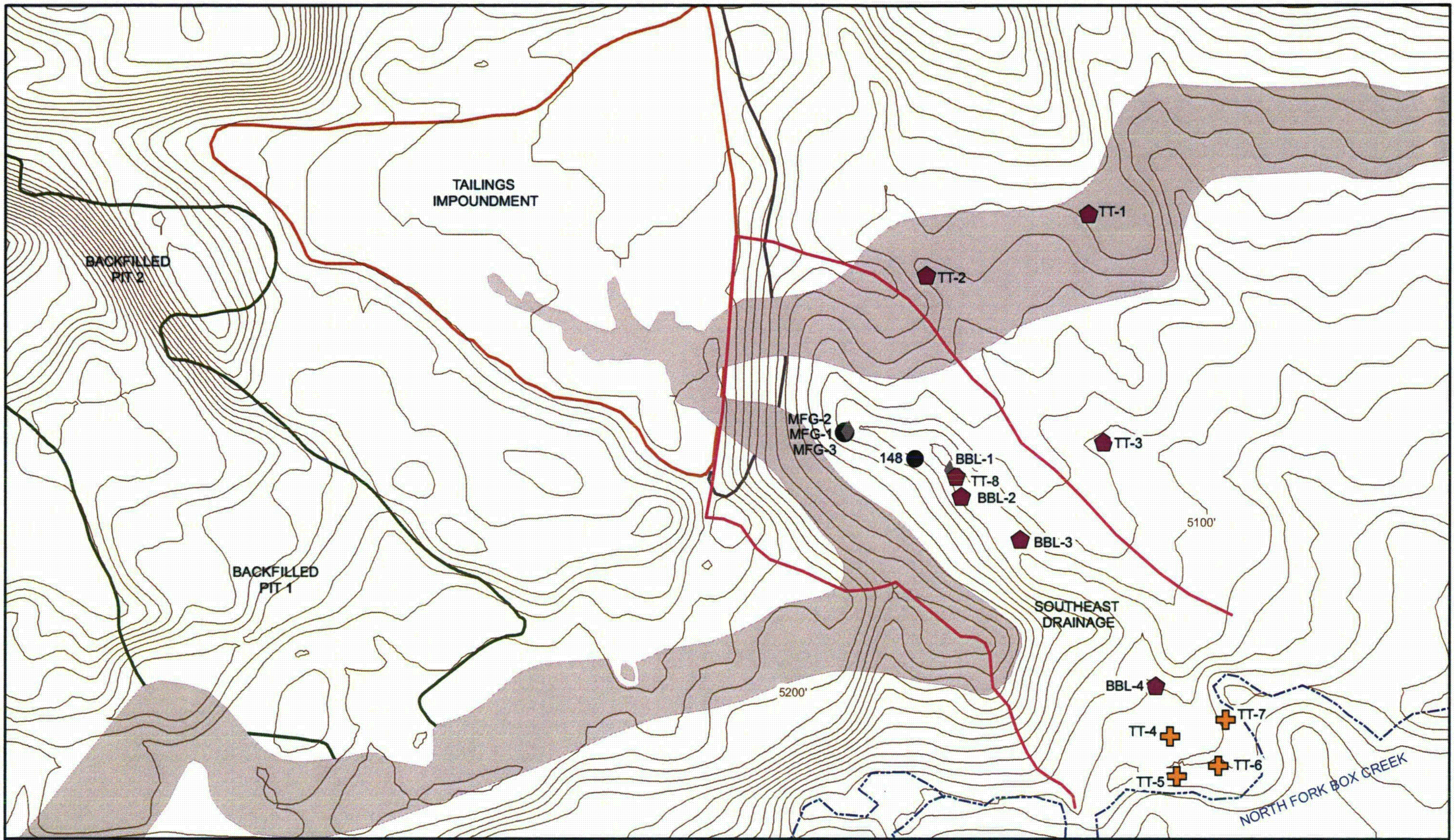
- SURFACE WATER SAMPLING SITE
- CREEK
- EXTENT OF MINING
- EXTENT OF TAILINGS
- TAILINGS DAM
- 10 FT ELEVATION CONTOURS

0 2,000 4,000 FEET

CLIENT	ExxonMobil Environmental Services
PROJECT	HIGHLAND MINE & MILL SITE
TITLE	SURFACE WATER SAMPLING LOCATION MAP

amec

DRAWN BY	KMW	CHECKED BY	BW
FILENAME	677520026	DATE	11/28/12
FIGURE No.	HAZ1-2		



LEGEND

- WELLS SCREENED IN NORTH FORK BOX CREEK ALLUVIUM
- WELL SCREENED IN 50SS
- WELLS SCREENED IN REGOLITH
- WELLS SCREENED IN OTHER FORMATIONS
- TDSS OUTCROP
- 10 FT ELEVATION CONTOURS
- CREEK
- EXTENT OF MINING
- EXTENT OF TAILINGS
- SOUTHEAST DRAINAGE AREA
- TAILINGS DAM

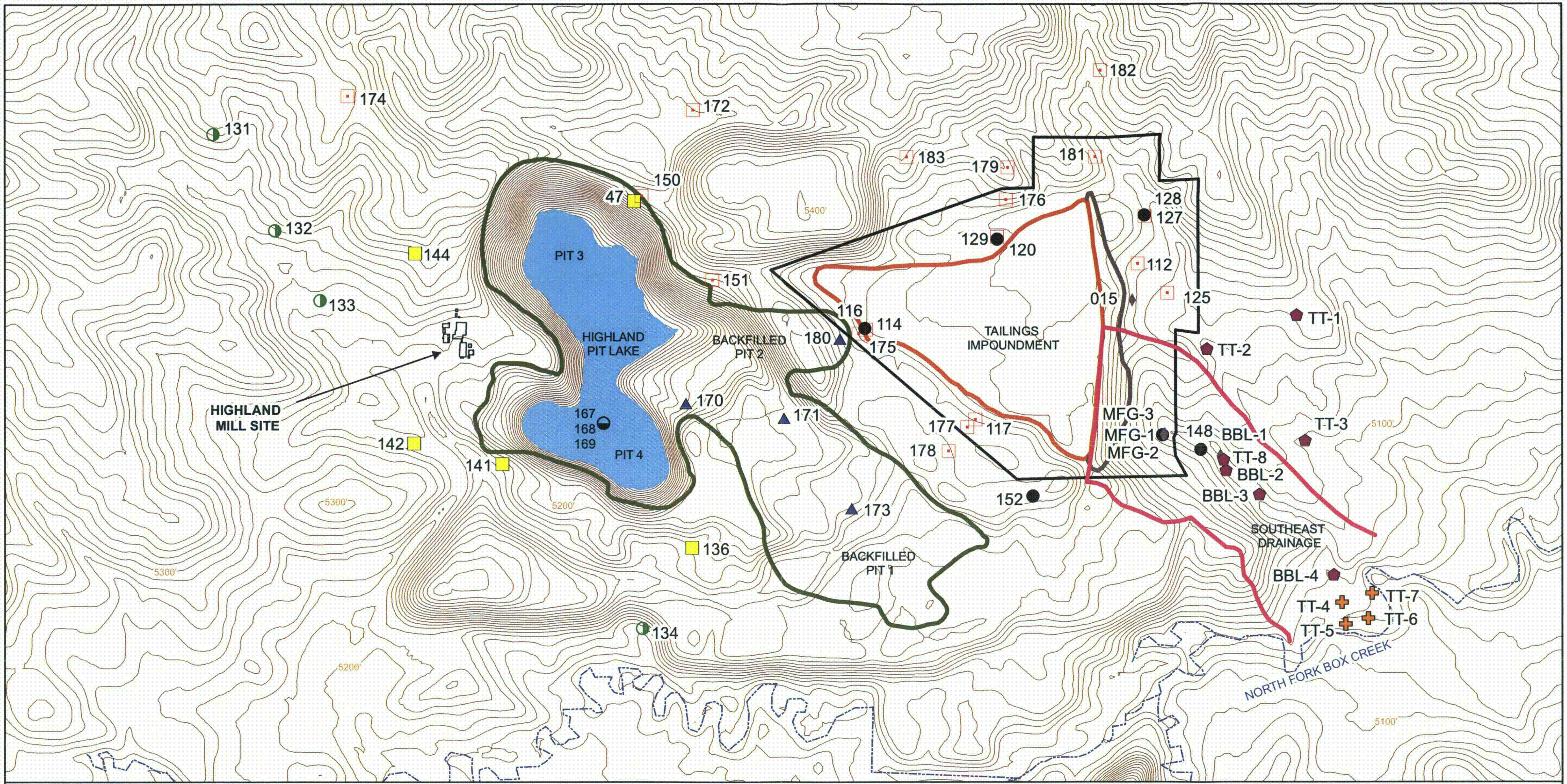
0 750 1,500 FEET

CLIENT	ExxonMobil Environmental Services
PROJECT	HIGHLAND MINE & MILL SITE
TITLE	MONITORING WELL LOCATIONS IN AND ADJACENT TO THE SOUTHEAST DRAINAGE

amec

DRAWN BY	KMW	CHECKED BY	BW
FILENAME	677520026	DATE	11/28/12

FIGURE No. HAZ2-1



LEGEND

- DEWATERING WELLS OPEN TO ALL LITHOLOGIC UNITS
- WELLS SCREENED IN NORTH FORK BOX CREEK ALLUVIUM
- HYDRAULICALLY ISOLATED WELLS SCREENED IN TDSS
- WELLS SCREENED IN TDSS
- WELLS SCREENED IN 50SS
- WELLS SCREENED IN BACKFILL
- WELLS SCREENED IN REGOLITH
- WELLS SCREENED IN OTHER FORMATIONS
- PIT LAKE SAMPLING LOCATION
- SOUTHEAST DRAINAGE AREA
- CREEK
- EXTENT OF MINING
- EXTENT OF TAILINGS
- TAILINGS DAM
- EXISTING LONG-TERM SURVEILLANCE BOUNDARY
- 10 FT ELEVATION CONTOURS

0 1,000 2,000 FEET

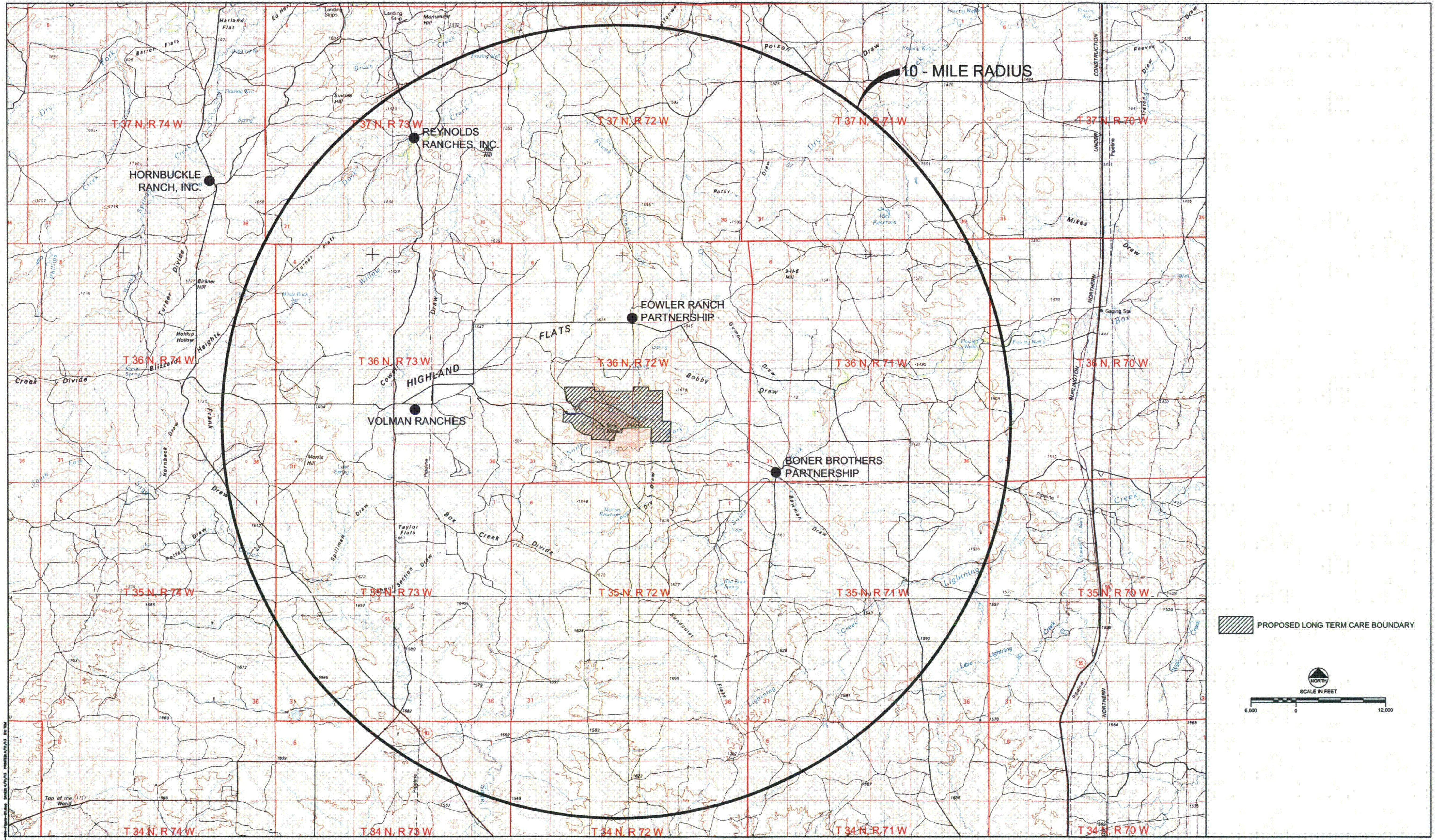
CLIENT: ExxonMobil Environmental Services

PROJECT: **HIGHLAND MINE & MILL SITE**

TITLE: **SITE MAP**

amec

DRAWN BY	KMW	CHECKED BY	BW
FILENAME	677520026	DATE	11/28/12
FIGURE No.	CA1-1		



No.	DESCRIPTION	BY	CHKD.	APPROVED	DATE

REVISIONS

DWG No.	DRAWING TITLE

REFERENCES

ENGINEERING RECORD	BY	DATE

DESIGNERS

PREPARED BY

WORTHINGTON MILLER ENVIRONMENTAL, LLC.

PREPARED FOR

ExxonMobil

TITLE

FIGURE LU-2
HIGHLAND RECLAMATION PROJECT
10-MILE RADIUS RESIDENTS

PROJECT: HIGHLAND	DATE: APRIL 2013	DRAWING	REVISION
SCALE: AS SHOWN	FILE: 10-MILE-FIGURE-01		

ATTACHMENTS

Attachment H1	Highland Mine & Millsite Supplemental Hydrologic and Geochemical Characterization Work Plan
Attachment H3	Highland WL Summaries
Attachment GC-1-1	Electronic Version of Minteq.v4.dat (on compact disc)
Attachment GC-4-1	Letter from Pronghorn

ATTACHMENT H1

Highland Mine & Millsite

Supplemental Hydrologic and Geochemical Characterization

Work Plan

HIGHLAND MINE & MILLSITE SUPPLEMENTAL HYDROLOGIC AND GEOCHEMICAL CHARACTERIZATION WORK PLAN

Prepared for:
ExxonMobil Environmental Services Company

Prepared by:
AMEC Environment & Infrastructure
2000 S. Colorado Blvd., Suite 2-1000
Denver, Colorado 80222

April 8, 2013

Contents

Tables

Figures

1.0 INTRODUCTION

The Highland Uranium Mine and Millsite (Site) is a reclaimed uranium mine encompassing approximately 1,750 acres that includes of a pit lake, tailings impoundment, and waste rock piles. The Site is located in Converse County, Wyoming and is owned by ExxonMobil Corporation (ExxonMobil). On May 12, 2011 ExxonMobil submitted a License Amendment Request (LAR) for U.S. Nuclear Regulatory Commission (NRC) License No. SUA-1139 that included: (1) a proposed supplemental point of compliance (POC) well for located to the southeast of the tailings impoundment and within the Southeast Drainage (MFG-1, uranium ACL = 0.7 mg/L), (2) a new proposed uranium ACL = 3 mg/L in existing POC Well 175, and (3) expansion of the long-term surveillance boundary (LTSB) with new proposed point of exposure (POE) locations for monitoring ACL constituents (Pit Lake and Well Tt-7 adjacent to North Fork Box Creek). Based on a review of the LAR, the NRC staff provided written Requests for Additional Information (RAIs) on May 29, 2012 pertaining to site hydrology and geochemistry. The NRC's primary requests included clarification of assumptions used in the numerical groundwater model prepared by Tetra Tech (Tetra Tech 2007) and additional technical bases to support the conceptual hydrologic and geochemical site models as related to new proposed POC and POE locations.

In a meeting between ExxonMobil and NRC held on August 14th, 2012, the NRC requested that additional work be conducted to update the conceptual and numerical groundwater flow models for the Site. The NRC also requested that new Site investigations be performed to characterize potential secondary sources and extent of subsurface contamination in both the East and Southeast Drainages, and to the north of the tailings impoundment. This proposed hydrological and geochemical work plan is designed to detail activities for collect the information needed to update the conceptual and numerical groundwater models and to further define the magnitude and extent of potential subsurface contamination consistent with NUREG-1620 (USNRC, 2003).

2.0 SUPPLEMENTAL HYDROLOGICAL CHARACTERIZATION

In response to NRC's requests, ExxonMobil has agreed to update the conceptual site model (CSM) and numerical groundwater flow model for the Site. Updating the conceptual model of groundwater flow will include additional data collection. The following work elements have been developed based on review of available data and discussion with NRC:

- Install 20 new monitoring wells to collect water level and water quality data within the primary Ore-Body Sandstone (OBSS) units in the vicinity of the existing pit lake and Tailings Impoundment.
- Perform a detailed review of publically available regional hydrogeologic data, including data from nearby In-Situ Recovery (ISR) mining operations and oil and gas production.

- Update the Site and regional conceptual model of groundwater flow and constituent transport, focusing both on the Highland open pit and the Southeast Drainage.
- Perform additional predictive assessments as necessary, including the potential development of a numerical groundwater flow model, to evaluate long-term conditions related to regional groundwater flow, pit lake development, and flow within the Southeast Drainage.

2.1 Monitoring Well Installation

The primary objective of the proposed additional monitoring wells is to provide water level and water quality data specific to the individual OBSS units at the Site. Screened intervals of new monitoring wells will be targeted specifically to these units, designated as the 30 Sandstone (30SS), 40 Sandstone (40SS), and 50 Sandstone (50SS). Monitoring wells have been targeted for seven locations in the vicinity of Highland Pit Lake and the Tailings Impoundment, as shown on Figure 1. A nest of three monitoring wells is planned for six of the locations, targeting the 30SS, 40SS, and 50SS units. At the location north of the pit lake, two additional wells are planned to target the 40SS and 50SS units, as data are already available from the 30SS from the nearby ISR mine unit operated by Cameco Resources (Cameco). A summary of the proposed Site monitoring wells is provided in Table 1.

Table 1: Summary of Proposed Site Monitoring Wells for Hydrogeologic Characterization

Monitoring Well Grouping	Well	OBSS Target	Estimated Depth (ft)
Group 1 (near DW-35/144)	1	30SS	450
	2	40SS	390
	3	50SS	340
Group 2 (between DW-46 and DW-47)	4	30SS	370
	5	40SS	320
	6	50SS	250
Group 3 (near RM-4)	7	30SS	300
	8	40SS	250
	9	50SS	200
Group 4 (near DW-41)	10	30SS	325
	11	40SS	250
	12	50SS	215
Group 5 (near 117 and 177)	13	30SS	350
	14	40SS	300
	15	50SS	275
Group 6 (near DW-18)	16	40SS	340
	17	50SS	305
Group 7 (near well 183)	18	30SS	350
	19	40SS	300
	20	50SS	275

At each monitoring well location, the deepest boring will first be drilled using air-rotary techniques at a 10-inch diameter. Depths in Table 1 have been estimated based on previous drilling at the site to ensure that the deepest borings penetrate the bottom of the 30SS unit. The following geophysical logs will be performed in the open boreholes:

- Radioactivity Logging
    - Spectral Gamma Ray
- Electrical Logging
    - Spontaneous Potential
    - 16-inch Short Normal Resistivity
    - 64-inch Long Normal Resistivity
    - 6-foot Lateral Resistivity
    - Focused Resistivity
- Mechanical Logging
    - Caliper

Nested monitoring wells (Groups 1 through 7) will be installed at each location (Figure 1) as summarized in Table 1. Data from the geophysical logs will be used to identify the depth and thicknesses of the OBSS units and to define proper well depths and screened intervals. Each monitoring well will be completed using 5-inch Schedule 40 polyvinyl chloride (PVC) screen and blank casing with 0.020-inch slotted PVC well screen interval. Filter pack material (well-graded, clean sand, generally less than 2 percent by weight passing a No. 200 sieve and less than 5 percent by weight of calcareous material) will be placed in the annular space around the well screen and will extend to approximately 0.5 foot below to 2 feet above the top of the well screen. Approximately 3 feet of bentonite chips or pellets, hydrated in stages, will be placed above the top of the filter pack. The annular space above the bentonite transition seal will be filled with a neat cement grout, cement/bentonite grout, or high-solids bentonite grout to the ground surface. Monitoring well construction will be completed in accordance with Wyoming State Engineer's Office Water Well Minimum Construction Standards for monitoring wells

Water level data from the newly installed monitoring wells will be collected on a monthly basis for at least a six-month period, extending over two quarterly monitoring rounds for the other wells onsite. Water quality samples will be collected within the newly installed wells over two quarterly monitoring rounds. The chemical constituent list for water quality sampling will include constituents currently required for all Site compliance monitoring under USNRC License No. SUA-1139. In addition to the compliance analytes, samples will also be analyzed for ferrous iron as an indicator of redox conditions and uranium isotopes to supplement previous isotopic data collected at the Site.

2.2 Regional Hydrogeologic Data Review

Significant ISR mining is occurring within the vicinity of the Highland site, primarily at Cameco's Smith Ranch–Highland and Reynolds Ranch (SRH-RR) satellite ISR facilities. Many of the sandstone units being mined are consistent with the OBSS units encountered at the Highland Site. ExxonMobil will review all publically-available hydrogeologic information associated with the nearby ISR mining activities, including information reported to both the State of Wyoming and the NRC. Information to be reviewed will include water levels, aquifer test data, water quality, and mine production data. These data will be used for assessing regional groundwater flow conditions in relation to the Highland Site.

2.3 Update Regional and Site Conceptual Models

ExxonMobil discussed the current conceptual model of groundwater flow and constituent transport in its ACL application (EMES, 2011). The groundwater CSM was based on detailed review of available historic information and recent water level and water quality monitoring at the Site. The CSM will be updated, as appropriate, based on data from newly installed monitoring wells (Table 1) and additional available regional hydrogeologic data (Section 2.2). The updated CSM will form the basis for updated predictive analysis of long-term groundwater flow and constituent transport at the Site.

2.4 Additional Predictive Groundwater Flow Assessments

ExxonMobil will perform additional predictive assessments, as necessary, of long-term groundwater flow conditions at the Site. The methods used for additional assessments will be developed based on newly acquired data and the updated CSM, and may include spreadsheet analysis, analytical models, or numerical groundwater flow modeling. ExxonMobil will develop a scope of work for predictive assessments for NRC review prior to performing the assessments. Results are expected to be reported as an Addendum to the current ACL application (EMES, 2011).

3.0 SUPPLEMENTAL GEOCHEMICAL CHARACTERIZATION

The geochemical component of this work plan is designed to complete data gaps associated with the stated guidelines for characterization of geochemical conditions and water quality presented in Section 4.1.3 (3) of NUREG-1620 (USNRC, 2003). Additional data will be collected to better:

- Define the extent of contamination - Additional groundwater wells will be installed for monitoring water quality to the North and surrounding the pit lake;
- Evaluate the source term - Geochemical characterization of vadose zone and saturated zone aquifer materials will be conducted to identify potential secondary sources;

- Characterize the subsurface geochemical properties - The chemical and mineralogical properties of aquifer materials will be characterized to refine inputs for geochemical modeling;
- Identify contaminant attenuation mechanisms - Knowledge of attenuation mechanisms is ultimately required to improve the CSM and for geochemical modeling (NRC, 2003). The chemical and mineralogical characterization of the aquifer materials will provide insight into mechanisms such as ion exchange by clay minerals, surface adsorption by mineral oxides, and possible redox reactions.

3.1 Eastern Drainage

Well 125 serves as the POC at the Eastern Drainage and has been monitored since 1986. Chloride and sulfate concentrations in POC Well 125 have exceeded those observed in background Well 182, indicating potential for tailings impacts in the Eastern Drainage. Both chloride and sulfate in Well 125 have been decreasing steadily since about 1990 and are approaching background levels. Groundwater data indicates that concentrations of arsenic, chromium, gross alpha, and nickel have remained less than their respective ground water protection limits (GPLs) and concentrations of cadmium, lead, radium-226+228 have not exceeded their respective GPL for more than 20 years in Well 125. An ACL of 0.089 mg/L for uranium was established via License Amendment 49 approved in May of 1999. The concentration of uranium has been decreasing since about 1989 and is now below the MCL (of 0.03 mg/L), and the concentration of selenium has also been below the MCL since 1989. Thorium-230 activity ranged from <0.2 pCi/L to 0.4 pCi/l from 1991 to 2006, since then the activity has fluctuated considerable and has been detected possibly at or above the GPL of 0.55 pCi/L on several occasions.

In response to a previous NRC request for additional characterization to the east and southeast of the impoundment, ExxonMobil installed three monitoring wells in the Eastern Drainage (Tt-1, Tt-2, and Tt-3) between December 2008 and January 2009. Wells Tt-2 and Tt-3 are located in the first drainage to the east of tailings impoundment and downgradient of POC Well 125. The wells are screened within the regolith at depths of 75.9 (Tt-2) and 67.3 (Tt-3) feet bgs. Well Tt-1 is located on a ridge further to the east and is screened in the regolith at 92.8 ft bgs. The wells have been monitored quarterly since 2009 and the data indicate that:

- Arsenic, cadmium, chromium, gross alpha, lead, nickel, radium-226+226, selenium, and thorium-230 concentrations in Tt-1, Tt-2, and Tt-3 are often non-detectable or present at very low concentrations. Groundwater data from these wells indicate that the constituents have not exceeded their respective GPLs.
- Uranium has been consistently detected in Eastern Drainage regolith wells at concentrations above background (Well 182), with decreasing concentrations

in the downgradient direction from Tt-2 to Tt-3. However, uranium concentrations are below the site GPL and show no increasing trends.

To evaluate potential secondary sources and background concentrations, seven shallow regolith borings are proposed for the Eastern Drainage. Five of the seven proposed regolith borings (Figure 1) are intended for evaluation of potential secondary sources in the Eastern Drainage. Two additional regolith borings further to the northeast (Figure 1) will provide information on background constituent concentrations within the regolith and OBSS aquifer materials. Each regolith boring will be located in the center of the drainage and will extend to a depth of approximately 75 feet (Table 2). A sample of the regolith will be collected from above and below the saturated zone for a total of 14 samples from the regolith borings.

Table 2: Highland Proposed Borings for Supplemental Geochemical Characterization

Area	Number of Borings	Estimated Total Depth (ft)	Number of Samples
Eastern Drainage	7	75	14
Southeast Drainage	8	50	16
Total Numbers and Feet Drilled by Type	15	925	30

The aquifer samples will be analyzed for concentrations of total and extractable hazardous constituents (arsenic, chromium, gross alpha, nickel cadmium, lead, radium-226+228, uranium, selenium, and thorium-230). Total concentrations will be measured from a strong-acid digestion of the sample (e.g., Method SW 3050). Leachable concentrations of hazardous constituents and indicator parameters (pH, chloride, sulfate) will be measured using the Meteoric Water Mobility Procedure (MWMP) to evaluate the potential for their dissolution and mobility in the subsurface (ASTM, 2003).

Additional aquifer sample characterization will include total organic carbon content, bulk and clay mineralogy using X-ray diffraction (XRD) analysis, cation exchange capacity, calcite and gypsum content, and amorphous iron content. The chemical and mineralogical characterization will provide direct measurements of those geochemical parameters necessary to understand the potential for attenuation of groundwater contaminants (NRC, 2003).

3.2 Southeast Drainage

Well MFG-1 is the proposed new POC Well for the Southeast Drainage. Concentrations of sulfate and chloride in wells MFG-1 (50SS) and MFG-2 (40SS) are above background concentrations as measured at Well 182. The concentration of uranium is also above background and the MCL at Well MFG-1. Uranium concentrations also exceeded background and the MCL in several downgradient monitoring wells (BBL-2, BBL-3, BBL-4, TT-4, TT-5, TT-7, and TT-8). Although selenium and radium-226+228 are below their respective MCLs in MFG-1 and other upgradient wells (BBL-1 and TT-8), concentrations of selenium above the MCL has been observed in Well BBL-2 and radium-226+228 above the MCL has been measured in Well BBL-3. Additional characterization is required to understand whether these discontinuous observations are isolated occurrences or potentially indicate the presence of a secondary source term, and how these contaminants may be associated with those in proposed POC Well MFG-1.

Eight shallow regolith borings are proposed for additional characterization of the Southeast Drainage, with emphasis on the downgradient edge of the impoundment and in the vicinity of wells BBL-1, BBL-2, and BBL-3 (Figure 1). The eight regolith borings will be located in the channel centers along the Southeast Drainage and will extend to a depth of approximately 50 feet (Table 2). A sample of the regolith will be collected from above and below the saturated zone for a total of 16 samples from the regolith borings (Table 2).

In a manner identical to the Eastern Drainage characterization study (Section 3.1), the Southeast Drainage aquifer samples will be analyzed for concentrations of total and extractable hazardous constituents (arsenic, chromium, gross alpha, nickel cadmium, lead, radium-226+228, uranium, selenium, and thorium-230). Total concentrations will be measured from a strong-acid digestion of the sample (e.g., Method SW 3050). Leachable concentrations of hazardous constituents and indicator parameters (pH, chloride, sulfate) will be measured using the Meteoric Water Mobility Procedure (MWMP) to evaluate the potential for their dissolution and mobility in the subsurface (ASTM, 2003).

Additional aquifer sample characterization will include total organic carbon content, bulk and clay mineralogy using X-ray diffraction (XRD) analysis, cation exchange capacity, calcite and gypsum content, and amorphous iron content. The chemical and mineralogical characterization will provide direct measurements of those geochemical parameters necessary to understand the potential for attenuation of groundwater contaminants (NRC, 2003).

3.3 North Area

Well 176 is screened in the TDSS and is the licensed POC well for groundwater protection to the north of the impoundment. Well 176 contains non-detectable uranium concentrations but with increasing and elevated concentrations of chloride and sulfate. Radium-226+228 activities have historically fluctuated above and below the GPL of 5 pCi/L in Well 176.

Increasing sulfate and chloride concentrations in TDSS Well 176, in addition to TDSS Wells 183 and 179, may indicate continued migration of the seepage front to the north. However, the concentrations of hazardous constituents to the north are currently below GPLs in TDSS Wells 179, 181, and 183. Wells 128 and 129 are completed in the OBSS (50ss) beneath and on the northern edge of the tailings impoundment. The concentrations of chloride and sulfate in Well 128 are equivalent to background and relatively stable and hazardous constituents are all below their respective GPLs. In contrast, the concentrations of chloride and sulfate as well as selenium are elevated above background in Well 129 and fluctuate widely. However, chemical data from these wells must be interpreted cautiously as both Wells 128 and 129 are essentially dry and only produce 2.0 and 1.25 gallons of water quarterly and cannot be purged before sample collection.

Therefore, the proposed North Area monitoring wells (in the vicinity of Well 183) are located to better define the current extent of indicator and COC constituents in the OBSS to the north (Figure 1). The Group 7 Wells (Table 1) will consist of a cluster of three wells screened in the 50SS, 40SS, and 30SS units. Water quality samples will be collected within the newly installed wells over two quarterly monitoring rounds. The chemical constituent list for water quality sampling will be as currently required for all Site compliance monitoring under USNRC License No. SUA-1139. In addition to the compliance analytes, samples will also be analyzed for ferrous iron as an indicator of redox conditions and uranium isotopes to better understand the uranium isotopic signature in the OBSS.

4.0 REFERENCES

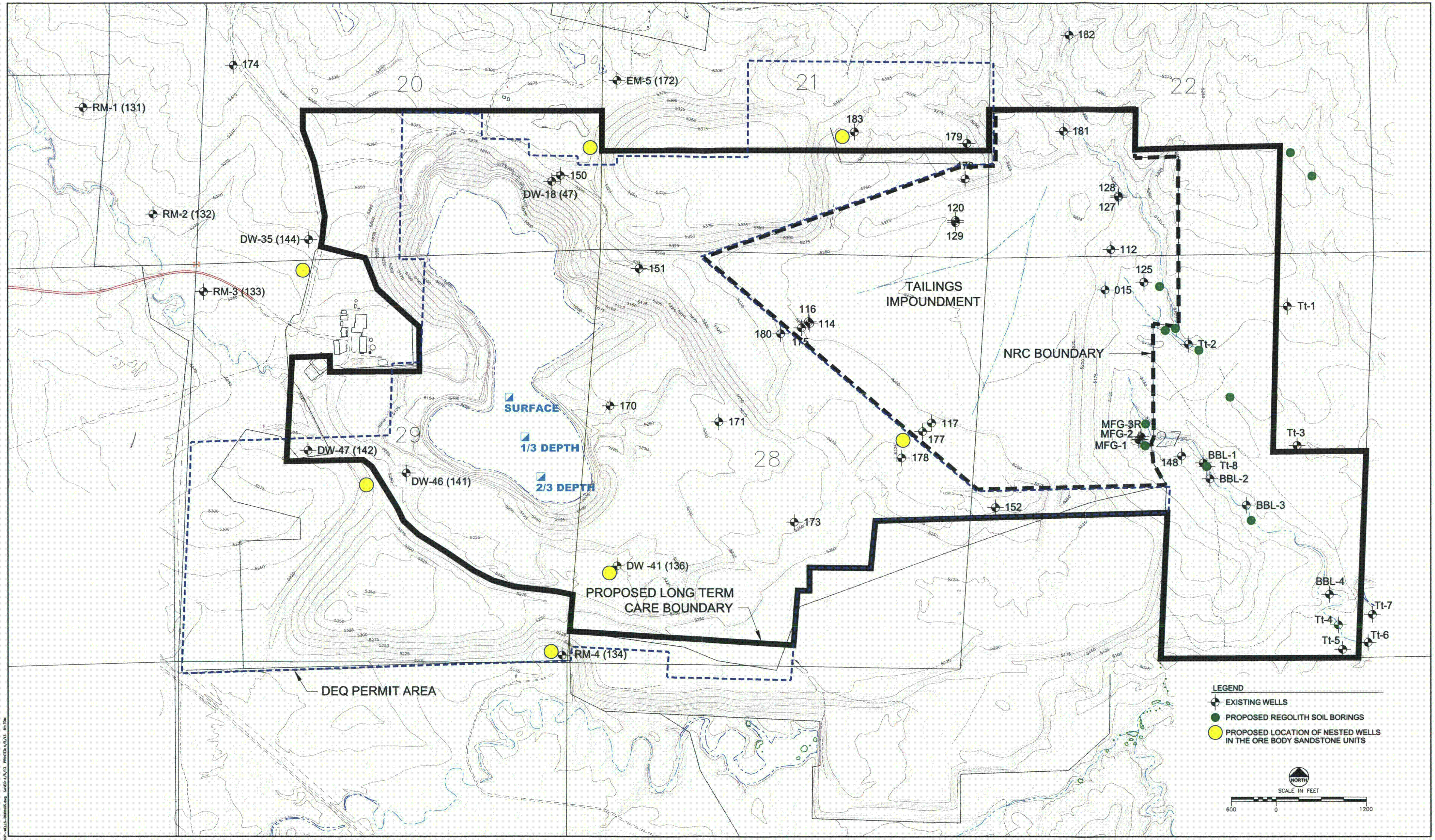
American Society for Testing and Materials (ASTM). 2003. Standard Test Method for Column Percolation Extraction of Mine Rock by the Meteoric Water Mobility Procedure. Designation E 2242-02. ASTM International, West Conshohocken, PA.

ExxonMobil Corporation (ExxonMobil). 2011. Highland Uranium Mine and Millsite Request for Amendment to Radioactive Materials License SUA-1139: Application to Amend Existing Alternate Concentration Limits. May.

Tetra Tech, Inc. 2007. Long Term Pit Lake and Groundwater Hydrology at the Highland Mine Site. Prepared for ExxonMobil (Fairfax, VA). May 17.

U.S. Nuclear Regulatory Commission (USNRC). 2003. Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Under Title II of the Uranium Mill Tailings Radiation Control Act of 1978. Final Report. Office of Nuclear Material Safety and Safeguards. Washington, D.C.

Figure 1. Property Map with Existing and Proposed Wells



No.	DESCRIPTION	BY	CHKD.	APPROVED	DATE

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REFERENCES

ENGINEERING RECORD	BY	DATE

DESIGNERS

PREPARED BY

WORTHINGTON MILLER ENVIRONMENTAL, LLC.

PREPARED FOR

ExxonMobil

TITLE

PROPERTY MAP WITH EXISTING AND PROPOSED WELLS

PROJECT: HIGHLAND
DATE: APRIL 2013
DRAWING:
REVISION:
SCALE: AS SHOWN
FILE: PROP-WELLS-BORINGS