

REVISED FINAL WORK PLAN

August 2, 2012

Prepared for:

Rio Algom Mining LLC

Supplemental Site Assessment to Address Out-of-Compliance Status at Trend Wells RL-1 and EF-8

Lisbon Facility



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LISBON FACILITY, RIO ALGOM MINING LLC**

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1.0 INTRODUCTION

Montgomery & Associates (M&A) has prepared this work plan on behalf of Rio Algom Mining LLC (RAML) for a supplemental site assessment (SSA) to address out-of-compliance (OOC) status at Trend Wells RL-1 and EF-8 at the Lisbon Facility located near La Sal, Utah (Site).

1.1 CHRONOLOGY AND BACKGROUND INFORMATION

Uranium mining and milling occurred at the Site from 1972 to 1989. Seepage from two tailings impoundments constructed during mining is suspected to have resulted in uranium contamination in groundwater beneath the Site. The tailings impoundments were covered with impervious material in the mid-2000s to prevent further impacts. **Figure 1** shows the current site features.

In 2001, RAML submitted an Application for Alternate Concentration Limits (ACLs) and in 2003 a response to request for further information document (Lewis Water Consultants, Inc., 2001; KOMEX, 2003). In response to the approved 2003 Application for ACLs, a Long

Term Groundwater Monitoring Plan (LTGMP) was prepared in 2004 (KOMEX, 2004). Since 2004, groundwater monitoring has been conducted at the Site in accordance with the LTGMP. Groundwater monitoring activities are also conducted in accordance with Section 53 of Radioactive Materials License No. UT 1900481 (License), issued by the Utah Division of Radiation Control (DRC) in January 2010. The primary constituent of concern (COC) in groundwater at the Site is uranium. Other COCs include molybdenum, selenium, and arsenic. Total dissolved solids, chloride, sulfate, bicarbonate, and groundwater elevation are also monitored at the Site.

Trend wells RL-1 and EF-8 are currently out of compliance with the License because uranium concentrations in groundwater have exceeded Target Action Levels (TALs) for more than two consecutive sampling events at these wells, as shown on **Figures 2 and 3**. In a February 7, 2011 letter to RAML, the DRC requested that RAML contract with an independent consultant to address the out-of-compliance status at Trend Well RL-1 (DRC, 2011a). Specifically, DRC requested that the consultant carry out the following actions: (1) review pertinent information and documents, including the existing ACL model, relevant laboratory data, the LTGMP and (2) provide potential additional groundwater modeling, as appropriate. In the letter, DRC requested that RAML prepare an Action Plan to address the following performance objectives (POs):

- PO #1 – Justify whether the current RL-1 data set is or is not sufficient to depict the uranium concentration trend;
- PO #2 – Conclude with definitive evidence whether the Lisbon Valley Facility is operating within or outside of the analyzed condition of the Nuclear Regulatory Commission (NRC) approved “Application for Alternate Concentration Limits” (Approved May 11, 2004), and LTGMP, and;
- PO #3 – Determine whether the ACL model should be revisited/ revised to account for more recent data.

The Action Plan was prepared by M&A on behalf of RAML and submitted to DRC on June 1, 2011 (M&A, 2011a). In accordance with the Action Plan, M&A conducted an evaluation of hydrogeologic conditions, groundwater quality, and the ACL groundwater model. A technical memorandum summarizing the evaluation was submitted to DRC on August 10, 2011 (M&A, 2011b). As discussed in the memorandum, M&A recommended that additional work be conducted at the Site before final conclusions could be reached on the POs. On October 13, 2011, representatives from RAML, M&A, and DRC met to discuss the results of the evaluation and develop a plan to address compliance conditions at the Site. During the meeting, conceptual aspects of the SSA were discussed and RAML agreed to submit a work plan for the SSA by December 16, 2011.

The initial work plan was submitted to DRC on December 16, 2011, in accordance with Condition 56 of Amendment 4 of Radioactive Materials License No. UT 1900481. The initial work plan outlined a two-phase probabilistic groundwater modeling approach to aid in development of the SSA field program, evaluation of the SSA results, and re-establishment of compliance conditions at the Site. The Phase 1 groundwater modeling (**Task 1** of the initial work plan) was completed in March 2012 as planned.

The DRC issued comments on the initial work plan in a Request for Information (RFI) letter dated February 6, 2012 (DRC, 2011b). In response to these comments, RAML submitted a second work plan titled “Final Work Plan, Supplemental Site Assessment to Address Out-of-Compliance Status at Trend Wells RL-1 and EF-8” to DRC on April 13, 2012. The DRC issued comments on the second work plan in an RFI letter dated May 1, 2012 (DRC, 2011c). Shortly thereafter, the Bureau of Land Management (BLM) determined that an Environmental Assessment (EA) was required under the National Environmental Policy Act (NEPA) before a Right of Way (ROW) to drilling locations on BLM lands could be granted. The current work plan addresses the DRC comments provided in their May 1, 2012 RFI letter and proposes a phased project approach that allows time for the completion of the EA before wells on BLM land are drilled.

1.2 PROJECT PHASES

The second work plan, submitted to DRC on April 13, 2012, provided details for a single-phase field program that would have been completed in 2012. Implementation of the field program was contingent on obtaining access to drilling locations on BLM land. Subsequent to submittal of the second work plan, RAML was advised by the BLM that the process for obtaining ROWs to the drilling locations would require an EA before initiation of work. Representatives from BLM have indicated that the EA/ROW process could take six months to one year to complete. The timeframe required to complete the EA and obtain ROWs precludes drilling wells on BLM land during the 2012 field season.

Some of the wells proposed in the second work plan are on or close to property owned by RAML. Wells on RAML property are not subject to an EA under NEPA; therefore, RAML plans to drill wells located on their property in a Phase 1 field program in 2012. The Phase 1 field program will also include slug testing and groundwater sampling in all existing and new Phase 1 wells. Concurrent with Phase 1, RAML will initiate work on the EA/ROW process for wells on BLM land, with the intention of completing it by spring 2013 so that Phase 2 work can be conducted during summer 2013. Representatives of DRC verbally concurred with this phased approach in a June 13, 2012 phone call with RAML and M&A.

RAML is committed to completing the Phase 2 field program by the end of the 2013 drilling season. To accomplish this, ROWs to Phase 2 drilling locations need to be secured by spring 2013. The EA/ROW process requires a map showing the locations of Phase 2 drilling locations and the estimated areas of land disturbance expected to access and drill the wells. The Phase 2 drilling locations are the same as proposed in the second work plan. According to BLM, it is optimal for the EA/ROW process if the Phase 2 drilling locations are approved by DRC. Therefore, to facilitate an efficient and timely EA/ROW process, the current work plan includes a map showing Phase 1 and Phase 2 drilling locations, but only provides well drilling and construction details for the Phase 1 wells. The number and design of the Phase 2 wells

will be submitted to DRC for approval after completion of Phase 1 and before the Phase 2 field program begins. Changes or additions to the Phase 2 drilling locations could require a second EA and ROW approval. For long-term planning purposes, the current work plan includes a schedule of Phase 1 and Phase 2 activities.

1.3 RESPONSES TO COMMENTS

RAML has included responses to DRC's May 1, 2012 comments on the second work plan in **Table 1**. Where applicable, **Table 1** indicates the work plan section number where specific comments on the second work plan are addressed.

1.4 WORK PLAN ORGANIZATION

The work plan includes the following sections and appendices:

Section 2.0 – Summary of Site Conditions

Section 3.0 – Supplemental Site Assessment Description

Section 4.0 – References Cited

Appendix A – Existing Well Information

Appendix B – Summary of Phase 1 Groundwater Modeling

Appendix C – Well Construction and Testing Procedures

Appendix D – Supplemental Site Assessment Groundwater Sampling Plan

2.0 SUMMARY OF SITE CONDITIONS

Previous investigations, data analyses, and modeling have resulted in a substantial amount of information about the Site. Many Site features and conditions are well understood as a result of this work. The previous work served as the basis for developing the current ACLs. However, much of the previous work was conducted during dynamic groundwater conditions caused by mine operations and Corrective Action Program (CAP) pumping. These dynamic groundwater conditions complicated characterization efforts and modeling of groundwater flow and uranium transport. Since the CAP ceased in 2004, groundwater levels have been recovering. The nature of groundwater level recovery after 2004 has resulted in new data and interpretations. Review of these new data and information indicates that the hydrogeologic conceptual model at the Site needs to be refined. Because of well abandonment, data obtained after 2004 are more limited than before 2004, which results in data gaps. These data gaps need to be addressed to refine the conceptual model, conduct additional modeling, and revise the ACLs.

The sections below briefly summarize Site hydrogeologic and water quality conditions and discuss the key data gaps.

2.1 GEOLOGY

The primary geologic formations at the Site are the Burro Canyon Formation (BCF) and the Brushy Basin Member of the Morrison Formation (BBM). Uppermost groundwater at the Site is encountered in the BCF. The BCF is composed of very fine to fine grained sandstone with interbedded silt and mudstones. The BCF has primary porosity and secondary fracture porosity (Earthfax, 1989). Underlying the BCF is the BBM, which is

reported to be about 390 feet thick near the Site (KOMEX, 2003). The BBM is composed of bentonitic claystone with lenses of fine grained sandstone and mudstone (Earthfax, 1989).

The geologic setting of the Site has two important hydrologic features: (1) the Lisbon Valley Anticline (LVA) and (2) the Lisbon Fault (LF). The axis of the LVA strikes southeast to northwest through the Site and passes directly under the lower tailings impoundment. The southeastern and northwestern extents of the LVA have not been characterized. The LF, located along the southwestern boundary of the Site, is a high angle reverse fault with approximately 2,200 feet of vertical displacement and strikes southeast to northwest.

2.2 HYDROGEOLOGY

The primary aquifer at the Site is the Burro Canyon Aquifer (BCA), which occurs in the BCF. The BCA is likely bounded on the southwest by low conductivity rocks on the southwest side of the LF; however, aquifer conditions along the fault could be complex as a result of fracturing associated with the LF. Folding of the BCF along the crest of the LVA causes the base of the BCF to be above the water table in some areas along the crest of the LVA. In this area, the water table is in the BBM and the BCA is dry. The shape and size of the dry area (referred to as the “dry zone” in previous Site documents) in the BCA along the LVA crest has varied since mining operations began in the early 1970s. The extent of the dry area is poorly delineated by available Site data. Additional exploratory drilling or wells are needed to improve delineation of the dry area in the BCA. Improved delineation of the dry area will improve future projection of groundwater flow and uranium transport.

The “dry zone” was previously conceptualized to separate the BCA into two separate aquifer areas: the North Aquifer and the South Aquifer. The convention of separate North and South Aquifers was developed as convenient terminology during early stages of Site

characterization. However, this convention complicates communications and planning of the supplemental assessment and will no longer be used. Instead, the BCA will be considered one aquifer with areas along the LVA crest where it is dry and the water table is in the underlying BBM.

Hydraulic Conductivity

Horizontal hydraulic conductivity (K_h) of the BCA was characterized by slug tests and pumping tests (see Table 2-1, Lewis Water Consultants, Inc., 2001). The reported estimates of BCA K_h vary over several orders of magnitude due to varying degrees of fracturing. K_h tends to be higher southwest of the tailings impoundments than northwest of the tailings impoundments. Previous reports have identified three populations of K_h in the BCA: (1) unfractured rock (average K_h of 0.2 feet per day [ft/day]), (2) fractured rock (average K_h of 6 ft/day), and (3) extensively fractured rock (south aquifer only; average K_h of 100 ft/day) (Lewis Water Consultants, Inc., 2001). The vertical hydraulic conductivity (K_v) of the BCA has not been estimated. Additional hydraulic and laboratory testing are needed to develop better estimates of K_h and K_v for the BCA. Better estimates of the BCA hydraulic conductivities will enable better estimation of the rate of groundwater flow and uranium transport.

Very limited characterization of K_h and K_v of the BBM has been conducted to date. The average K_h and K_v of the BBM are expected to be less than that of the BCF based on geologic descriptions of the two formations. Fractures could enhance the K_h and K_v of the BBM. The K_h of the BBM could be on the order of 0.01 ft/day to 1 ft/day based on reported estimates from a slug test and pumping test in borehole H-72 (Site records indicate H-72 was an open borehole not a cased well) (Lewis Water Consultants, Inc., 2001). Additional hydraulic and laboratory testing are needed to develop better estimates of K_h and K_v for the upper portion of the BBM. Better estimates will improve understanding of the rate of groundwater flow and potential uranium transport in the upper portion of the BBM.

2.3 EXISTING WELLS AND GROUNDWATER CONDITIONS

Fourteen wells currently exist at the Site (**Figure 1**). **Appendix A** includes well construction schematics, where available, and a table of well information. Available records indicate that most of the wells are screened immediately above the contact between the BCA and BBM. **Table 2** below summarizes the relationship between the groundwater level and screened interval for the wells.

TABLE 2. GROUNDWATER LEVEL AND SCREENED INTERVAL IN WELLS

WELL NAME	MAY 2011 GROUNDWATER LEVEL ELEVATION (feet msl) ^a	TOP OF SCREEN ELEVATION (feet msl)	BOTTOM OF SCREEN ELEVATION (feet msl)	TOP OF SCREEN SUBMERGENCE ^b (feet)	SATURATED SCREEN LENGTH ^c (feet)
EF-3A	6,496.19	6,408	6,378	88	30
EF-6	6,495.50	6,464	6,434	32	30
EF-8	6,498.49	6,361	6,331	137	30
H-63	6,552.43	6,545	6,515	7	30
LW-1	6,575.28	6,517	6,487	58	30
ML-1	6,487.33	6,468	6,448	19	20
		6,378	6,363	109	15
MW-5	6,589.38	6,577	6,547	12	30
MW-13	6,547.63	6,513	6,433	35	80
OW-UT-9	6,580.04	6,584	6,566	-4	14
RL-1	6,536.17	6,547	6,527	-11	9
RL-3	6,534.11	6,539	6,519	-5	15
RL-4	6,524.69	6,543	6,503	-18	22
RL-5	6,534.05	6,535	6,498	-1	36
RL-6	6,444.08	6,452	6,442	-8	2

Notes:

^a ft msl – feet above mean sea level

^b negative submergence values indicate water table below top of screen

^c bold italics indicate water table within screened interval of well

In six of the wells (OW-UT-9, RL-1, RL-3, RL-4, RL-5, and RL-6), the water table is within the screened interval. The water table wells are located north and northwest of the tailings impoundments. In eight of the wells (MW-5, H-63, MW-13, EF-3A, EF-8, EF-6, LW-1 and ML-1), the screened interval is submerged below the water table (designated as deep-screen wells). The deep-screen wells are generally located south and southwest of the tailings, with the exception of LW-1 and MW-5, which are located north and northeast of the

tailings, respectively. The rationale for not constructing companion shallow water table wells near some of the deep-screen wells is unknown. Shallow wells are needed near the deep-screen wells to fully characterize groundwater quality.

Well ML-1 reportedly has a single-casing with two screened intervals. The two hydrostratigraphic zones screened in ML-1 are separated by about 70 feet. The lithologic log and well schematic for ML-1 are included in **Appendix A**. Based on this well schematic, the final construction of ML-1 is uncertain. Specifically, the first page of the well log indicates the well was filled with cuttings between the depths 80 and 97 feet while the second page indicates that the well has blank PVC between the depths 90 and 148 feet. Additionally, the degree of hydraulic communication between the two screened intervals is unknown. Water level data from ML-1 may represent the average hydraulic head of the two screened zones depending on how the well is actually constructed. Additional investigation of well construction and hydraulic connection between the two units is necessary to meaningfully interpret water level and uranium concentration data in well ML-1. Borehole flowmeter testing in ML-1 could provide information on hydraulic gradients near the well. Depth specific sampling in ML-1 could provide information on deep and shallow groundwater quality.

Well RL-6 is approximately 18 feet deep. In contrast, the depth of the other 13 existing wells ranges from 124 to 242 feet. Well RL-6 appears to be located in or near an ephemeral wash. A well schematic and lithologic log for RL-6 are not available; therefore, the rationale for the shallow well depth is unknown. It is unclear whether water level data from this well are meaningful given the small saturated thickness (about 2 feet) in the well. In addition, it is unclear if groundwater from this well is from the same hydrostratigraphic zone(s) screened by the other wells. Additional investigation near RL-6 is needed.

Groundwater Flow Directions and Gradients

Figure 4 shows a groundwater elevation contour map inferred from the May 2011 groundwater elevation data. The inferred extent of the dry area in the BCA is also shown on **Figure 4**. The extent of the dry area was estimated as the difference in elevation between the May 2011 groundwater level elevation and the elevation of the geologic contact between the BCF and BBM (inferred from well lithologic logs by Lewis Water Consultants, Inc., 2001).

Inferring horizontal hydraulic gradients and groundwater flow directions from the contour map should consider the limitations and uncertainties in the groundwater data discussed above. The contour map was prepared with the typical simplifying assumption that groundwater occurs in a homogeneous and isotropic hydrostratigraphic unit. This assumption leads to smooth and continuous contours of groundwater elevation. Site conditions are known to be heterogeneous and probably anisotropic (due to fracturing and unidirectional flow by gravity); however, these conditions are not readily accounted for when contouring the existing groundwater level data unless sophisticated and subjective methods are used. Therefore, the groundwater contours shown on **Figure 4** do not take into account potential refraction across boundaries between geologic units of differing hydraulic conductivity.

Despite potential limitations in the data and considering the body of other hydrogeologic and water quality data for the Site, the inferred current direction of horizontal groundwater flow at the Site appears to be generally towards west-southwest. Actual groundwater flow directions are expected to differ from this general direction in some areas due to complexities associated with the LVA and LF. Historic hydraulic gradients and groundwater flow directions differed from current hydraulic gradients and groundwater flow directions due to drawdown created by the extraction wells and mounds created by seepage from the tailings impoundments and Bisco Lake, located east of the tailings. Current groundwater level data are insufficient to estimate vertical hydraulic gradients and

groundwater flow directions. Additional wells are needed to improve delineation of horizontal and vertical hydraulic gradients and groundwater flow directions.

Estimated horizontal groundwater velocities are reported to vary from a few feet per year (ft/year) in unfractured rock to over 100 ft/year for extensively fractured rock (Lewis Water Consultants, Inc., 2001). Lower groundwater velocities may exist in areas of low hydraulic conductivity and higher groundwater velocities may exist in areas with high hydraulic conductivity (e.g., fracture zones). Additional wells will also improve estimates of groundwater velocities, which are critically important for projecting future uranium transport in groundwater and revising the ACLs.

2.4 URANIUM CONCENTRATIONS

A map depicting 2011 uranium concentration contours is presented on **Figure 5**. The concentration contours are dashed where uncertain. The contours represent the current understanding of the uranium plume in the BCA. The uranium concentration contours are based on data from water table wells and deep-screen wells. Historic data from abandoned wells indicate that uranium concentrations in the BCA were as high as 180 milligrams per liter near the tailings. Therefore, it is possible that higher uranium concentrations still exist in the BCA. Additional wells are needed to improve delineation of current uranium concentrations.

As discussed above, data from wells ML-1 and RL-6 may not be representative of the same hydrostratigraphic zone(s) screened by the other wells. Sampling records for ML-1 indicate that the deeper screened zone is sampled during the monitoring program; therefore, uranium concentration data characterize the aquifer zone immediately above the contact with the BBM. Water quality data from RL-6 may be from a shallow perched groundwater zone above the regional groundwater system in the BCA. Additional exploratory drilling and

potentially a new well are needed near RL-6. If possible, borehole flowmeter testing and depth specific sampling will be conducted in ML-1 to better characterize groundwater flow and water quality conditions near the well.

Seepage from the upper and lower tailings impoundments is suspected to be the primary source of uranium in groundwater. Groundwater levels near the tailings impoundments fluctuated due to mounds created by seepage and dewatering created by the CAP pumping. These fluctuations in groundwater levels may have left residual uranium in the unsaturated zone beneath and near the tailings impoundments. Groundwater level recovery near the tailings impoundments could dissolve residual uranium back into the groundwater system, where it can migrate and prolong the uranium source. Additional characterization of the vadose zone near the tailings impoundment would improve understanding of the potential source of residual uranium from the vadose zone.

2.5 SUMMARY OF DATA GAPS

As indicated above, data gaps exist in the hydrogeologic conceptual model. These data gaps need to be addressed before revised ACLs can be developed. Additional shallow and deep wells, hydraulic testing, and groundwater sampling are needed to address the data gaps. The following types of additional data are needed to address the data gaps:

- **Groundwater Level Data** – additional groundwater level data from new shallow and deep wells in the BCA are needed to improve delineation of horizontal hydraulic gradients and groundwater flow directions, and provide data to characterize vertical hydraulic gradients and flow directions. Additional groundwater level data are also needed to improve estimates of groundwater velocities. Groundwater level data from wells screened in the BBM are needed to

estimate horizontal hydraulic gradients and groundwater flow directions in the BBM and vertical hydraulic gradients between the BCA and BBM.

- **Hydraulic Conductivity Data** – additional and better K_h data are needed to improve estimates of groundwater velocities. If possible, K_v data should be obtained to characterize vertical flow in the BCA and between the BCA and BBM. Additional K_h and K_v data will also improve understanding of the importance of fracture flow.
- **Uranium Concentration Data** – additional uranium concentration data will be obtained to characterize both the vertical and horizontal extent of the plume.

Additional characterization is needed in the following areas:

- **Near Wells RL-6 and ML-1** – additional exploratory drilling near RL-6 and well testing in ML-1 are needed to further characterize groundwater flow and water quality conditions.
- **Tailings Source Area** – characterization of the vadose zone near the tailings impoundments is needed to improve understanding of the source area.

Section 3.0 presents a plan to address these data gaps.

3.0 SUPPLEMENTAL SITE ASSESSMENT DESCRIPTION

This section presents the proposed approach to the SSA and outlines the tasks and activities that comprise the work to be conducted. **Task 1** of the initial work plan (Phase 1 Groundwater Modeling) is complete and is summarized in **Appendix B**. **Task 2** of the initial work plan (Final Work Plan) will be complete upon approval of this work plan.

Phase 1 field work is described in this work plan; Phase 2 field work will be described in a brief work plan included with the Phase 1 Technical Memorandum. Phase 2 field work will be evaluated and results from both phases of field work will be incorporated into Phase 2 modeling. Findings from both field investigation phases and results from Phase 2 modeling will be used to aid in the development of revised ACLs. After the approval of revised ACLs, an appropriate long term groundwater monitoring program will be developed.

3.1 CONDUCT PHASE 1 FIELD PROGRAM ON RAML PROPERTY

The overall goal of the entire phased field program is to address the data gaps discussed in **Section 2.0**. The Phase 1 model results were used, in part, to identify areas where new data will meaningfully reduce uncertainty and address data gaps. **Appendix B** summarizes the Phase 1 modeling. In addition to the model results, recommendations and input provided by DRC in their comments on the initial work plan and second work plan were used to develop the field program.

The Phase 1 field program will include installation of new wells, conducting of hydraulic tests, coring and physical properties analysis of the BCF and BBM, coring and laboratory analyses of samples for uranium concentrations, and groundwater sampling and laboratory analyses. This will be done in accordance with specifications described in Utah Division

of Radiation Control, Radioactive Materials License, Supplementary Sheet, Amendment 4, signed by Director Rusty Lundberg and dated February 6, 2012. These specifications include the provision, "the licensee shall provide at least a 14 calendar day written notice to allow the Executive Secretary [Director] to observe all drilling and well installation activities."

RAML evaluated the possibility of conducting a geophysical survey to aid in delineating the water table and contact between the BCA and BBM along the crest of the LVA. After further evaluation and in light of the number of new wells that will be installed, RAML determined that the geophysical survey would not substantially enhance the SSA and has elected not to conduct it.

RAML plans to install eight wells on RAML property in Phase 1. **Figure 6** shows the proposed location of the Phase 1 wells. The well locations were selected based on an evaluation of Site data, the results of the Phase 1 modeling, and recommendations from DRC in their RFI letters dated February 6, 2012 and May 1, 2012.

Figure 6 also shows the Phase 2 drilling locations that are on BLM land. All activities involving new wells on BLM land require a ROW be granted from BLM before any work begins. In order to begin the ROW application process it is necessary to specify the location of Phase 2 wells on BLM land and obtain DRC approval of the locations. The number and design of Phase 2 wells will be developed after the Phase 1 field program and data evaluation are completed. RAML will include a brief work plan for the Phase 2 wells in the Phase 1 data submittal.

3.1.1 Phase 1 New Wells

Table 3 provides details about the Phase 1 wells. **Appendix C** provides additional details on the drilling method and construction specifications for the new wells. All new wells will be designed and constructed in compliance with UAC R317-6-6.3(I)(6), the Utah Division of Water Rights Standards (R655-4 UAC), and the Resource Conservation and Recovery Act

guidance document entitled *Ground Water Monitoring Technical Enforcement Guidance Document* (U.S. Environmental Protection Agency, 1986). All wells will be constructed under the supervision of a licensed Professional Geologist in the State of Utah and by a State of Utah licensed well driller. The M&A project manager is a licensed geologist in the State of Utah.

As required by DRC, RAML will submit geologic logs and well completion diagrams for the new wells within 60 calendar days of completion. The geologic logs will be prepared by a State of Utah licensed Professional Geologist. DRC also requested well completion diagrams for the existing wells. Well completion diagrams are not available for all existing wells. **Appendix A** includes available well completion diagrams and a table of well information.

Well Construction Procedures

Table 3 provides details related to Phase 1 well location, construction, rationale, and planned hydraulic testing. As required by DRC, all Phase 1 wells in which saturated BCA is encountered will fully screen the saturated zone of the BCA or will screen the saturated portion of the BCA not screened by an existing companion well. In the latter case, the newly screened well will be located as close to the existing companion well as is practicable. RAML may elect to install additional discrete screened zones while drilling as appropriate based on field conditions.

The drilling procedures were developed based on available information and may be modified in the field in accordance with the conditions encountered. Key aspects of the drilling procedures that require pre-field planning include locating the water table and coring, drilling, and constructing the wells in a manner that avoids water quality cross-contamination between the BCA and BBM. For paired wells, the deeper well will be drilled first. RAML will provide DRC with a well construction schedule prior to startup. To the extent required

during the field program, RAML will communicate with DRC on drilling status and unexpected conditions.

3.1.2 Hydraulic Testing

Field-based hydraulic testing is planned for all new and existing wells to estimate formation K_h . Laboratory testing on cores will be conducted from selected wells. **Table 3** summarizes the planned hydraulic testing program for the new wells. **Appendix C** includes details of the testing program. Slug tests will be conducted in all existing and Phase 1 new wells. Physical properties analyses will also be conducted on core samples collected at the site. **Appendix C** includes details about these laboratory analyses.

3.1.3 Groundwater Monitoring

Groundwater monitoring will be conducted in all new and existing wells during the Phase 1 field program. Monitoring will include measuring depth to water and collecting groundwater samples for laboratory analyses. **Appendix D** includes details on the monitoring program. At the request of DRC, groundwater sampling will be conducted at least one week after well development in new wells. Post-well development samples may be analyzed to obtain water quality data for planning purposes. At a minimum, samples will be analyzed for uranium, molybdenum, selenium, arsenic, total dissolved solids, chloride, sulfate, and bicarbonate. Other analyses may be conducted if warranted by conditions encountered during drilling and sampling. Sampling will be performed by qualified and trained personnel. Additionally, residual uranium analyses will be conducted on core samples from the vadose zone. **Appendix C** includes details about the core sampling and laboratory analyses in the vadose zone near the tailings.

Sampling Methodology

DRC expressed concerns about the adequacy of low-flow sampling at the Site. To address DRC's concerns about sampling methods, RAML plans to conduct a comparative sampling event as part of the field program. **Appendix D** includes information on the methods and procedures for the comparative sampling event. The comparative sampling event will include collecting samples from all existing and Phase 1 new wells using purge, low-flow, and no-purge methods (using the HydraSleeve). The comparative sampling event will specifically investigate methods for discrete sampling in wells with long screened intervals. Results of the comparative sampling will be evaluated and used to select the appropriate sampling method for the Site. A Sampling and Analysis Plan (SAP) will be prepared and submitted to DRC for approval. The schedule for preparing the SAP will be determined in collaboration with DRC. Additionally, RAML may elect to take discrete samples while drilling.

3.1.4 Field Program Schedule

Figure 7 presents an estimated schedule. The schedule is based, in part, on projections from the driller on the duration of well installation and development. RAML is planning a concurrent day-shift only drilling and well testing program. Including pre-drilling planning, the Phase 1 field program is expected to take about 2 months to complete. The Phase 1 field program is tentatively scheduled to start in mid August 2012. The actual start date will depend on work plan approved by DRC and availability of subcontractors.

Contingency Plan

This section contains a general contingency plan outlining the basic decision-making and communication process to address unexpected conditions in the field. Significant field planning and review of Site conditions have been conducted during preparation of the work plan to avoid the need for detailed contingency planning. The primary scenarios where

contingency measures might be needed include: (1) if a well needs to be relocated or (2) if a well design needs to be revised in the field. Each scenario is discussed below.

Scenario 1 – Well Relocation

A visit to the Site took place on July 19 and 20, 2012 to verify the Phase 1 well locations and meet with other project stakeholders. During the visit, each well site was inspected for drilling impediments (e.g., utilities, limited access, etc.) and well locations were adjusted as needed. The field verified Phase 1 locations are presented in **Figure 6** and are not expected to change. In the unlikely event that a well needs to be relocated, RAML will determine viable options, contact DRC to discuss them, and work collaboratively with DRC to relocate the well as quickly as possible. Relocating a well will require obtaining access and preparing a new drill pad.

Scenario 2 – Modifying a Well Design

Significant planning of well construction procedures has been completed for the work plan. **Appendix C** includes the methods and procedures for well design and construction. The decision-making process is based on prior information about hydrogeologic conditions, well design, and well construction procedures. The most likely change to well construction plans is dividing a single large screen into several smaller screens based on hydrogeologic conditions encountered. If a well design needs to be modified, RAML will determine viable options, contact DRC to review them, and work collaboratively with DRC to re-design the well or resolve issues. If a well needs to be abandoned and relocated, the contingency measured for Scenario 1 will apply.

If other unanticipated revisions to the field program are needed, RAML will identify and prioritize options and consult with DRC on appropriate remedial measures.

3.2 PHASE 1 DATA EVALUATION AND REPORTING

RAML and M&A will evaluate data obtained from the Phase 1 field program and summarize them in a technical memorandum. The evaluation is expected to include preparation of geologic logs; preparation of well schematics; interpretation, tabulation, and mapping of new water level and water quality data; preparation of hydrogeologic cross-sections; and analysis of slug tests. Data evaluation and reporting will commence during the field program to the extent possible and are expected to take about 4 months to complete (**Figure 7**). The technical memorandum will include recommendations and a plan for the number and design of Phase 2 wells. The technical memorandum will be submitted to DRC for approval. RAML understands the DRC's approval of the Phase 2 well drilling will be required before initiating field activities.

The Phase 1 field program, data evaluation, and SSA reporting are projected to take about 6 months to complete after receiving approval of the work plan from DRC (**Figure 7**).

4.0 REFERENCES CITED

- Earthfax Engineering, Inc. 1989. **Recommended Corrective-Action Plan for Control of Groundwater Contamination at the Lisbon Uranium Mill:** March 27, 1989.
- KOMEX, 2003, **Response to Request for Additional Information (RAI), Application for Alternate Concentration Limits Source Materials License SUA -119, Rio Algom Mining LLC, Lisbon Facility, La Sal, Utah:** prepared for Rio Algom Mining LLC, October 13, 2003.
- _____, 2004. **Long Term Groundwater Monitoring Plan, Application for Alternative Concentration Limits Source Materials License SUA-1119 RAMC Lisbon Facility La Sal, Utah,** February 19, 2004.
- Lewis Water Consultants, Inc., 2001. **Application for Alternative Concentration Limits Source Materials License SUA-1119 RAMC Lisbon Facility La Sal, Utah:** March 1, 2001.
- Montgomery & Associates, 2011a. **Action Plan to Address Out of Compliance Conditions at Target Action Level Well RL-1, Rio Algom Mining LLC – Lisbon Operation,** June 1, 2011.
- _____, 2011b. **Technical Evaluation of Lisbon Valley Facility Groundwater Quality,** August 10, 2011.
- U. S. Environmental Protection Agency, 1986, **Ground Water Monitoring Technical Enforcement Guidance Document:** USEPA/530/SW-86/055, September 1986.
- Utah Division of Radiation Control, 2011a, **DRC Notice of Enforcement Discretion and Confirmatory Action Letter:** letter sent to Chuck Wentz, Rio Algom Mining LLC, February 7, 2011.
- _____, 2011b, **DRC Review of the Rio Algom Mining, LLC (RAML) work plan, prepared by Montgomery & Associates (M&A) entitled “Supplemental Site Assessment to Address Out-of-Compliance Status at Trend Wells RL-1 and EF-8, Lisbon Facility, dated December 13, 2011:** Request for Information letter sent to Billy M. Ray, BHP Billiton, February 6, 2012.

_____, 2011c, **DRC Review of the Rio Algom Mining, LLC (RAML) work plan, prepared by Montgomery & Associates (M&A) entitled “Supplemental Site Assessment to Address Out-of-Compliance Status at Trend Wells RL-1 and EF-8, Lisbon Facility, dated December 13, 2011:** Request for Information letter sent to Billy M. Ray, BHP Billiton, May 1, 2012.

**TABLE 1. RESPONSES TO COMMENTS ON SECOND WORK PLAN FROM
UTAH DIVISION OF RADIATION CONTROL**

DIVISION OF RADIATION CONTROL COMMENT	RIO ALGOM MINING LLC RESPONSE
1. Change column headed “Saturated Thickness” in Table 2 to be more clear.	See Table 2 in Section 2.3
2. Construction of Well ML-1 is uncertain.	See revised text in Section 2.3 , paragraph 3; RAML agrees that there is substantial uncertainty about the construction of ML-1 and how data from this well should be interpreted; RAML will investigate the construction of well ML-1 and report back to DRC.
3. Uncertainty about hydrogeology in the vicinity of Well RL-6.	See revised text in Section 2.3 , paragraph 4; RAML agrees that there is uncertainty about the hydrogeology in this area and proposed additional drilling near RL-6 for this reason; RAML agrees that drilling needs to be undertaken carefully.
4. A State of Utah Licensed Professional Geologist must supervise all work.	See revised text in Section 3.1.1 , paragraph 1; an M&A, State of Utah Licensed Professional Geologist will supervise the project.
5. All wells must be screened over the entire saturated thickness of the aquifer (either as individual wells or in a cluster); all wells must be purge sampled or have screened lengths of 10 feet or less; all wells must be installed properly.	See revised text in Section 3.1.1 , paragraph 3 and Table 3 ; RAML agrees to screen the entire saturated thickness of the Burro Canyon Aquifer for all wells drilled during the Phase 1 field program; comparative sampling will be conducted in all wells during the Phase 1 field program to determine whether discrete representative samples can be collected from fully screened (potentially with long screens) wells; RAML will ensure that during drilling all wells are stable and have their sand or gravel pack properly installed.
6. Phase 2 probabilistic modeling will contribute to making significant decisions about the site but may not be controlling.	Comments related to modeling will be addressed before Phase 2 modeling begins.
7. A main purpose of creating cross sections is to evaluate assumptions about cross sections across the crest of the LVA; add a well due east of MW-110 (now labeled MW-103) and north-northwest of H-63.	RAML agrees that cross sections will be used to evaluate the extent of saturation across the anticline; RAML agrees to add the requested well for this purpose; this well is identified as well MW-104 in Figure 6 .
8. Add a well due east of MW-110 and north-northwest of H-63, reconsider if well MW-107DB is necessary.	RAML agrees to add the requested well as described above; RAML still plans to screen a well in the BBM near existing well EF-3A to characterize vertical gradients and the upper portion of the Brushy Basin Member.
9. DRC agrees to allow low flow sampling if RAML complies with a set of specific conditions listed in the May 1, 2012 DRC Request for Information letter, or if expressly approved in writing in a signed DRC letter after a written request for such sampling at a specific well is made by RAML.	See revised text in Section 3.1.3 , paragraph 2; RAML will conduct a comparative analysis of sampling methods during the phased field program; data and analysis will be shared with DRC to determine the most appropriate sampling approach.

TABLE 1. Continued

DIVISION OF RADIATION CONTROL COMMENT	RIO ALGOM MINING LLC RESPONSE
10. RL-2 figure is incomplete.	RL-2 is an abandoned borehole; the schematic was included in the second work plan in error and it has been removed from the current work plan.
11. Discrepancies exist in the ML-1 well schematic.	As stated above, RAML recognizes these discrepancies and will investigate the construction of well ML-1; however, no additional data exists at this time.
12. Modify hydraulic conductivity zones in subsequent modeling	Comments related to modeling will be addressed before Phase 2 modeling begins.
13. Clarify or remove statement about the possibility of additional changes to Phase 2 modeling.	Comments related to modeling will be addressed before Phase 2 modeling begins.
14. Reconsider if RAML would like to drill BBM wells beneath saturated BCF; clarify statement about this.	RAML plans to drill BBM wells beneath saturated BCM to investigate BBM water quality and the nature of gradients between the BBM and BCF.
15. DRC does not approve of potential contamination of formerly clean water.	RAML does not plan to do any pumping tests in the Phase 1 field program.
16. Planned recovery time is insufficient for water level to return to its initial state.	RAML does not plan to do any pumping tests in the Phase 1 field program.
17. 12 hours is an insufficient amount of time for a pumping test.	RAML does not plan to do any pumping tests in the Phase 1 field program.
18. Appropriate observation wells are not present for the pumping test.	RAML does not plan to do any pumping tests in the Phase 1 field program.

**TABLE 3. PROPOSED NEW MONITOR WELLS
SUPPLEMENTAL SITE ASSESSMENT
RIO ALGOM MINING LISBON FACILITY**

WELL ID	APPROXIMATE COORDINATES NAD 1927 UTAH STATE PLANE SOUTH		ESTIMATED DEPTH (feet bgs)	CONDUCTOR CASING LENGTH (feet bgs)	ESTIMATED SCREEN LENGTH (feet)	ESTIMATED SCREENED INTERVAL (ft bgs)	SCREENED FORMATION	PLANNED HYDRAULIC TESTS		RATIONALE	PLANNED WELL CONSTRUCTION
	Easting	Northing						SLUG	CORE/LAB ^a		
MW-100	2,636,030	594,046	203	20	64	139-203	BCA	X		Characterize groundwater conditions and uranium concentration in the BCA above the LW-1 screen	Screen saturated zone from water table to top of LW-1 screen
MW-101	2,634,374	593,380	190	20	30	160-190	BCA	X		Characterize groundwater conditions and uranium concentration in area of historic high concentration	Screen saturated BCA from water table to BCA/BBM contact
MW-102	2,635,904	592,089	205	20	30	175-205	BCA	X		Characterize groundwater conditions and uranium concentration in area of historic high concentration	Screen saturated BCA from water table to BCA/BBM contact
MW-102DB	2,635,891	592,103	250	150	30	220-250	BBM	X	X	Characterize groundwater conditions and uranium concentration in BBM	Core borehole to BCA/BBM interface; cement in steel conductor casing and let cure; core 35 feet into BBM; screen bottom 30 feet of borehole
MW-103	2,635,761	589,640	80	20	30	50-80	BCA/BBM	X	X	Obtain core samples from vadose zone to characterize residual uranium concentration; characterize shallow groundwater conditions	Screen well in water table; if BCA is saturated, fully screen well in the BCA; if water table is in BBM, core borehole to BCA/BBM interface; cement in steel conductor casing and let cure; core 35 feet into BBM; screen bottom 30 feet of borehole
MW-104	2,637,491	589,397	187	20	30	187-157	BBM	X		Characterize groundwater conditions and uranium concentration in area of historic BCA saturation	Screen well in water table; if BCA is saturated, fully screen well in the BCA; if water table is in BBM, screen top thirty feet of saturation
MW-105	2,636,119	588,118	125	20	39	86-125	BCA/BBM	X		Characterize groundwater conditions and uranium concentration in the BCA above the MW-13 screen	Screen saturated zone from water table to top of MW-13 screen
MW-106	2,639,271	587,429	205	20	30	175-205	BCA	X		Characterize groundwater conditions and uranium concentration along the crest of the LVA	Core borehole; screen well in water table; if BCA is saturated, fully screen well in the BCA; if water table is in BBM, screen top thirty feet of saturation

NOTE: Water level, water quality, and lithology data will be collected at all new wells. All wells will be constructed according to Utah Division of Water Rights Standards

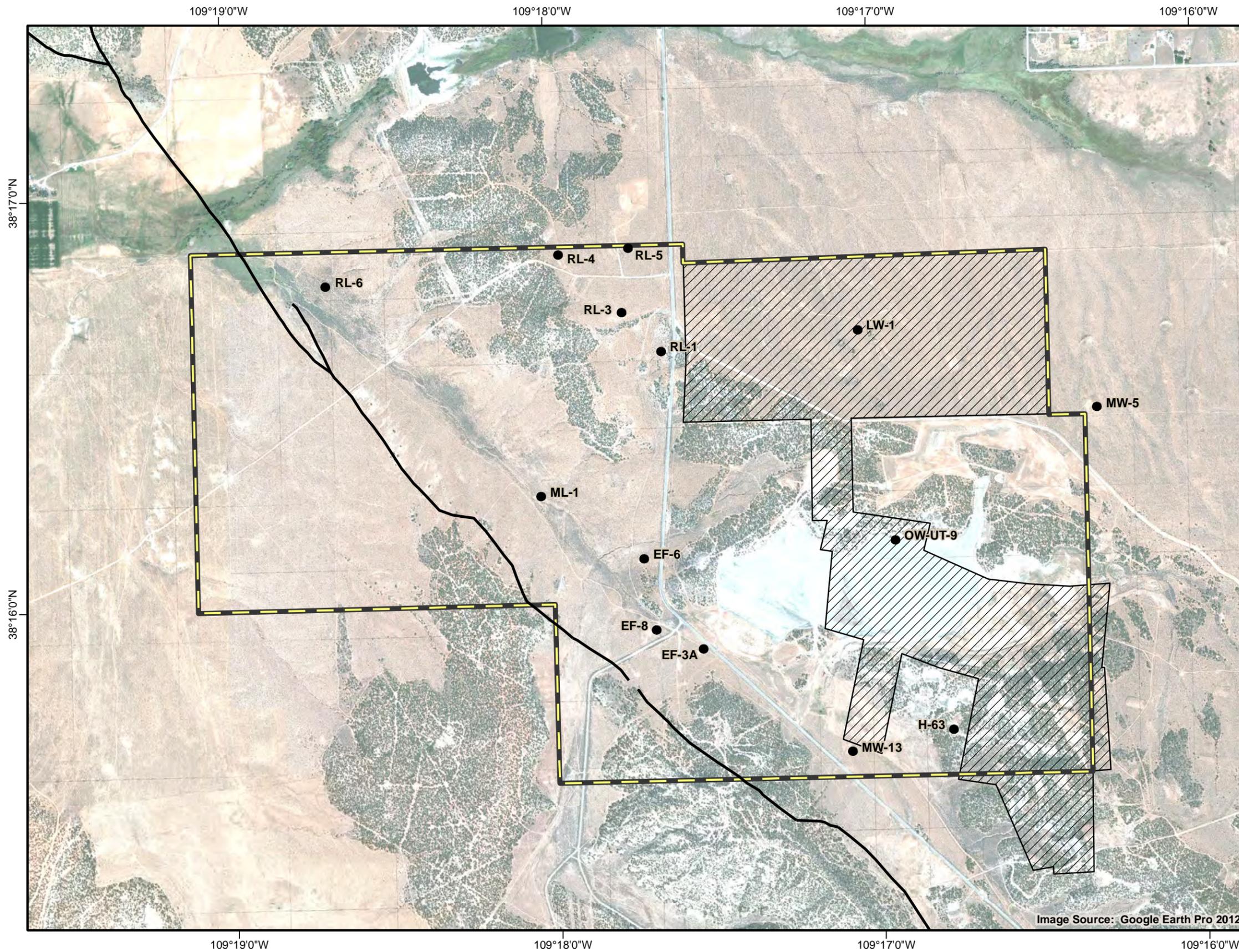
BCA - Burro Canyon Aquifer

BBM- Brushy Basin Member of Morrison Formation

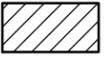
^a Core samples from BBM would be tested in laboratory for horizontal and vertical conductivity

TBD = to be determined

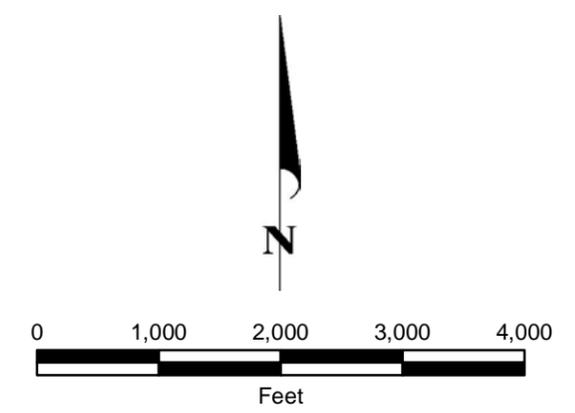




EXPLANATION

-  Well and Identifier
-  Lisbon Valley Fault
-  Long Term Surveillance and Maintenance Boundary
-  Rio Algom Mining LLC Property Boundary

38°17'0"N
38°16'0"N
38°17'0"N
38°16'0"N



**RIO ALGOM MINING LLC
LISBON FACILITY**

SITE OVERVIEW MAP



2012

Water Resource Consultants **FIGURE 1**

Image Source: Google Earth Pro 2012

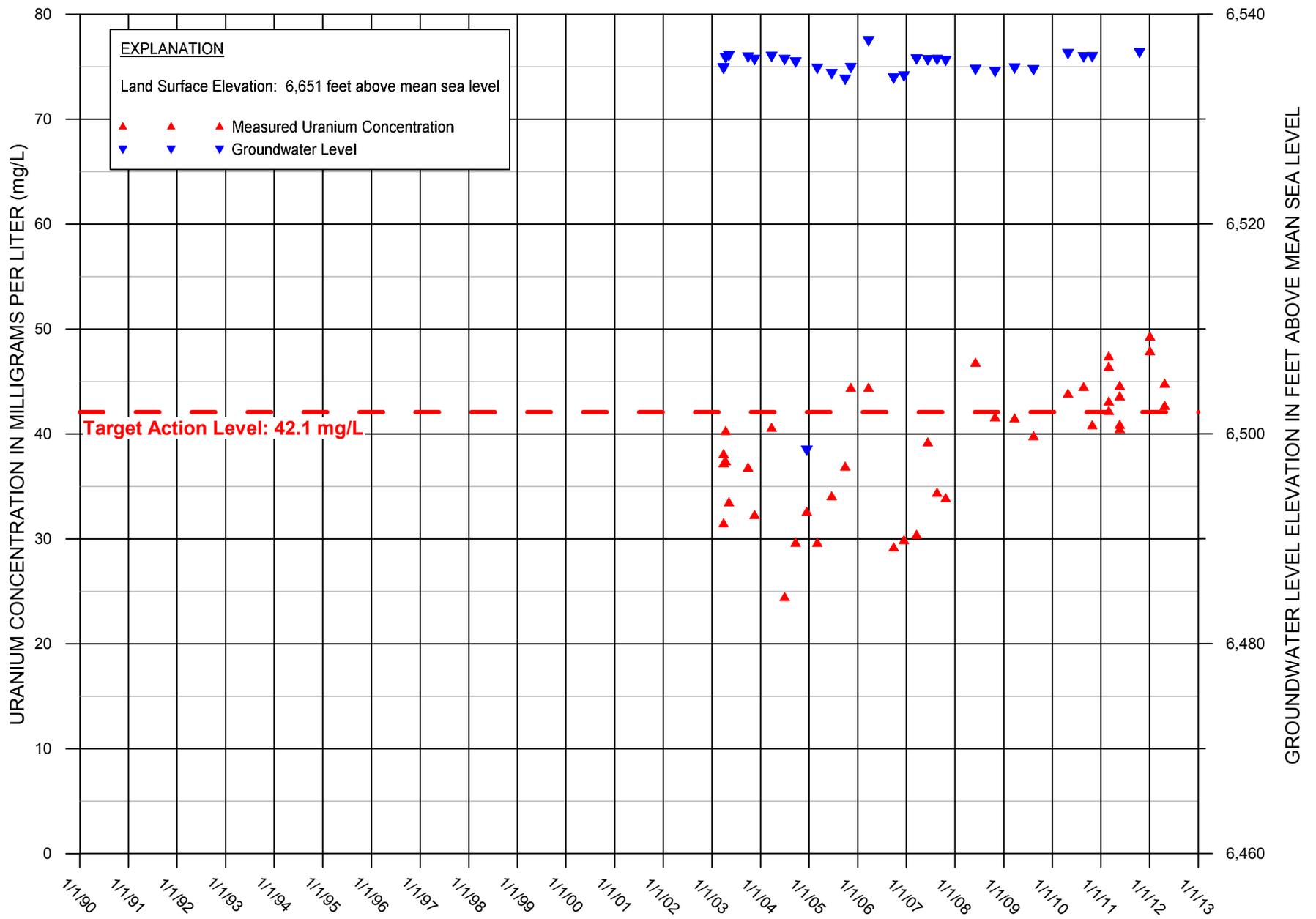


FIGURE 2. URANIUM CONCENTRATIONS AND GROUNDWATER LEVELS FOR TREND WELL RL-1, LISBON FACILITY, RIO ALGOM MINING LLC



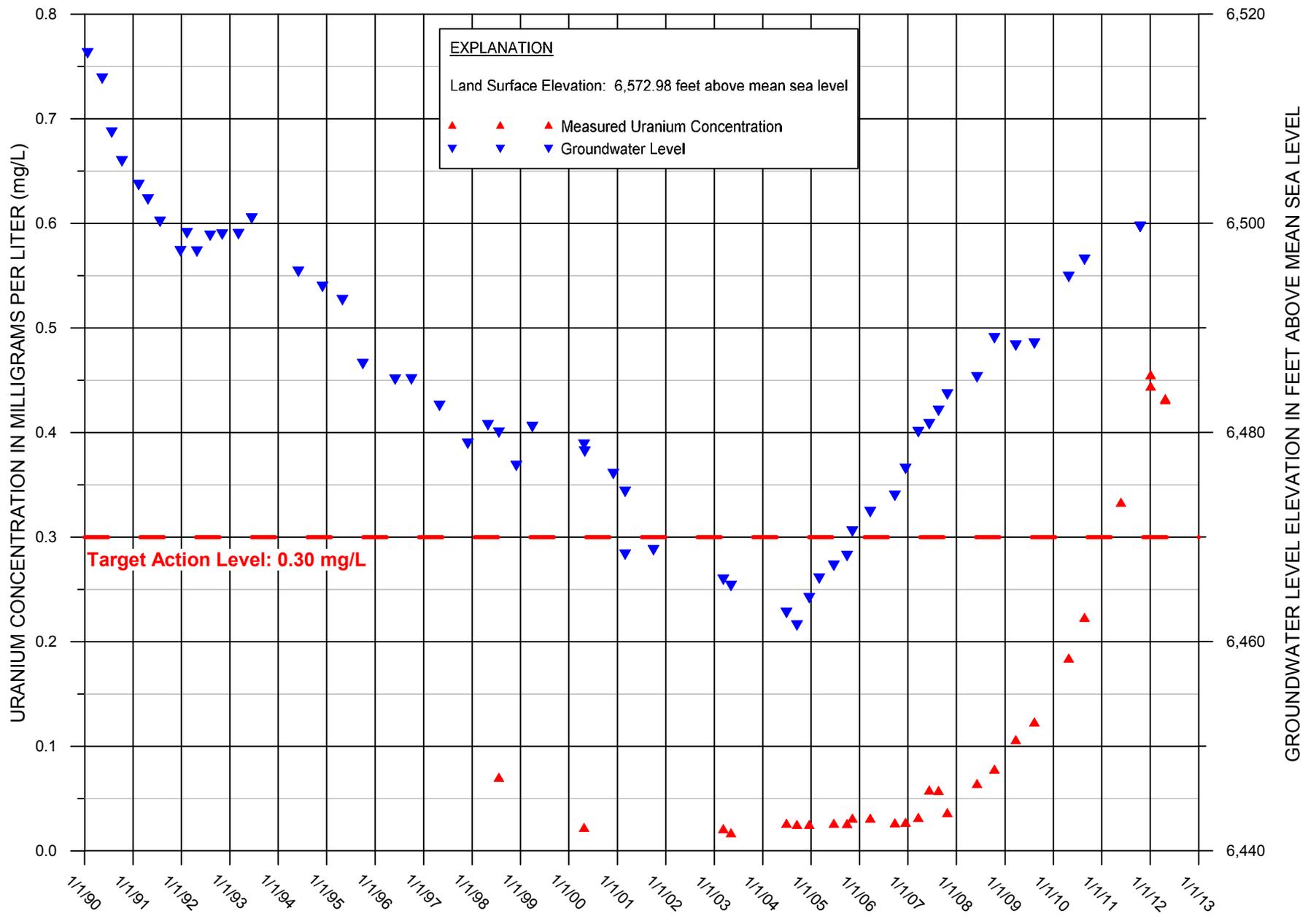
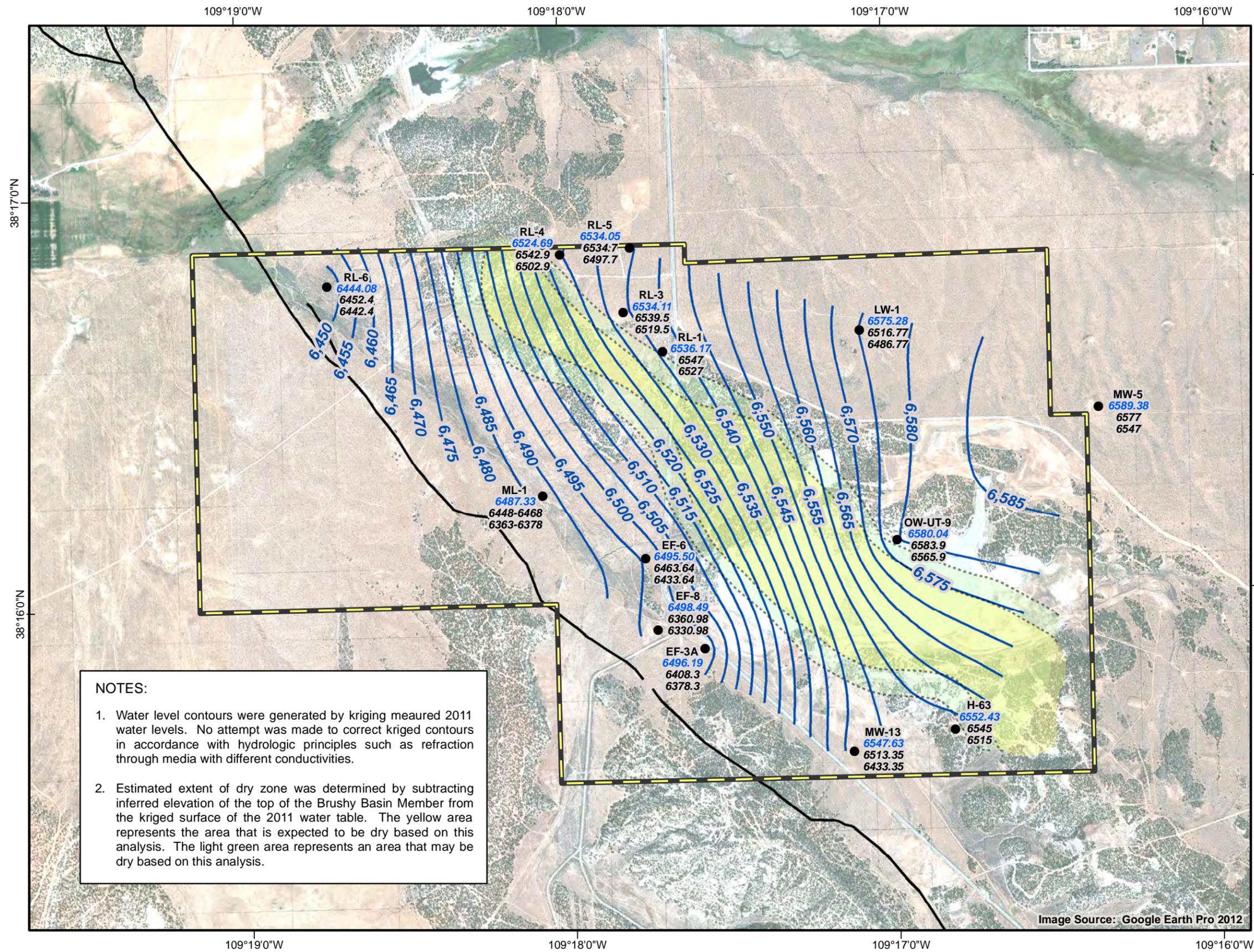


FIGURE 3. URANIUM CONCENTRATIONS AND GROUNDWATER LEVELS FOR TREND WELL EF-8, LISBON FACILITY, RIO ALGOM MINING LLC





EXPLANATION

- Existing Well and Identifier
- 6588.6 — Water Level Elevation (feet above mean sea level)
- 6577 — Top of Screen Elevation (feet above mean sea level)
- 6547 — Bottom of Screen Elevation (feet above mean sea level)
- 6,585 — Water Level Contour, in feet above mean sea level
- Lisbon Valley Fault
- ▭ Long Term Surveillance and Maintenance Boundary
- ▭ Estimated Minimum Extent of Dry Zone in Burro Canyon Aquifer
- ▭ Estimated Maximum Extent of Dry Zone in Burro Canyon Aquifer

0 1,000 2,000 3,000 4,000
Feet

NOTES:

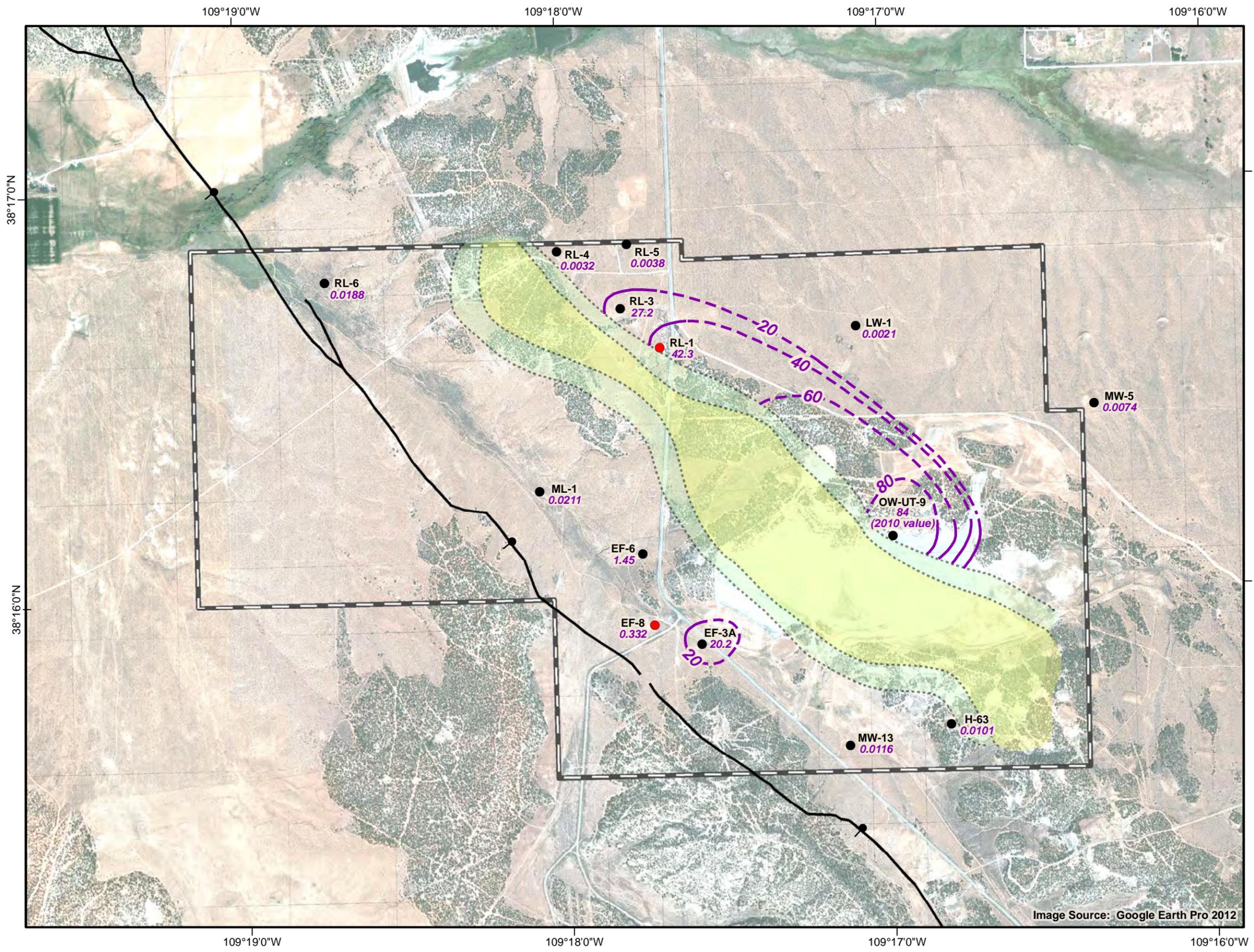
1. Water level contours were generated by kriging measured 2011 water levels. No attempt was made to correct kriged contours in accordance with hydrologic principles such as refraction through media with different conductivities.
2. Estimated extent of dry zone was determined by subtracting inferred elevation of the top of the Brushy Basin Member from the kriged surface of the 2011 water table. The yellow area represents the area that is expected to be dry based on this analysis. The light green area represents an area that may be dry based on this analysis.

**RIO ALGOM MINING LLC
LISBON FACILITY**

**2011 GROUNDWATER
LEVEL CONTOURS**

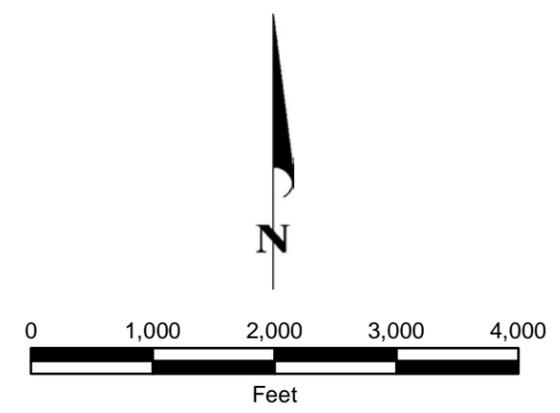
**MONTGOMERY
& ASSOCIATES**
Water Resource Consultants

2012
FIGURE 4



EXPLANATION

- MW-5
0.0074 Well and Identifier
Uranium Concentration, in milligrams per liter (mg/L)
- EF-8 Out-of-Compliance Well and Identifier
- 60 --- Uranium Concentration (mg/L); dashed where inferred
- ▭ Long Term Surveillance and Maintenance Boundary
- ⊥ Fault
- Estimated Minimum Extent of Dry Zone in Burro Canyon Aquifer
- Estimated Maximum Extent of Dry Zone in Burro Canyon Aquifer

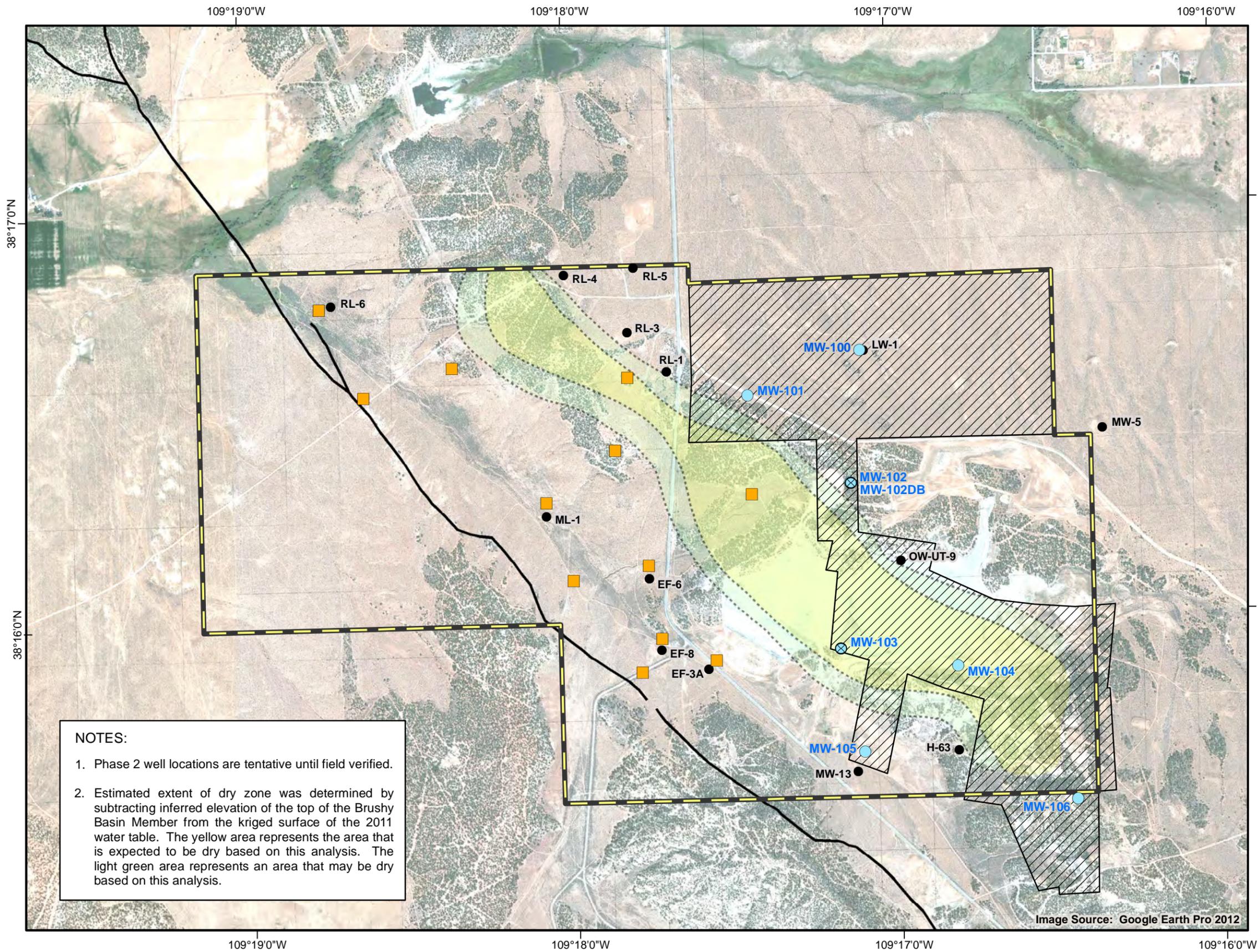


**RIO ALGOM MINING LLC
LISBON FACILITY**

**2011
URANIUM
CONCENTRATIONS**

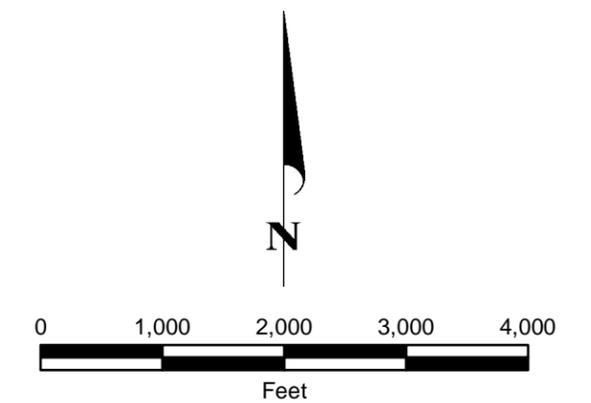
MONTGOMERY & ASSOCIATES
Water Resource Consultants

2012
FIGURE 5



EXPLANATION

- Existing Well and Identifier
- MW-5
- Phase 1 Well and Identifier
- MW-101
- ⊗ Cored Borehole
- Phase 2 Drilling Location
- Lisbon Valley Fault
- ▭ Long Term Surveillance and Maintenance Boundary
- ▭ Estimated Minimum Extent of Dry Zone in Burro Canyon Aquifer
- ▭ Estimated Maximum Extent of Dry Zone in Burro Canyon Aquifer
- ▨ Rio Algom Mining LLC Property Boundary



NOTES:

1. Phase 2 well locations are tentative until field verified.
2. Estimated extent of dry zone was determined by subtracting inferred elevation of the top of the Brushy Basin Member from the kriged surface of the 2011 water table. The yellow area represents the area that is expected to be dry based on this analysis. The light green area represents an area that may be dry based on this analysis.

**RIO ALGOM MINING LLC
LIBSON FACILITY**

**PROPOSED
INVESTIGATION
WELL LOCATION MAP**


2012

Water Resource Consultants FIGURE 6

APPENDIX A

EXISTING WELL INFORMATION

TABLE A1. EXISTING WELL INFORMATION LISBON FACILITY RIO ALGOM MINING LLC

WELL ID NUMBER	COORDINATES in UTM FEET NAD27		LAND SURFACE ELEVATION (feet)	CASING INNER DIAMETER (inches)	TYPE OF CASING MATERIAL	SCREENED ZONE LENGTH (feet)	DEPTH OF WELL (feet)	TOP OF CASING TO TOP OF SCREEN (feet)	TOP OF CASING TO PUMP INLET (feet)
	EASTING	NORTHING							
EF-3A	649,426	4,236,334	6,579.0	4.0	PVC	30	215	173	190
EF-6	649,157	4,236,742	6,568.0	4.0	PVC	30	137	105	125
EF-8	649,218	4,236,426	6,573.0	4.0	PVC	30	244	212	230
H-63	650,572	4,236,000	6,685.0	4.0	PVC	30	172	140	155
LW-1	650,282	4,237,871	6,720.0	4.0	PVC	30	223	203	215
ML-1	648,691	4,237,015	6,529.1	4.0	PVC	20	157	60	
						15	157	150	152
MW-13	650,101	4,235,891	6,638.3	4.0	PVC	80	206	125	165
MW-5	651,186	4,237,459	6,742.0	5.0	PVC	30	197	165	180
OW-UT-9	650,281	4,236,845	6,701.9	4.0	PVC	18	142	118	127
RL-1	649,220	4,237,678	6,651.0	5.0	PVC	20	124	104	
RL-3	649,039	4,237,845	6,702.6	4.0	PVC	20	183	163	178
RL-4	648,745	4,238,101	6,679.9	5.0	PVC	40	178	137	165
RL-5	649,061	4,238,141	6,684.7	4.0	PVC	37	186	150	170
RL-6	647,593	4,237,975	6,460.0	5.0	PVC	10	20	7.65	18.0

PVC = Poly Vinyl Chloride
 UTM = Universal Transverse Mercator
 NAD = North American Datum



Project Name: Piezometer Installation
Client: Rio Algom
Location: LaSal, Utah
Drilled By: Rex Wyatt
Drill Date: Mar. 20, 2003
Compiled By: D. Foster

Surface Elevation: 6651.0ft



KOMEX INTERNATIONAL LTD.
 ENVIRONMENTAL AND ENGINEERING CONSULTANTS
Monitoring Well #: RL-1

Depth (ft)	Symbol	Description	Well Data	Comments
0		Ground Surface		
0-10		SANDY SILT ALLUVIUM (0-10ft) Light reddish brown (5YR 6/4), dry, loose.		Stove Pipe Surface Completion Locking expansion cap Grout 0-2ft
10-60		SANDSTONE (10-60ft) Light yellowish brown (10YR 6/4), poorly sorted, fine to coarse grained, angular to subrounded, bumpy drilling. At 20ft, as above, smooth drilling. At 30ft, semi-bumpy drilling. At 40ft, as above, semi-bumpy drilling. At 45ft, smooth drilling At 50ft, as above, well sorted, fine to medium grained.		
60-102		SANDSTONE (60-102ft) Very pale brown (10YR 7/3), well sorted, fine to medium grained, bumpy drilling. At 90ft, as above, poorly sorted, fine to coarse grained, angular to subrounded.		5" dia. Sch 40 PVC Blank Casing 3.75" dia. borehole Bentonite Chips 2-102ft
102-123.5		SANDSTONE (102-123.5ft) White (10YR 8/1), well sorted, fine grained. At 120ft, as above, moderately to well sorted, fine to medium grained, trace coarse grained, angular.		Top of Sand 102ft Top of Screen 104ft 5" dia. Sch 40 PVC Screen (0.010" Slot) Sand Filter Pack Bottom of Sand and Screen 124ft
123.5-132		SHALE (123.5-132ft) Reddish brown (2.5YR 7/4).		Native Backfill 124-132ft
132		Total Drilled Depth		

Figure 2-1. Boring log and well construction for RL-1.

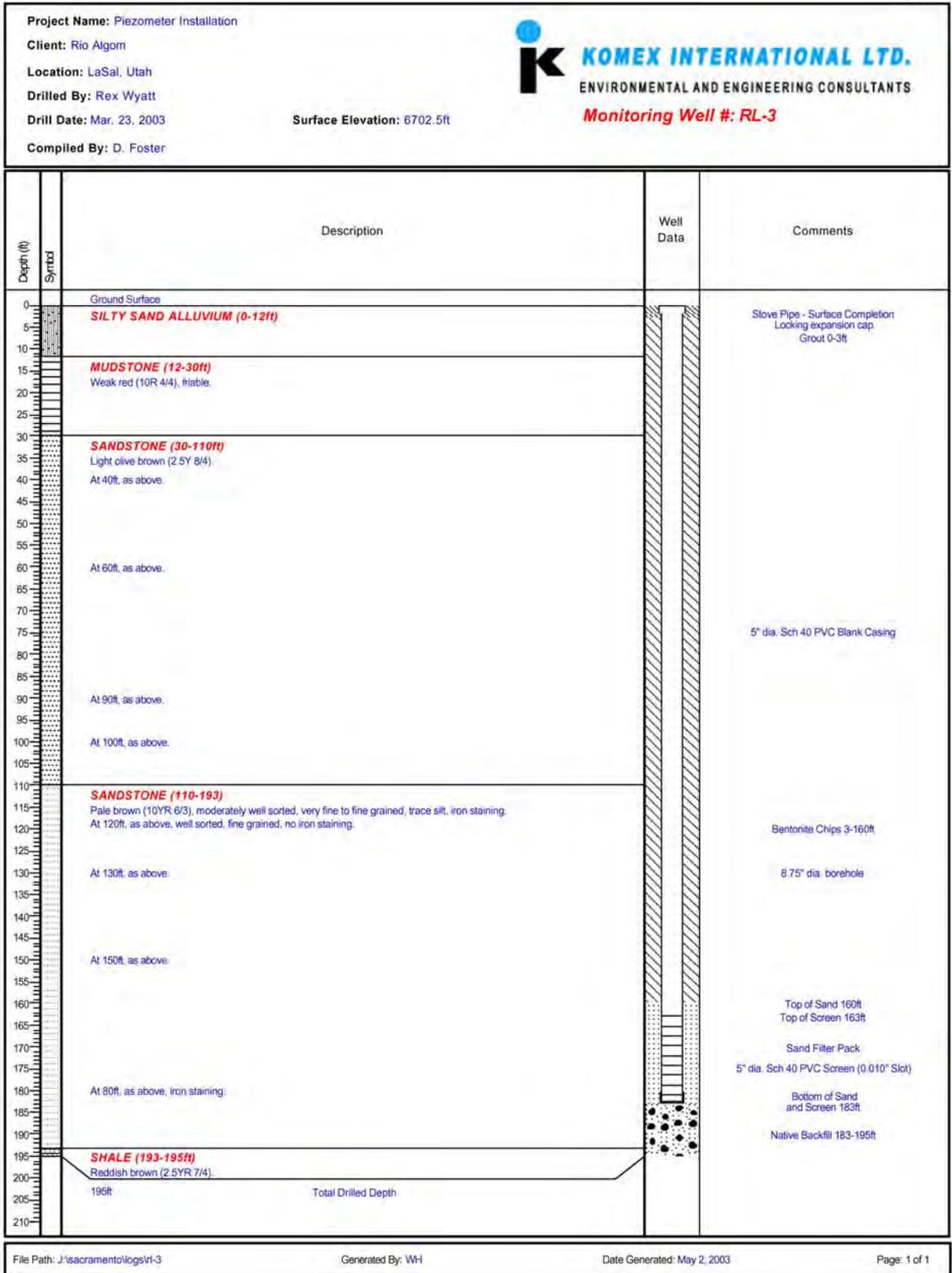


Figure 2-3. Boring log and well construction for RL-3.

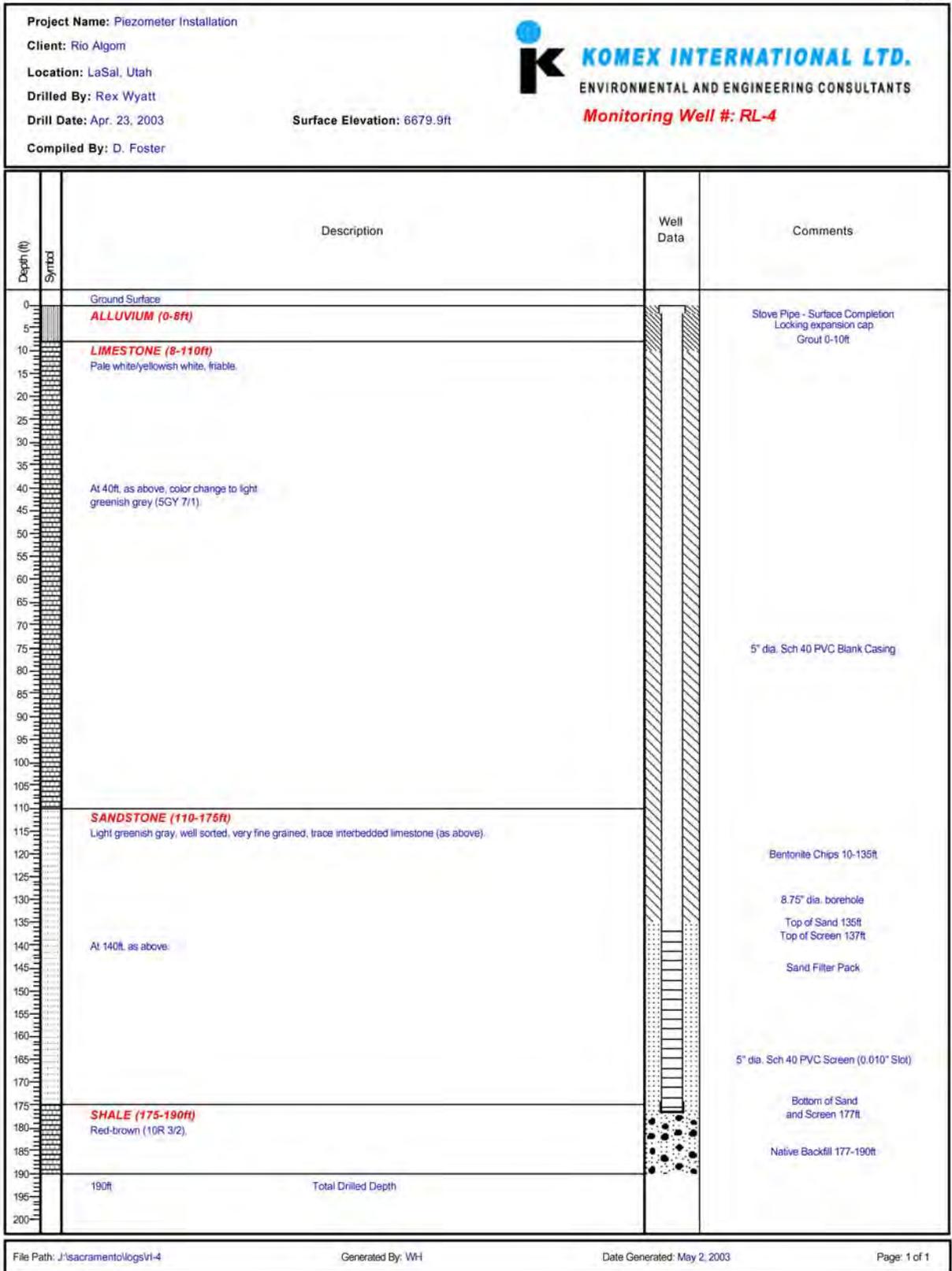


Figure 2-4. Boring log and well construction for RL-4.

Project Name: Piezometer Installation
Client: Rio Algom
Location: LaSal, Utah
Drilled By: Rex Wyatt
Drill Date: Apr. 24, 2003
Compiled By: D. Foster



Surface Elevation: 6684.7ft

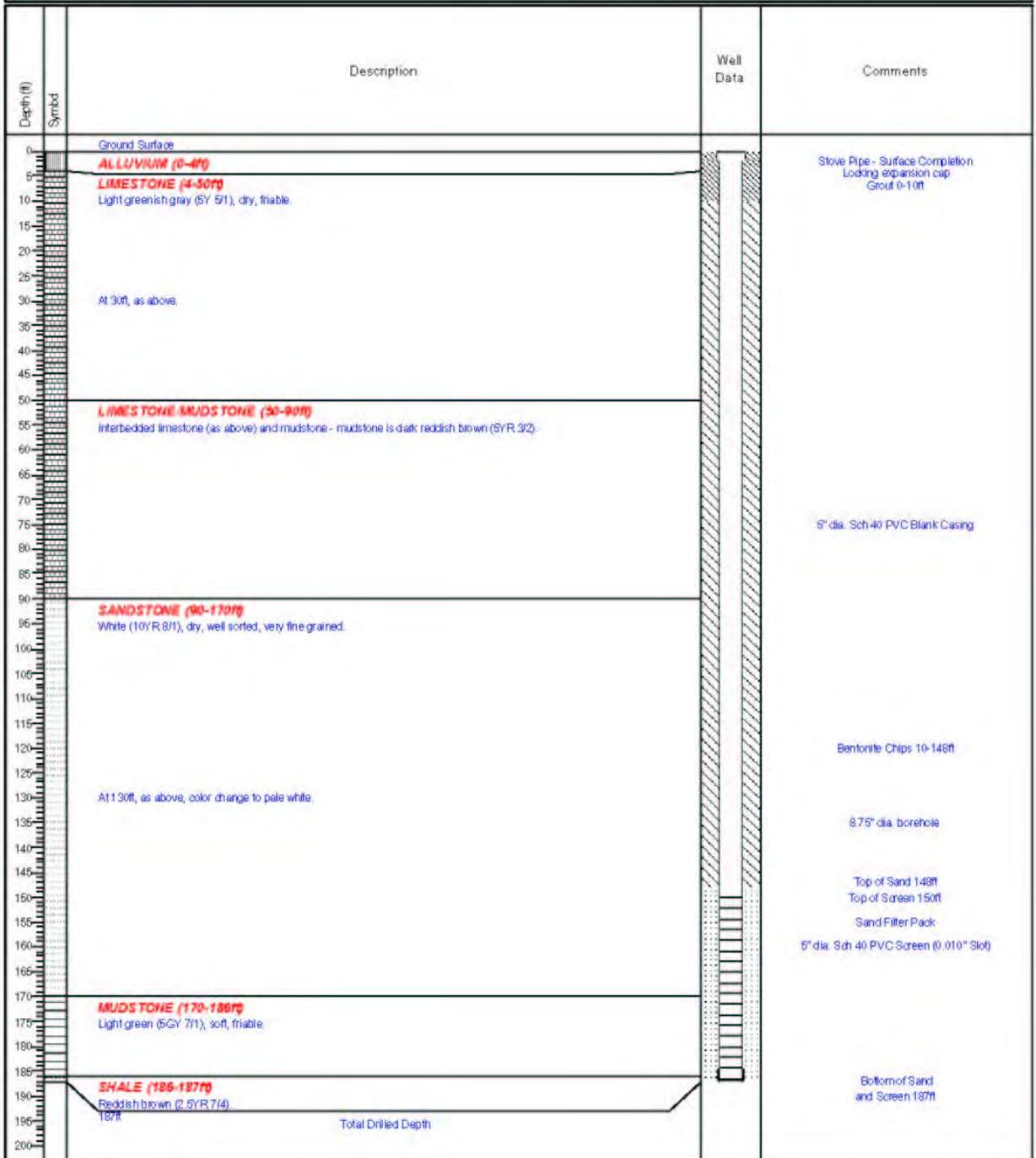


Figure 2-5. Boring log and well construction for RL-5.

HOLE NO.: OW-UT9

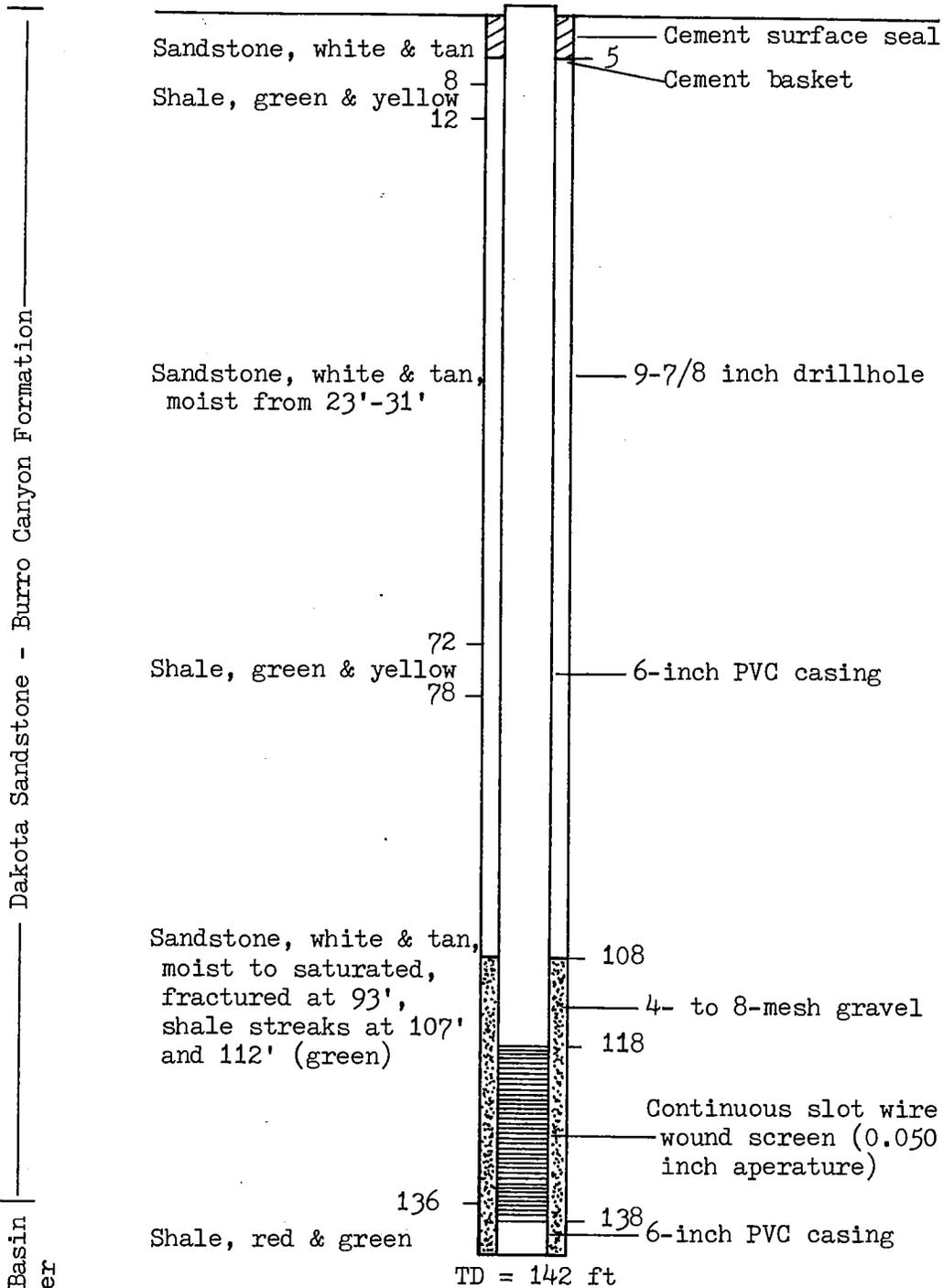
GROUND SURFACE ELEV.: 6701.9 feet

DATE DRILLED: 29 Jun 1983

VERTICAL SCALE: 1 inch = 20 feet

LITHOLOGIC LOG

WELL COMPLETION DETAILS



Dakota Sandstone - Burro Canyon Formation

Brushy Basin Member



Date: 9/9/98, 9/10/98
 Client: RAMC
 Project: Lisbon CAP Review
 Drilling Contractor: H. Beeman
 Drilling Crew:
 Geologist/Engineer(s): Bob Lewis
 Location Detail:

Boring/Well Number: ML-1
 Total Depth: 175 ft.
 Well Depth: 168 ft.
 Surface Elev.:
 Casing Elev.:
 Depth to First Water: 85 ft.
 Static Water Level:

Depth (ft)	Sample Interval	Sample Number	OVM/PID (ppm)	Water Quality	Description	Well Construction
0	AL			PH 7.85 CND=824 14.2°C (make-up H ₂ O)	Begin 2:40 9/9 Silty Sand (Alluvium), v.f.-f. grained, reddish-brown (0-13'). End 5:05 pm.	Neat Cement
10	SS				Begin 8:05 am 9/10. Sandstone (13-23'), v.f. grained, reddish-brown to grey, dry.	Neat Cement
20	SH/SLT				Mudstone and siltstone (23-33'), grey-olive, w/ some v.f. grained sandstone, very hard, dry.	
30	SS				Sandstone (33-57), v.f.-med. grained, buff brown-grey, siliceous, very hard, w/ minor dk. grey mudstone and micritic limestone	BLANK PVC 4"
40	SLT/LS				siltstone w/ v.f. grained sandstone (57-59), grey-green, hard. Limestone (59-61'), micritic, greenish-grey.	
50	SLT/SS				Siltstone and v.f. grained sandstone (61-71'), grey-green, Hard.	
60	SS				Sandstone, f.-med. grained, buff-brn, moist.	
70						
80						
90	CG/SS				Water @ 85 ft. Well making >40 gpm. Gravelly sandstone, buff-brown med-v. coarse grained, granule-pebble gravel ~20%, lithic, wet.	Cuttings



Date: 9/10/98
 Client: RAMC
 Project: Lisbon CAP Review
 Drilling Contractor: H. Beeman
 Drilling Crew:
 Geologist/Engineer(s): Bob Lewis
 Location Detail:

Boring/Well Number: ML-1
 Total Depth: 175 ft.
 Well Depth: 168 ft.
 Surface Elev.:
 Casing Elev.:
 Depth to First Water: 85 ft.
 Static Water Level:

Depth (ft)	Sample Interval	Sample Number	OVM/PID (ppm)	Water Quality	Description	Well Construction
90	C6				Well making > 50 gpm.	Neat Cement
100	155				Conglomerate and sandstone, buff-brn, med-v. coarse grained, granule-pebble gravel, lithic, angular (85-117').	
110				pH=7.9 CND=716 14.3°C		Neat Cement
120	55				sandstone (117-168'), v.f. grained, white, hard, w/ trace granule gravel	
130				pH=8.0 CND=821 13.3°C	As above, very hard (slow drilling ~ 5'/hr.)	Bent Seal 4" Blank PVC
140				pH=8.0 CND=695 13.8°C	Becoming coarser w/ gravel at 143', yellow-brn.	
150					As above, grey-green, trace lithic gravel.	30-3/4" PVC
160				pH=8.2 CND=820 14.3°C		
170	5H			pH=7.9 CND=819 14.6°C	Shale, greyish-green, soft (168-170'). shale, red, very hard (Brushy Basin). T.D. @ 175 ft @ 2:35 pm.	Cuttings
180						



APPENDIX B

SUMMARY OF PHASE 1 GROUNDWATER MODELING

APPENDIX B

PHASE 1 PROBABILISTIC MODELING

PHASE 1 PROBABILISTIC MODEL DEVELOPMENT

Important uncertainties exist at the Site that limit our ability to adequately model uranium fate and transport at the Site. Some of these uncertainties relate to the sparse nature of data available over the last 8 years, while other uncertainties relate to insufficient understanding of contaminant sources and hydrogeologic structures, properties, and conditions. Phase 1 probabilistic modeling was used to investigate these uncertainties and help guide the development of the field program so that valuable data for reducing key uncertainties are collected in advance of Phase 2 probabilistic modeling.

During Phase 1 modeling, a total of 8,000 groundwater flow models were run. Model likelihoods were then calculated based on the residuals between head data collected in the field during the years 2004-2011 and model projected heads. Due to complications with running the transport models using the Monte-Carlo method, the thirty best groundwater flow models were selected and transport models were run for each of them. Models in which uranium reached the Long Term Surveillance and Maintenance (LTSM) boundary were identified as important. Each model was then weighted based on the model likelihood and the importance of the model. Areas in which important and likely models vary significantly in their projections of head and uranium concentration were identified as areas where data should be collected.

Phase 1 modeling was adapted from the KOMEX (2003) model. The numerical groundwater modeling code MODFLOW 1996 (McDonald and Harbaugh, 1996) was used to develop a transient, three-dimensional, finite-difference groundwater flow model. The model setup and execution was facilitated using the industry standard modeling software, Groundwater Vistas (Rumbaugh and Rumbaugh, 2007). The KOMEX (2003) model was modified, to eliminate known shortcomings of the model and to investigate additional conceptualizations of the system. Changes made to the KOMEX model (2003) are presented in **Table B1**.

TABLE B1. MODIFICATIONS TO THE KOMEX MODEL (2003)

Model Feature	Komex Model	Phase 1 Model
Type of model	Steady-state	Transient
Rewetting/ dry zone of BCA	Cell rewetting is inactive. Beginning in 2004 cells resaturate instantly. The dry zone in the BCA is assumed to be constant and is represented by no flow cells.	Cells resaturate when adjacent cells exceed a water level threshold. Initial water levels are interpolated from 2003 heads. The extent of the dry zone of the BCA changes throughout model time and uniquely for each model.
Elevation of bottom of BBM	The bottom of the BBM is uniformly set to 5,900 ft above mean sea level.	The bottom of the BBM is uniformly set to 6,233 ft above mean sea level. This elevation was chosen so that the BBM is 50 ft thick in the thinnest active model cell.
Hydraulic conductivity zones	The majority of the BCA is a single zone. Two localized zones have higher conductivity representing areas of fracturing. BBM is represented as a single zone.	The BCA is divided into four zones as shown on Figure B1 . The BBM is represented as a single zone. Conductivities are assigned via stochastic modeling.
Recharge zones not including the tailings	Recharge is assigned in two zones that combined cover the entire model domain area.	Recharge is assigned in one zone that covers the entire model domain area. The recharge rate varies depending on the model conceptualization.
Boundary conditions	Single set of boundary conditions used.	Two sets of boundary conditions used depending on the model conceptualization. These boundary conditions are depicted on Figures B2 and B3 .
BCA/BBM layer boundaries	Layer boundary based on top of BBM contour used by Komex (2003) as shown on Figure B4 .	Layer boundaries based on top of BBM contours shown used by Komex (2003) Figure B4 and conceptualized contour as shown on Figure B5 .

NOTE: Rows highlighted in light green indicate variables that were changed stochastically. Rows highlighted in light blue represent variables changed as conceptual models.

Parameterizations and conceptualizations were varied in the probabilistic, Monte-Carlo modeling process. In this context, “parameterizations” refers to variables that could easily be modified using a random number generator. The only parameter modified in this way was hydraulic conductivity. Conceptualizations are variables or boundary conditions that could not be modified using a random number generator. This type of variable was instead modified by manually setting up the conceptual models. Flow models were run for 1,000 parameterizations for each of 8 different conceptual models. This led to a total of 8,000 different groundwater flow models. The 8 different conceptual models were composed

of 2 options for each of 3 different variables (2^3 possible combinations). The conceptual model variables were:

- extent of anticline (basic or extended)
- amount of recharge (0 inches per year or 0.9 inches per year)
- boundary conditions along eastern/north-eastern boundary of model (constant head or no flow)

Model layer one, the Burro Canyon Aquifer (BCA), has four hydraulic conductivity zones as shown on **Figure B1**. Model zone 2 is the area to the southwest of the Lisbon Valley Anticline (LVA). Within this zone, reported hydraulic conductivity values ranged from 0.01 feet per day (ft/day) to 798 ft/day. Zone 3 is the area in the northwest portion of the model. Hydraulic conductivity values have not been reported for this zone. Zone 4 is the zone to the northeast of the LVA. Hydraulic conductivity values reported in this zone range from 0.04 ft/day to 34 ft/day. Zone 5 is the thin zone running parallel to the Lisbon Fault. Hydraulic conductivity values have not been reported for this zone. Model layer two, the Brushy Basin Member (BBM), is model zone 1 has one uniform hydraulic conductivity zone. Hydraulic testing in the BBM occurred in wells H-72. Reported values ranged from 0.01 to 0.96 ft/day. Hydraulic conductivity of the BBM is minimally characterized and therefore uncertain.

Probability distributions and ranges were used by the random number generator to generate hydraulic conductivity values for each model zone. All hydraulic conductivity zones were assigned log-uniform probability distributions. This means that an equal number of values are sampled within each order of magnitude of the range assigned to each zone. The range assigned to each hydraulic conductivity zone included each order of magnitude reported within each model zone. Since model zones 3 and 5 did not have any hydraulic conductivity values reported, the entire range of values reported in all other BCA zones was considered possible. In model zone 1, which represents the BBM, the parameter range was extended by one order of magnitude on each side of the reported values due to the limited amount of data for the BBM. The 1,000 model parameterizations were comprised of hydraulic conductivity values randomly sampled from log-uniform probability distributions for each of five model hydraulic conductivity zones. Probability distributions, and minimum and maximum values for each hydraulic conductivity zone are displayed in **Table B2**.

TABLE B2. PROBABILISTIC MODEL PARAMETERS

Variables	Zone	Low	High	Distribution	Description
Horizontal Hydraulic Conductivity (ft/day)	1	0.001	10	Log Uniform	Uniform within Brushy Basin Member
	2	0.01	1,000	Log Uniform	South West of Lisbon Valley Anticline
	3	0.01	1,000	Log Uniform	Northwest region of model
	4	0.01	100	Log Uniform	North East of Lisbon Valley Anticline
	5	0.01	1,000	Log Uniform	Thin zone along Lisbon Valley Fault

Modeling of contaminant transport utilized MT3DMS (Zheng and Wang, 1999). Only advective transport was simulated; this assumption was made because advective transport is believed to dominate diffusive transport and attenuation processes are considered negligible. Otherwise initial conditions and transport parameters were identical to those used by KOMEX (2003).

During Phase 1 transport modeling, problems were encountered when running MT3DMS stochastically. Because of this issue, it was not possible to run all flow models as transport models during Phase 1 modeling. Contaminant transport models were run for only the thirty best fitting flow models.

FINDINGS FROM PHASE 1 MODELING RESULTS

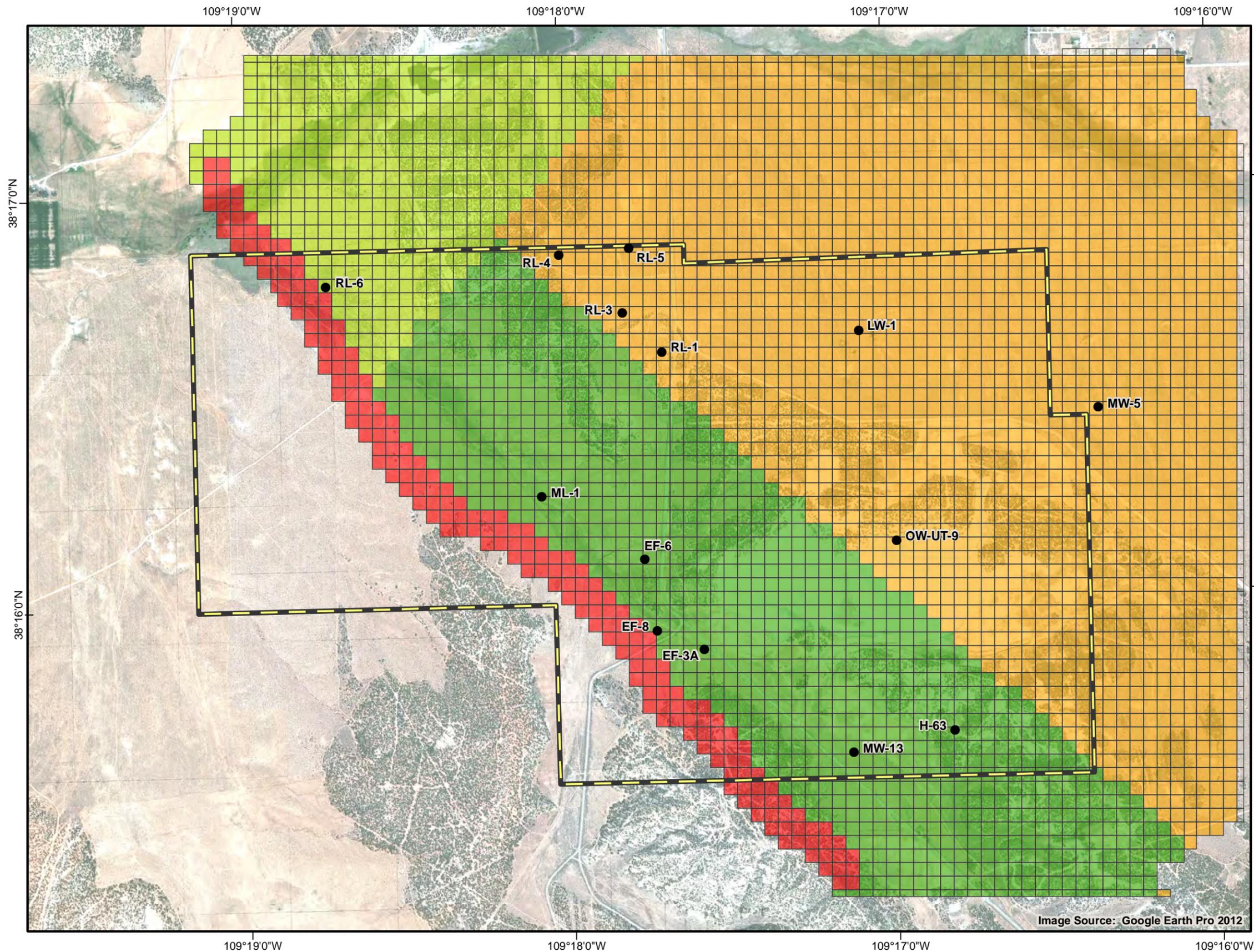
After each model was run, models were given a “likelihood” and “importance” weight. Models that are “likely” are simulations that show a good fit between projected and measured groundwater levels and uranium concentrations during the period 2004-2011 at currently monitored wells. This goodness of fit was calculated using a normalized Root Mean Squared Error statistic. Models were then evaluated to determine if they are important. Models that projected uranium reaching the northern LTSM boundary any time during the 200-year model period were identified as important. The model likelihood and importance were then combined to calculate a single likelihood-importance weight for each model. Models that have a weight close to one are both important and likely; models that have a weight close to zero were neither important nor likely. Finally, the likelihood-importance weighted head and concentration variance among all models was calculated resulting in a data discrimination index. The data discrimination index is highest in areas where models that match historic data well and result in important outcomes have the most variance. The data discrimination index was used to help guide the development of the field program and is integrated into the proposed field program.

Other interesting findings can be noted from the Phase 1 modeling and will be of value in Phase 2 modeling. For example, the best fitting flow models have a relatively high hydraulic conductivity (10s to 100s of ft/day) in zone 5 and a lower hydraulic conductivity (0.1 to 2 ft/day) in zone 2. Also, the best fitting flow models have a very low conductivity in the BBM (on the order of 0.001 ft/day). These findings are not a claim about the actual nature of hydrogeologic units at the Site. However, if hydraulic property data collected in the field program are in agreement with these findings the range of hydraulic conductivity values used in Phase 2 models can be constrained. If hydraulic property data collected in the field program are in disagreement with these findings, it may point to other modeling conceptualizations that need to be addressed.

A third key finding from Phase 1 modeling is that some flow and transport models that fit historic data well project uranium reaching the northern LTSM boundary while the majority of the models do not. This finding supports the use of probabilistic modeling. The non-unique nature of solutions to groundwater flow and transport results from uncertainty associated with data collection, model conceptualization, parameter estimation, and numerical modeling methods. For this reason, consideration of multiple models is essential for robust decision making.

REFERENCES CITED

- Komex, 2003, **Response to Request for Additional Information (RAI), Application for Alternate Concentration Limits Source Materials License SUA -119, Rio Algom Mining LLC, Lisbon Facility, La Sal, Utah:** prepared for Rio Algom Mining LLC, October 13, 2003.
- McDonald, M.G., and A.W. Harbaugh, 1996, **User's Documentation for MODFLOW-96, an update to the U.S. Geological Survey Modular Finite-Difference Groundwater Flow Model:** U.S. Geological Survey Open-File Report 96-485, 56 p.
- Rumbaugh, J.O., and D.B. Rumbaugh, 2007, **Groundwater Vistas (Version 5.39):** Environmental Simulations Inc., Reinholds, Pennsylvania, 2007.
- Zheng, C., and Wang, P.P., 1999, **MT3DMS, A Modular Three-Dimensional Multispecies Transport Model for Simulation of Advection, Dispersion and Chemical Reactions of Contaminants in Groundwater Systems:** Vicksburg, Mississippi, Waterways Experiment Station, U.S. Army Corps of Engineers, 2007.



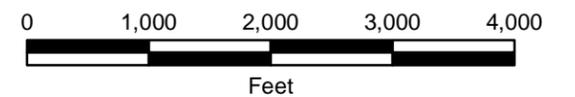
EXPLANATION

-  Well and Identifier
-  Model Grid Cells
-  Long Term Surveillance and Maintenance Boundary

Hydraulic Conductivity Zones

-  2
-  3
-  4
-  5

NOTE: Model Zone 1 uniformly represents the Brushy Basin Member and is not shown in this figure.



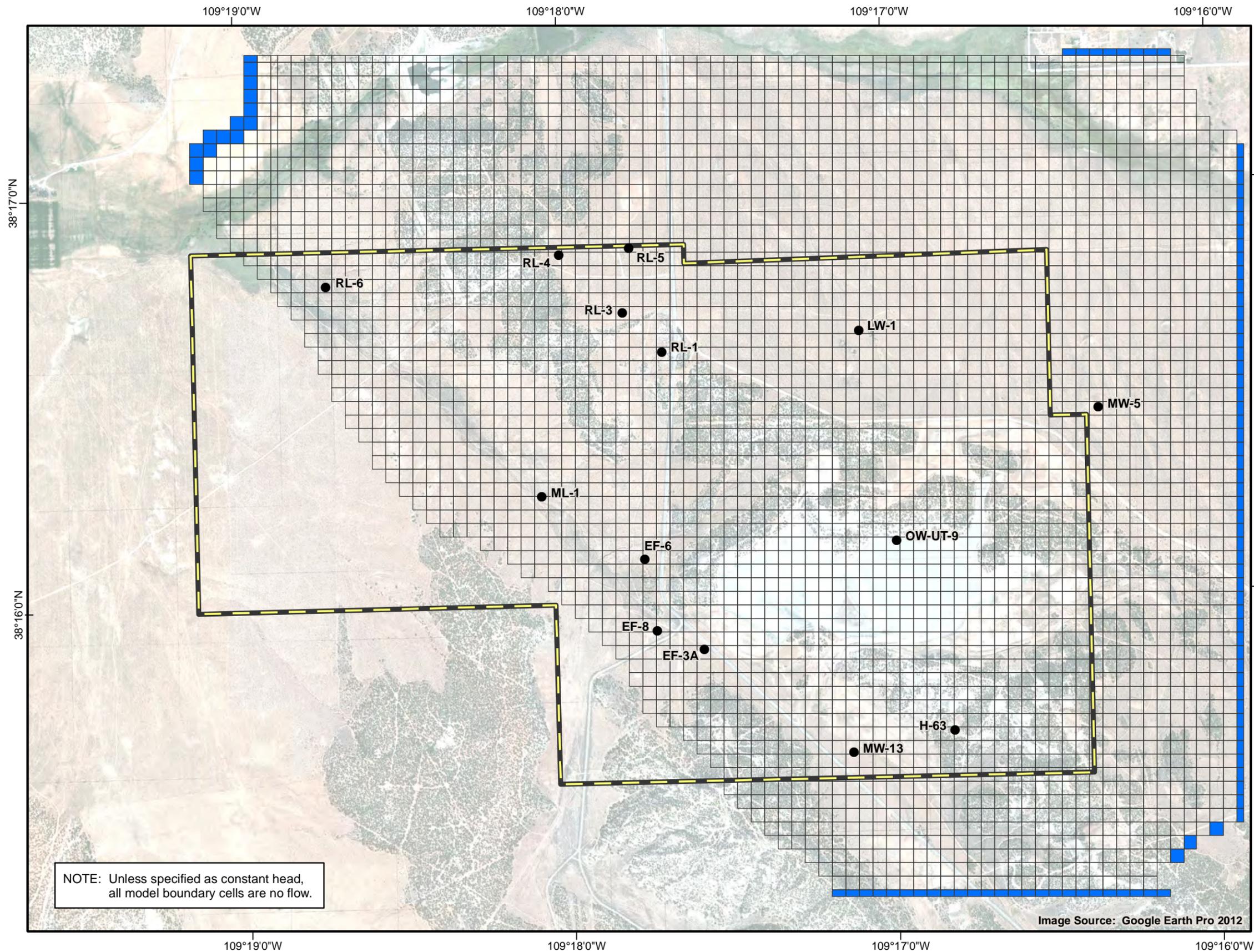
**RIO ALGOM MINING LLC
LISBON FACILITY**

**HYDRAULIC CONDUCTIVITY
ZONES OF THE
BURRO CANYON AQUIFER**



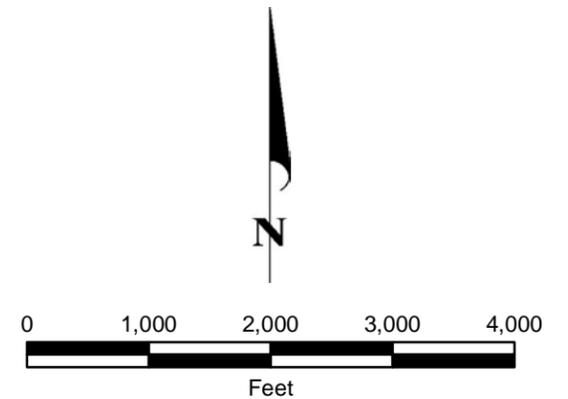
2012

FIGURE B1



EXPLANATION

- Well and Identifier
- Model Grid Cells
- Constant Head Boundary Cells
- Long Term Surveillance and Maintenance Boundary



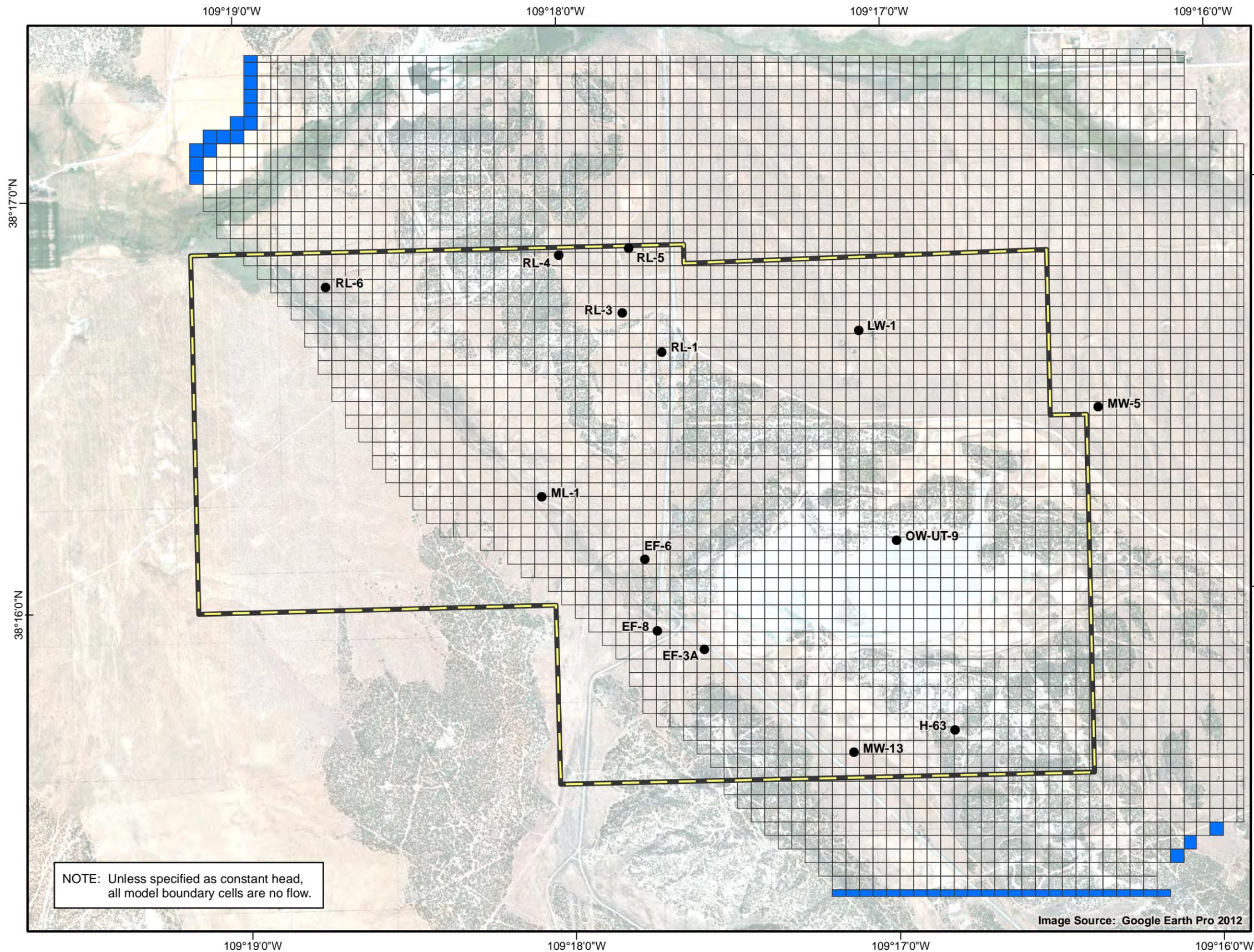
**RIO ALGOM MINING LLC
LISBON FACILITY**

**BURRO CANYON AQUIFER
BOUNDARY CONDITION
CONCEPTUALIZATION 1**

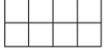
**MONTGOMERY
& ASSOCIATES**
Water Resource Consultants

2012

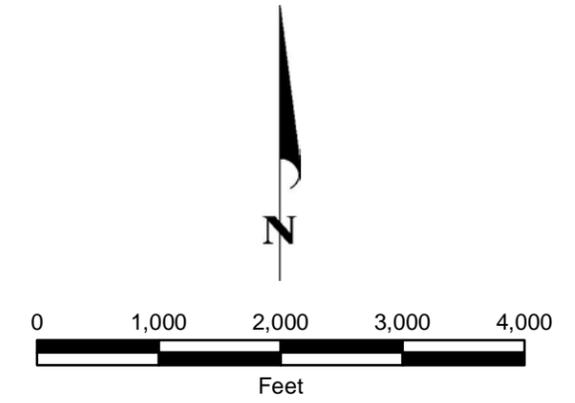
FIGURE B2



EXPLANATION

-  Well and Identifier
-  Model Grid Cells
-  Constant Head Boundary Cells
-  Long Term Surveillance and Maintenance Boundary

38°17'0"N
38°16'0"N



**RIO ALGOM MINING LLC
LISBON FACILITY**

**BURRO CANYON AQUIFER
BOUNDARY CONDITION
CONCEPTUALIZATION 2**

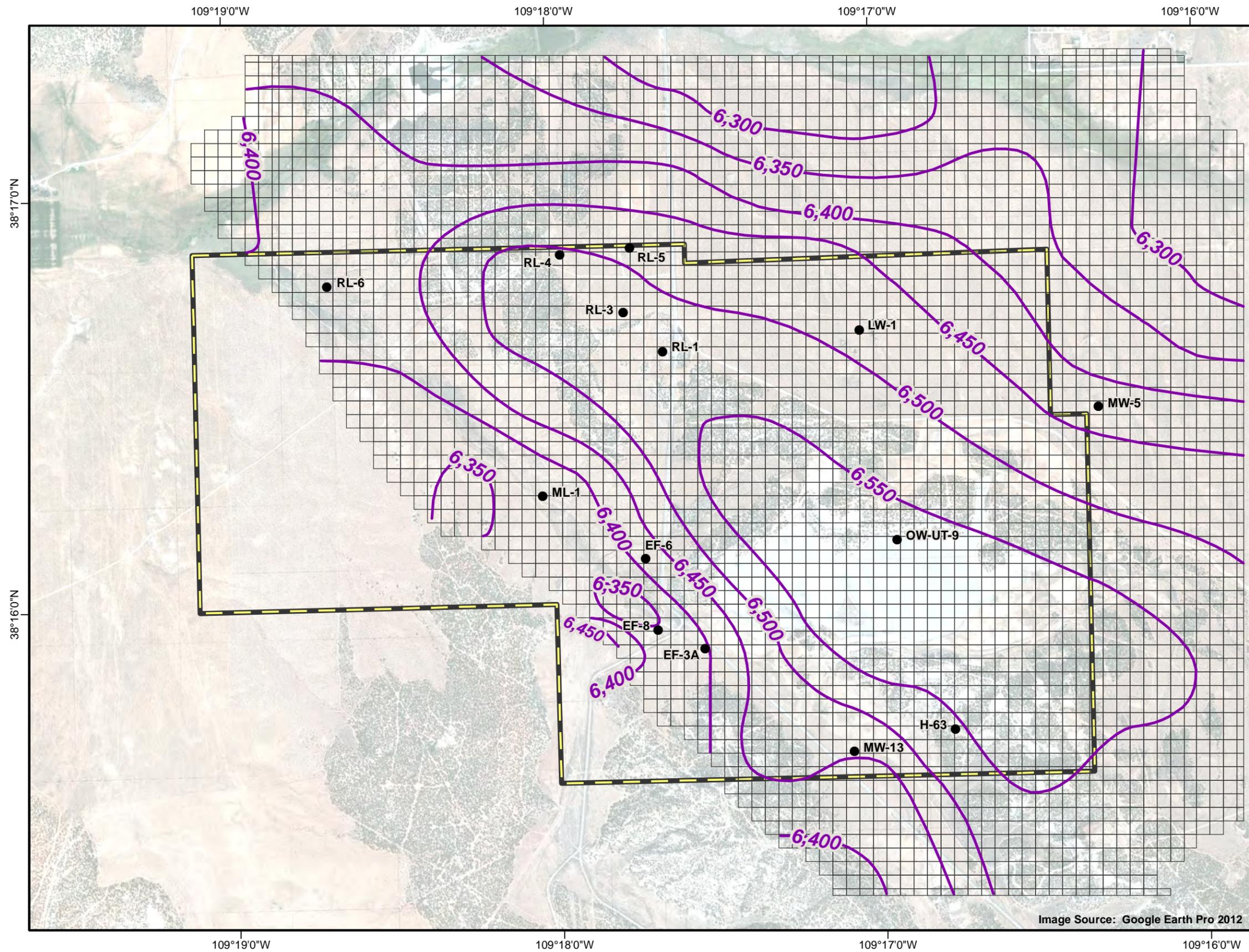
 **MONTGOMERY & ASSOCIATES**
Water Resource Consultants

2012

FIGURE B3

NOTE: Unless specified as constant head, all model boundary cells are no flow.

Image Source: Google Earth Pro 2012



EXPLANATION

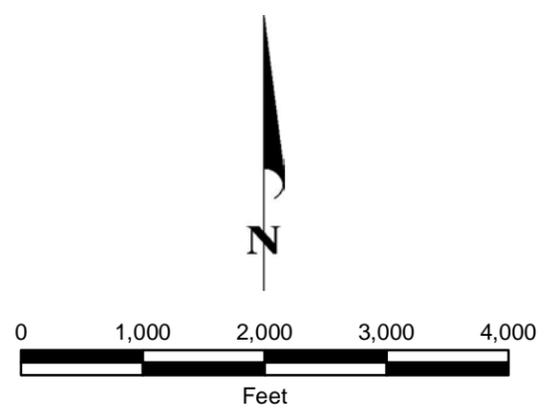
- Well and Identifier
- Inferred Elevation of Top of Brushy Basin Member (KOMEX, 2003)
- Model Grid Cells
- Long Term Surveillance and Maintenance Boundary

38°17'0"N
38°16'0"N

38°17'0"N
38°16'0"N

109°19'0"W
109°18'0"W
109°17'0"W
109°16'0"W

109°19'0"W
109°18'0"W
109°17'0"W
109°16'0"W



**RIO ALGOM MINING LLC
LISBON FACILITY**

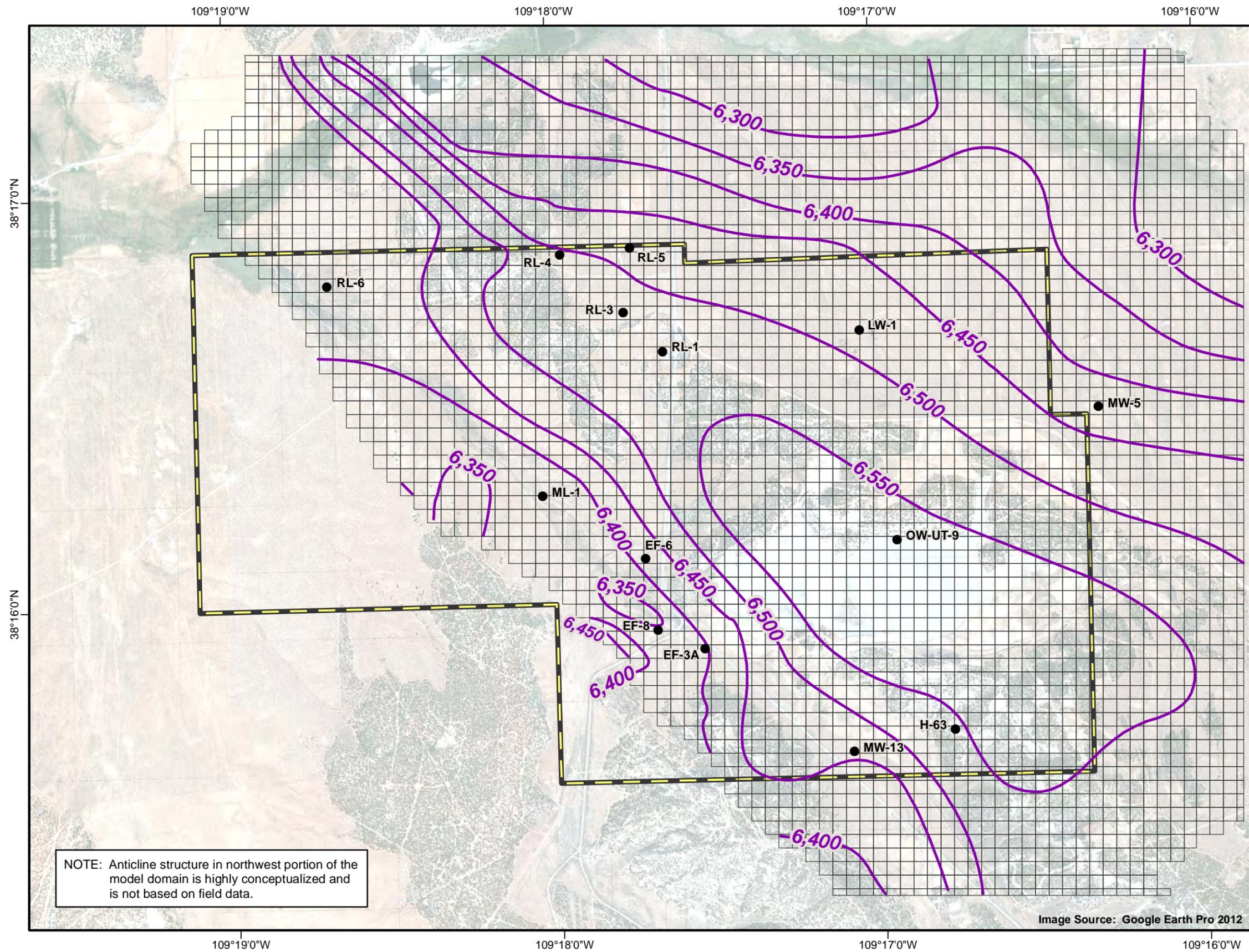
**BASIC
ANTICLINE
STRUCTURE**

2012

Water Resource Consultants

FIGURE B4

Image Source: Google Earth Pro 2012

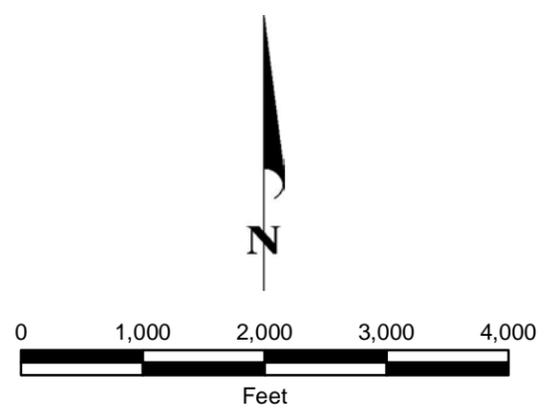


NOTE: Anticline structure in northwest portion of the model domain is highly conceptualized and is not based on field data.

Image Source: Google Earth Pro 2012

EXPLANATION

- MW-5** Well and Identifier
- Inferred Elevation of Top of Brushy Basin Member
- Model Grid Cells
- Long Term Surveillance and Maintenance Boundary



**RIO ALGOM MINING LLC
LISBON FACILITY**

EXTENDED ANTICLINE STRUCTURE



2012

FIGURE B5



APPENDIX C

WELL CONSTRUCTION AND TEST PROCEDURES

APPENDIX C

WELL INSTALLATION METHODS AT RIO ALGOM MINING LLC LISBON FACILITY

SCOPE AND APPLICABILITY

The following sections describe methods for the drilling, installation, and development of wells at the Rio Algom Mining LLC Lisbon facility (RAML) in Lisbon, Utah. The methods are intended to be general in nature. As the work progresses, appropriate revisions may be necessary and may be implemented as required to meet project objectives.

DRILLING PREPARATION

Drilling will use conventional or reverse-circulation air drilling methods. Drilling will be conducted by an approved well constructor, licensed in the State of Utah. Wells will be designed and constructed in accordance with Utah Administrative Codes (UAC) R317-6-6.3(I)(6), UAC R655-4-15, and U.S. EPA RCRA Ground Water Monitoring Technical Enforcement Guidance Document. Prior to commencing the drilling program, proposed well locations will be field-verified. Each well site will be inspected for drilling impediments (e.g., utilities, limited access, etc.).

DRILLING AND WELL CONSTRUCTION

Drilling procedures were developed based on available information and may be modified in the field in accordance with the conditions encountered.

Fully Penetrating BCA Wells

Some wells in the Phase 1 field program will be fully penetrating water table wells (e.g., the well screen will bridge the water table and the entire saturated thickness of the aquifer will be screened). The water table will be encountered in the BCA. For each fully penetrating water table well, steel conductor casing will be advanced to the top of the BCA and cemented in place to seal off overburden/alluvium. The total drilling depth of these wells will be determined by the depth to the BCA/BBM contact. When drilling has reached the suspected water table depth (based on water levels in existing vicinity wells), boreholes will be monitored for water production at 10-foot increments. At each increment, the borehole will be evacuated of drill water by airlifting; airlifting will continue for a prescribed period of time to determine whether the borehole is producing water. Once a determination has been made that the water table is encountered, the field team may elect to take a groundwater sample from the upper portion of the aquifer if deemed appropriate. Drilling will then

continue to the BCA/BBM interface. The well will be constructed with a screen extending from the BCA/BBM contact to 5 feet above the water table.

Companion BCA Water Table Wells

Wells drilled adjacent to existing monitoring wells are considered companion water table wells. These wells will be drilled so that they screen the entire saturated thickness of the aquifer in conjunction with the existing adjacent well. All of the existing wells on RAML property are screened immediately above the BCA/BBM contact. When drilling Phase 1 companion wells, steel conductor casing will be advanced to the top of the BCA and cemented in place to seal off overburden/alluvium. When drilling has reached the suspected water table depth (based on water levels in existing vicinity wells), boreholes will be monitored for water production at 10-foot increments. At each increment, the borehole will be evacuated of drill water by airlifting; airlifting will continue for a prescribed period of time to determine whether the borehole is producing water. Once a determination has been made that the water table is encountered, the field team may elect to take a groundwater sample from the upper portion of the aquifer if deemed appropriate. The borehole will then be advanced to the top of the adjacent existing wells screen. The well will be constructed with the bottom of the screened interval at the top of the adjacent existing wells screen and the top of the screened interval five feet above the water table.

BBM Wells

These are wells that are completed in the BBM. There are two general well constructions that will be installed in the BBM: BBM water table wells and BBM wells that are screened beneath saturated BCA.

Wells that are drilled in which a water table is first encountered in the BBM will be built as BBM water table wells. Once the water table has been identified, the well will be built with 30 feet of screened interval, 5 feet of which will extend above the water table. If the water table in the BBM is within 5 feet of the BBM/BCA contact, the screen will not extend into the BCA. Appropriate measures will be taken to ensure that there is no cross contamination between the BCA and BBM.

Some BBM wells will be cored and will be screened beneath saturated BCA. In these cases a core barrel will be advanced to collect continuous core to the BCA/BBM contact. After the cored borehole is reamed to the appropriate diameter, a steel conductor casing will be installed to the contact and cemented in place to seal off the BCA aquifer and prevent cross contamination to the BBM. Once the integrity of the seal has been verified, continuous core will be collected 35 feet into the BBM. After the cored borehole is reamed, the well will be built with 30 feet of screened interval in the BBM.

Core Samples

Coring will be conducted to retrieve undisturbed samples for hydrochemical analyses. Borings will be cored using an HQ (2.5-inch diameter) core barrel. For hydrochemical analyses of the vadose zone to assess residual uranium concentrations, a core barrel will be advanced to the estimated depth of the water table to collect continuous core samples. Selected core samples will be submitted to a certified hydrochemical laboratory licensed by the State of Utah for analysis of leachable uranium by U.S. EPA Method 1311 TCLP metals extraction. Once coring is completed, the cored borehole will be reamed to the appropriate diameter and drilling will continue as describe above.

Coring will also be conducted to retrieve undisturbed samples for physical properties analyses. In this case, undisturbed core will be retrieved from the approximate depth of the water table to the bottom of the borehole. The number of samples from each well location will be determined by the lithology encountered during drilling and field observations of physical properties. Core samples will be submitted to a physical properties laboratory and analyzed for saturated vertical and horizontal hydraulic conductivity by ASTM D2434M rigid wall method.

Well Construction

Most new wells will be constructed with 4-inch diameter flush-threaded schedule 40 PVC casing and well screen with 0.010 machine slots. The screened interval will be determined by saturated thickness of the aquifer in all water table wells. The screened interval of BBM wells will be 30 feet. If the field team believes that a shorter screened interval will lead to higher quality data, they may elect to install nested 2-inch diameter flush-threaded schedule 40 PVC casings and well screen with 0.010 machine slots. Wells constructed in this manner would be installed such that the nested wells in aggregate would screen the entire saturated thickness of the aquifer. For all wells, a filter pack consisting of 10/20 washed silica sand (or similar appropriate material) will be placed in the annulus. This filter pack will extend 2 to 5 feet above the screened interval, provided that this does not expose the BCA/BBM contact to cross contamination. A 2-foot layer of fine transitional sand will be placed above the filter pack and the annulus will be sealed to ground surface using high solids bentonite grout (or similar appropriate material).

Wells will be completed with a locking above-grade steel monument. The PVC well casing will extend at least 1 foot above grade. Three steel protective posts and a concrete pad will be installed at each site to protect the surface completion.

FIELD DOCUMENTATION

Drilling and well construction will be overseen by a qualified professional geologist. The geologist will document daily site conditions, drilling activities, and well construction. The

field geologist will also provide lithologic descriptions of materials encountered during drilling. Copies of the driller's logs/daily reports will be maintained by the field geologist.

DECONTAMINATION

All down-hole drilling equipment including rods, hammers, bits, core barrels, and temporary casing will be steam cleaned between borings.

WELL DEVELOPMENT

New wells will be developed as needed after installation. Wells will be surged using a surge block and purged until development water is free of sediment and field parameters including pH, specific conductance, and temperature have stabilized.

INVESTIGATION DERIVED WASTE

All drill cuttings, drilling fluids, decontamination water, and development water will be containerized during drilling activities and properly disposed using methods approved by RAML and Utah Division of Radiation Control (DRC).

REPORTING

As-built reports for new wells will be submitted to the Executive Secretary for approval within 60 calendar days of completion in accordance with DRC requirements. As-built reports will be prepared under the direction of a Professional Geologist licensed by the State of Utah, or a senior geologist approved beforehand by the Executive Secretary. Reports will include the following:

- Geologic logs detailing lithology and physical properties of all subsurface materials encountered during drilling.
- Well completion diagrams detailing the following:
 - Total depth and diameter of the borehole
 - Depth, type, diameter, and physical properties of well casing and screen
 - Well screen slot size
 - Depth intervals, type, and properties of annular filter pack and seal
 - Design and construction of protective surface casing
 - Horizontal coordinates and water level elevation measuring point measured to the nearest 0.01 feet by an engineer or land surveyor licensed by the State of Utah

REFERENCES

U.S. EPA, 1986, **RCRA Ground Water Monitoring Technical Enforcement Guidance Document**: September 1986.

Utah Division of Water Rights, 2011, **State of Utah Water Well Handbook, Based on the Administrative Rules for Water Wells (R655-4 UAC)**: April 2011.

Utah Division of Administrative Rules, 2012, **Utah Administrative Code Rule R317-6 Ground Water Quality Protection**: April 1, 2012.

APPENDIX C

STANDARD OPERATING PROCEDURES FOR HYDRAULIC TESTING AT RIO ALGOM MINING LLC LISBON FACILITY WELLS

SCOPE AND APPLICABILITY

The following sections describe standard operating procedures (SOPs) for conducting slug tests at monitoring wells at the Rio Algom Mining LLC Lisbon facility (RAML) in Lisbon, Utah. The SOPs are intended to be general in nature. As the work progresses, appropriate revisions may be necessary and may be implemented as needed to meet project objectives.

SLUG TESTING METHOD

A slug test involves the near instantaneous injection or withdrawal of a volume or slug of water or solid cylinder. The test is conducted by displacing a known volume of water from a well and measuring the artificial fluctuation of the groundwater level. A solid cylinder will be used for all slug tests conducted at the RAML facility. Tests will comprise the introduction of a solid slug into the groundwater, with a subsequent delay allowing for groundwater head to return to static conditions, followed by rapid removal of the slug and measurement of rising head.

Under the current proposed hydraulic testing program, slug testing will be conducted at all new and existing wells at the RAML facility. The following SOPs are followed when conducting falling-head (slug lowered into a well) and a rising-head (slug removed from the well) slug tests.

Materials and Equipment

The following equipment is needed to perform slug tests. All equipment which comes in contact with the well should be decontaminated prior to commencing field activities.

- Field logbook
- Field test data sheets
- Integrated pressure transducer/datalogger, data cables, and field computer
- Solid cylinder slug and competent tether
- Stopwatch

Test Preparation

1. Review the well construction records for the well specifically focusing on total depth of the well, well diameter, and screen position and length. Tests will be conducted by a qualified groundwater professional.
2. Connect integrated pressure transducer/datalogger to field computer.
3. Synchronize the computer and transducer clocks. Check the battery in the transducer to ensure full power supply.
4. Select a logging rate of one reading per second. Set the transducer to start logging data. Record in the field logbook the transducer ID number being used.

Test Procedures

1. Open the well and manually measure the depth to water to the nearest 0.01 foot. Record this information on the field test data sheet and in the field logbook.
2. Lower the transducer into the well and place it at least 2 feet deeper than the length of the solid cylinder slug. The submerged depth of the transducer should not exceed the maximum submerged design depth for the transducer used.
3. Fasten the transducer data cable at the top of the well so that the transducer cannot move. Re-connect to the field computer for real-time monitoring.
4. Allow the transducer to equilibrate for at least 15 minutes.
5. Measure the water level again to verify that water level has returned to equilibrium after the deployment of the transducer. If it has not, repeat this step in 5-minute intervals until equilibrium is reached. Record this information on the field test data sheet and in the field logbook.
6. Lower the slug into the well and place the slug just above the water level.
7. Lower the slug quickly into the water. Record the time that the slug was placed into the water on the field test data sheet and in the field logbook.
8. Monitor the water level until it has recovered to within 90 percent of the static water level. This portion of the test is now complete.
9. Allow time for the water level to recover to a static condition. Quickly pull the slug out of the water. Record the time that the slug was pulled from the water on the field test data sheet and in the field logbook.

10. Monitor the water level until it has recovered to within 90 percent of the static water level.
11. Conduct a minimum of two slug tests at each well to ensure the data are repeatable. Where practical as time permits, conduct three slug tests at each well. The data collected from the transducer should be reviewed in the field to determine if additional slug tests are required.
12. Stop transducer from logging data. Download the data files from the transducer and record the file names on the field test data sheet and in the field logbook.
13. Decontaminate the transducer and data cable, water level meter, and slug for next use.

Investigation Derived Waste

No potentially contaminated groundwater will be removed from wells during slug testing. All equipment used during slug testing will be decontaminated after each use to prevent cross contamination. Decontamination water will be containerized, sampled for water quality, and properly disposed using methods approved by RAML and Utah Division of Radiation Control (DRC).

Data Analysis

Data collected during the slug testing will be evaluated using one or more appropriate analytical methods consistent with the conceptual model to estimate the hydraulic conductivity of the formation. Analytical solutions and software used to calculate the formation hydraulic conductivity will depend on the hydraulic responses observed during slug testing.

- Butler, J. J., 1998, The Design, Performance, and Analysis of Slug Tests, 252 p.
- Standard Test Method (Analytical Procedure) for Determining Transmissivity of Nonleaky Confined Aquifers by Overdamped Well Response to Instantaneous Change in Head (Slug Tests), ASTM D 4104-96.
- Standard Test Method for (Analytical Procedure) for Determining Transmissivity of Confined Nonleaky Aquifers by Underdamped Well Response to Instantaneous Change in Head (Slug Test), ASTM D 5785-95.

REFERENCES

ASTM, 1991, **Standard Guide for Selection of Aquifer Test Method in Determining of Hydraulic Properties by Well Techniques: D 4043**, 1991.

American Society for Testing and Materials (ASTM), 2002, **Standard Test Method (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers: D 4044-96**, 2002.

Butler, J. J., 1998, **The Design, Performance, and Analysis of Slug Tests**: 252 p.

U.S. Environmental Protection Agency (U.S. EPA), 1993, **Suggested Operating Procedure for Aquifer Pumping Tests**: February 1993.

_____, **Slug Tests**: Standard Operating Procedure No. 2046, October 1994.

Standard Test Method (Analytical Procedure) for Determining Transmissivity of Nonleaky Confined Aquifers by Overdamped Well Response to Instantaneous Change in Head (Slug Tests), ASTM D 4104-96.

Standard Test Method for (Analytical Procedure) for Determining Transmissivity of Confined Nonleaky Aquifers by Underdamped Well Response to Instantaneous Change in Head (Slug Test), ASTM D 5785-95.



APPENDIX D

SUPPLEMENTAL SITE ASSESSMENT GROUNDWATER SAMPLING PLAN

APPENDIX D

STANDARD OPERATING PROCEDURES FOR GROUNDWATER MONITORING AT RIO ALGOM MINING LLC LISBON FACILITY WELLS

SCOPE AND APPLICABILITY

The following sections describe standard operating procedures (SOPs) for measurement of water levels in wells and for collection of water quality samples from wells at the Rio Algom Mining, LLC Lisbon facility (RAML) in Lisbon, Utah. The SOPs described below are intended to be general in nature. As the work progresses, appropriate revisions may be necessary and may be implemented as needed to meet project objectives.

Under the current groundwater sampling program for the RAML facility, groundwater samples are obtained from existing wells using low-flow purging and sampling methods. As part of the additional characterization work to be conducted in 2012, a field evaluation of various groundwater sampling methods will be performed to determine the most appropriate method for representative sample collection. Comparative samples will be collected from all new and existing wells using the purgeless HydraSleeve method, the low flow minimal purge method, and volume-based standard purge method. SOPs for each sample collection method are described in the following sections.

GENERAL CONSIDERATIONS

Potential hazards associated with the planned tasks shall be thoroughly evaluated prior to conducting field activities. The site-specific Health and Safety Plan (HASP) for the RAML facility provides a description of potential hazards and associated safety and control measures.

Field personnel must wear powder-free nitrile gloves while performing the procedures described in this SOP. Specifically, powder-free nitrile gloves must be worn while measuring water levels, preparing sample bottleware, preparing and decontaminating sampling equipment, collecting samples, and packing samples. At a minimum, nitrile gloves must be changed prior to the collection of each sample, or as necessary to prevent the possibility of cross-contamination with the sample, the sample bottleware, or the sampling equipment.

Field sampling equipment shall be decontaminated prior to each use. Although water level measurement and sampling should typically be conducted from least to most impacted location, field logistics may necessitate other sample collection priorities. When sampling

does not proceed from least to most impacted location, extra precautions must be taken to ensure that appropriate levels of decontamination are achieved.

WATER LEVEL MEASUREMENT

Water levels will be measured in wells prior to purging or sampling. Construction details and any previous measurements for each well will be reviewed by the field staff before obtaining measurements.

Materials and Equipment

The following equipment is needed to measure water levels and well depth. All equipment which comes in contact with the well should be decontaminated prior to commencing field activities.

- Records of well construction details and previous measurements
- Electronic water level indicator with accuracy of 0.01 feet
- Field log or data sheet
- Weighted tape graduated to the nearest 0.01 feet

Measuring Point

Well depth and water level measurements will be referenced from a measuring point, established and marked at the top of the inner casing of each monitoring well. Generally, this point will be on the north side of the top of the casing. The measuring point will be permanently marked using an indelible marker or a notch cut into the casing. A licensed surveyor will survey the measuring point elevation of each monitoring well and reference this measurement to the local datum for location and elevation.

Well Depth Measurements

The total depth of each new well will be measured with a weighted measuring tape immediately after construction and will be verified periodically thereafter. The weighted tape will be lowered into the well until the tape becomes slack indicating the bottom of the well. Care will be taken to lower the tape slowly to avoid damage to the bottom of the well by the weight. The tape will be raised until it becomes taut. With the tape in this fixed position, the total depth of the well will be measured to the nearest 0.01 feet below the measuring point.

Water Level Measurements

Manual water level measurements will be obtained from wells with an electronic water level indicator prior to purging or sampling. If the well is equipped with an automated monitoring

device (pressure transducer), recorded data will be downloaded and viewed in the field on a portable computer. Water level will then be measured manually to verify that the automated device is functioning properly. The SOP for measuring water levels with an electronic water level indicator is as follows:

1. Open the protective outer cover of the monitoring well and remove any debris that has accumulated around the riser near the well plug. If water is present above the top of the riser and well plug, remove the water prior to opening the well plug. Do not open the well until the water above the well head has been removed.
2. Allow well to equilibrate for at least 5 minutes before measuring the water level.
3. Using an electronic water level indicator accurate to 0.01 feet, determine the distance between the established measuring point and the surface of the standing water present in the well. Repeat as necessary until two successive readings agree to within 0.01 feet. Record date and time of each water level measurement and the serial number of the water level indicator used.
4. Decontaminate the water level indicator in preparation for next use.

The accuracy of electronic water level indicators will be verified at least annually as part of routine maintenance. The entire length of the graduated tape/cable will be compared to a steel surveyor's tape of the same or greater length to determine accuracy at 100-foot increments. Water level indicators will be checked more frequently if there is reason to suspect the tape/cable was stretched during field operations.

GROUNDWATER SAMPLE COLLECTION PROCEDURES

As described above, a field evaluation of groundwater sampling methods will be performed in 2012 to determine the most appropriate method for representative sample collection. Once the appropriate sample method is selected for the ongoing RAML facility monitoring program, sampling procedures for this method will be duplicated to the maximum extent practical during subsequent sampling events.

Groundwater samples will be collected from new wells no sooner than seven days after the well has been developed. For the field evaluation of sample methods, the sequence of the concurrent sampling will comprise sample collection by the purgeless HydraSleeve method, followed by the low flow minimal purge method, followed by the volume-based standard purge method. SOPs for the three sampling methods are described below.

Materials and Equipment

The following equipment is needed to collect groundwater samples from wells. All equipment which comes in contact with the well should be decontaminated prior to commencing field activities.

General Materials and Equipment:

- Monitoring instruction sheet for each site
- Field logbook
- Field sampling data sheets (FSDS)
- Site maps
- Health & Safety Plan
- Indelible black-ink pens and markers
- Sample labels
- Chain-of-custody forms
- Custody seals
- Shipping labels
- Water level meter
- pH/conductivity/temperature/ORP meter, turbidity meter, and dissolved oxygen meter
- Insulated cooler(s)
- Laboratory-supplied sample containers
- Ice
- Decontamination equipment: Liquinox or similar, and jugs for potable water

Equipment for HydraSleeve Sampling:

- HydraSleeve
- Static deployment line calibrated with footmarks
- Weight with attachment clip
- Recovery reel

Equipment for Low-Flow and Standard Purge Sampling:

- Variable rate electric submersible pump and controller
- Portable generator
- Flow-through cell
- Disposable discharge tubing

Purgeless Sample Method

Purgeless sample collection will be conducted using the HydraSleeve method, which comprises deployment of a clean, flat, empty bailer into the well screen. A HydraSleeve consists of a disposable polyethylene tube-shaped bag, sealed at the bottom and flared open at the top with a check-valve. This method requires that a minimum of 6 feet of well screen be submerged below the water level for proper deployment. The benefits of purgeless

sampling include little or no purge water generated for disposal and little or no decontamination since the equipment is either dedicated or disposable.

HydraSleeve Deployment

1. Measure and record the depth to water to nearest 0.01 feet as described above. Compare water level with well construction details to confirm that the HydraSleeve sampling device can be deployed. Record this information on the FSDS and in the field logbook.
2. Install the HydraSleeve sampling device approximately 2 feet below the midpoint of the screened interval of the well and at least 4 feet below water level. Deployment of the sampler causes a disturbance to the well water chemistry by allowing mixing with the “stagnant” water contained in the well pipe above the screened portion of the well and by disturbance of any sediment attached to the well pipe. The device will be deployed at least 24 hours prior to sample collection.
3. Fasten the weight to the bottom of the device and attach to the deployment line with a snap hook. Determine the expected footmark on the graduated line at the top of casing when the top of the device is in the planned position. Deploy the sampling device slowly into the well.
4. For wells with a planned deployment depth near the bottom of the open screen a top weight will be used. The top weight (available from the HydraSleeve manufacturer) is a weighted stainless-steel pipe sized to fit around the outside of the top of the device. It is held in place by a clip that also holds the mouth of the device open. Upon deployment, the top weight compresses the device in the bottom of the well effectively lowering the deployment depth to approximately 6 to 12 inches above the bottom of the well.

HydraSleeve Retrieval and Sampling

1. After at least 24 hours, retrieve the HydraSleeve with one smooth motion of approximately 4 feet. If the top of the well casing is too high to raise the device in one motion, the sampler can partially raise the device then adjust his grip on the tether to complete the stroke. The device must be removed at a rate of 1 to 2 feet per second or faster to allow water to pass the check valve.
2. Perforate the top of the device with the provided discharge tube and direct the water to the appropriate laboratory-supplied sample containers. Apply labels to bottles and immediately return to ice chest.
3. Record sampling information on the FSDS and in the field logbook.
4. Decontaminate deployment line and associated equipment for next use.

Low Flow (Minimal Purge) Sample Method

U.S. EPA recommends the use of adjustable-rate bladder and electric submersible pumps during low-flow purging and sampling activities. The following SOPs assume that a non-dedicated electric variable rate submersible pump will be used to purge and sample wells by the low flow method. The following procedures will be used for low flow sampling:

Low Flow Well Purging

1. Prepare sampling equipment including calibration of field meters prior to use.
2. Measure and record the depth to water to the nearest 0.01 feet as described above. Using the specific details of well construction and current water-level measurement, determine the pump set depth, typically the mid-point of the saturated well screen or other target sample collection depth adjacent to specific high-yield zones. If disposable tubing is to be used, cut appropriate length of disposable tubing from roll and attach to pump.
3. Remove the decontaminated pump from the pump holder and rinse the pump off with water. Slowly lower the pump into the well to the target depth. Record the depth of the pump intake after lowering the pump into location.
4. Connect the cable for the control box to the pump reel. Start the generator. Make sure the generator is kept downwind from the sampling system.
5. Connect the discharge tubing from the pump to the **base** of the flow-through cell. Place the probes for the calibrated field meters into the flow-through box. Attach small section of discharge tubing to the top of the flow-through cell and place end of hose into bucket to catch purge water.
6. Place water level probe in well and record static water level on the field sampling data sheets (FSDS).
7. If the well has been previously sampled using low-flow purging and sampling methods, begin purging at the rate known to induce minimal drawdown. Frequently check the drawdown rate to verify that minimum drawdown is being maintained. If sampling the well for the first time, begin purging the well at the minimum pumping rate of 100 milliliters per minute (mL/min) and slowly increase the pumping rate to no more than 500 mL/min. Monitor and record drawdown in well (if any). Record data on FSDS. If drawdown exceeds 0.3 feet from static, adjust flow rate until drawdown stabilizes (if possible).
8. For wells **screened below the static water level**, if the drawdown does not stabilize at a pumping rate of 100 mL/min, continue pumping until the drawdown reaches a depth of two feet above the top of the well screen. Stop pumping and collect a groundwater sample once the well has recovered sufficiently to collect the appropriate sample volume. Document the details of purging, including the purge start time, rate, and drawdown on the FSDS and in the field logbook.

For wells **screened across the static water level**, if the drawdown does not stabilize at 100 mL/min, continue pumping. However, do not draw down the water level more

- than 25 percent of the distance between the static water level and pump intake depth. If the recharge rate of the well is lower than the minimum pumping rate, then collect samples at this point even though indicator field parameters have not stabilized. Begin sampling as soon as the water level has recovered sufficiently to collect the required sample volumes. Allow the pump to remain undisturbed in the well during this recovery period to minimize the turbidity. Document the details of purging on the FSDS and in the field logbook.
9. Start recording field parameters on the FSDS sheet every 3 minutes. Purging should continue at a constant rate until the parameters stabilize. Stabilization is considered achieved when three sequential measurements are within the ranges listed below:
 - pH ± 0.1 standard units
 - Specific Conductance $\pm 3\%$
 - Temperature $\pm 3\%$
 - ORP ± 10 millivolts
 - Turbidity $\pm 10\%$ (for values greater than 5 NTUs)
 - Dissolved Oxygen $\pm 10\%$

Low Flow Well Sampling

1. After specified parameters have stabilized, reduce flow rate on control box to approximately 100 mL/min.
2. Disconnect discharge tubing base of flow-through cell, being careful to contain water within the cell. Cut off approximately 0.5 feet from end of discharge tubing. Place a bucket beneath sampling tube to catch water.
3. Fill necessary sample bottles. Label sample bottles with a unique sample number, time and date of sampling, the initials of the sampler, and the requested analysis on the label. Additionally, provide information pertinent to the preservation materials or chemicals used in the sample. Record comments pertinent to the color and obvious odor. Record sampling information on FSDS sheet and in field logbook.
4. Fill all sample containers with minimal turbulence by allowing the groundwater to flow from the tubing gently down the inside of the container. Immediately seal each sample and place the sample on ice in a cooler to maintain sample temperature preservation requirements. Fill bottles in the following order:
 - Metals, and Radionuclides
 - Filtered Metals and Radionuclides
 - Other water-quality parameters.
5. Remove the pump from the well taking care that the tubing does not contact the ground while being retrieved. Decontaminate pump and tubing for next use.
6. Containerize and properly dispose of purge water and decon water generated during sampling.

Volume Based (Standard Purge) Sample Method

The following SOPs assume that a non-dedicated electric variable rate submersible pump will be used to purge and sample wells by the volume-based method. The following procedures will be used for standard purge sampling:

Well Purging

1. Prepare sampling equipment including calibration of field meters prior to use.
2. Measure and record the depth to water to the nearest 0.01 feet as described above. Calculate a casing volume for the well based on the specific details of well construction, the current depth to water measurement, and casing diameter. For wells with multiple casing diameters, calculate the volume for each segment and use the sum of the values.
3. Remove the decontaminated pump from the pump holder and rinse the pump off with water. Slowly lower the pump into the well to the target depth. Set the pump immediately above the top of the well screen or three to 5 feet below the top of the water table. Lower the pump if the water level drops during purging. Record the depth of the pump intake after lowering the pump into location.
4. Connect the cable for the control box to the pump reel. Start the generator. Make sure the generator is kept downwind from the sampling system.
5. Purge the well until at least three borehole volumes are removed. Maintain a purge rate so that recharge water is not entering the well in an agitated manner and the water level in the well does not drop below the pump intake. Containerize all purge water.
6. Record field parameters periodically and after each casing volume is purged. Stabilization is considered achieved when three sequential measurements are within the ranges listed below:
 - pH ± 0.1 standard units
 - Specific Conductance $\pm 3\%$
 - Temperature $\pm 3\%$
 - ORP ± 10 millivolts
 - Turbidity $\pm 10\%$ (for values greater than 5 NTUs)
 - Dissolved Oxygen $\pm 10\%$

- If the indicator parameters have not stabilized after the removal of six casing volumes, field instruments will be recalibrated. If no problems are found, sampling can be conducted; however, the project manager will be notified and all information will be recorded in the field notebook and/or field purge record.
7. If the yield of the well is low such that it can be pumped dry, then the recharged groundwater in the well will be considered representative regardless of the number of casing volumes of groundwater removed. If a well is pumped dry, the well may be sampled after 80 percent recovery.

Sampling after Standard Purge

1. Collect samples within 2 hours of purging, if possible. It is acceptable to collect samples within 24 hours of purging. Do not collect samples after 24 hours has passed.
2. Fill necessary sample bottles. Label sample bottles with a unique sample number, time and date of sampling, the initials of the sampler, and the requested analysis on the label. Additionally, provide information pertinent to the preservation materials or chemicals used in the sample. Record comments pertinent to the color and obvious odor. Record sampling information on FSDS sheet and in field logbook.
3. Fill all sample containers with minimal turbulence by allowing the groundwater to flow from the tubing gently down the inside of the container. Immediately seal each sample and place the sample on ice in a cooler to maintain sample temperature preservation requirements. Fill bottles in the following order:
 - Metals and Radionuclides
 - Filtered Metals and Radionuclides
 - Other water-quality parameters.
4. Remove the pump from the well taking care that the tubing does not contact the ground while being retrieved. Decontaminate pump and tubing for next use.
5. Containerize and properly dispose of purge water and decon water generated during sampling.

Sample Analyses

Groundwater samples will be submitted for hydrochemical analysis to analytical laboratories certified by the State of Utah. At a minimum, samples will be analyzed for uranium, molybdenum, selenium, arsenic, TDS, chloride, sulfate, and bicarbonate. Other analyses may be conducted if warranted by conditions encountered during drilling and sampling. The list of hydrochemical parameters and approved analysis methods are given in **Table 1**.

TABLE 1. GROUNDWATER SAMPLING PARAMETER LIST

Parameter ^a	Analytical Method	Lab Reporting Limit ^b	Preserve Method	Holding Time	Container & Size ^c
Total Dissolved Solids	SM 2540C	10	Cool	7 days	Plastic-250 mL
Bicarbonate, as CaCO ₃	SM 2320B	5	Cool	28 days	Plastic-250 mL
Chloride	EPA 300.0	1			
Sulfate	EPA 300.0	4			
Arsenic (As)	EPA 200.8 ^d	0.001			
Molybdenum (Mo)	EPA 200.8	0.1			
Selenium (Se)	EPA 200.8	0.001			
Uranium (U)	EPA 200.8	0.04	HNO ₃	6 months	Plastic-250 mL

^a Concentration for all parameters in milligrams per liter (mg/L)

^b Laboratory reporting limits in mg/L and based on Utah regulations and laboratory standard practice.

^c Containers are abbreviated as: P = plastic. Container size given in milliliters (mL).

^d All metals will be sampled and reported as dissolved

Sample Filtration

Samples collected for dissolved parameters will be field-filtered using a disposable, in-line, 0.45 micron filter. When the HydraSleeve sampling method is used water will be transferred from a clean unpreserved sample container, through the filter, and into the appropriate preserved sample container using a hand pump or syringe. When sampling using low flow or standard purge methods, the water samples will be pumped through the filter attached directly to the discharge tubing of the groundwater pumping system. A new filter and tubing will be used for each sample.

Quality Control Sampling

Quality Assurance/Quality Control (QA/QC) samples will consist of split samples, duplicate samples, and equipment rinsate blanks. For QA/QC purposes all QA/QC samples will be blind labeled. QA/QC samples will be clearly identified on the field sampling forms.

- Duplicate groundwater samples will be collected at a frequency of 10 percent of the total number of groundwater samples collected.
- A split sample will be collected at one well location using all three sample methods. At this location a second set of sample containers will be filled, and the two sets will be submitted to different laboratories.
- At least two equipment rinsate blanks will be collected to assess the effectiveness of equipment decontamination procedures. Equipment blanks will be prepared by pouring or pumping ASTM Type II reagent-grade water over or through sampling devices after decontamination procedures have been conducted.

Decontamination Procedures

Before use at each location, the submersible pump, temperature, pH, specific conductivity, ORP, dissolved oxygen meters, and depth to water indicators will be washed using a solution of water and Liqui-Nox™ and water, rinsed with potable water, sprayed with methanol or isopropanol, and rinsed a second time with distilled/deionized water.

Investigation Derived Waste

Investigation derived waste (IDW) generated during groundwater sampling will include monitoring well purge water and equipment decontamination water. Purge and decontamination water will be placed in drums (or similar approved containers) and labeled as “Non-Hazardous Waste”. The label will also include the accumulation date, facility contact, contact phone number, and a list of the monitoring wells from which the water was derived. The containers will be placed on the RAML property in a secured area or within a secured container. Water generated during groundwater sampling will be properly disposed following receipt of laboratory analytical results and disposal characterization. The site owner will remain as the generator of all wastes to be disposed, and will sign all transport and disposal manifests as such.

SAMPLE MANAGEMENT

Sample Containers/Sample Handling

The sample containers will be prepared and provided by the analytical laboratory. Samples will be preserved consistent with conditions presented in **Table 1**. The type and size of container used for each parameter and the type of preservative added, if any, will be recorded on the field sampling data form. Sample containers will be placed in an iced cooler immediately after sample collection. The sample containers will be kept closed, maintained under custody, and refrigerated until analysis. Maximum holding times from the time of sample collection until sample analysis are provided in **Table 1**.

Sample Designation and Labeling

All groundwater samples collected from monitoring wells, including any duplicate samples, will be recorded on field sampling data sheets. Each sample will be given a unique blind 4-digit sample identifier. Groundwater samples collected from the same well using different sample methods will be considered distinct samples and will be given unique sample identifiers. Sample containers will be labeled with the sample identifier, project name, data and time of sampling, and sampler’s initials.

Sample Custody

At the end of each sampling day and before samples are transferred off site, chain-of-custody entries will be made on the Chain-of-Custody/Laboratory Analysis Request form to document sample custody. Information on the container labels will be compared to the information on the chain-of-custody form and on the field sampling data forms, and the field logbook.

Once a sample is collected, it will remain in the custody of the sampler or other authorized personnel, until it is shipped to the laboratory. Upon transfer of sample possession to subsequent custodians, the persons transferring custody will sign the chain-of-custody form. During interstate transport, the chain-of-custody form will be placed in a resealable plastic bag and accompany each sample cooler to the laboratory. Signed and dated chain-of-custody seals will be placed on coolers prior to shipping. When the samples are received at the laboratory, the custody seal on the shipping container will be broken and the condition of the samples recorded by the laboratory custodian. Chain-of-custody records will be included in the analytical report prepared by each laboratory. Copies of the chain-of-custody records will be retained in the project file.

Upon receipt of the samples, the laboratory will complete the chain-of-custody record. The condition of each sample container will be noted. The laboratory will also maintain a sample-tracking record that will follow each sample through the laboratory process. The sample-tracking record must show the dates of sample extraction or preparation, and sample analysis for each sample. These records will be used to determine compliance with specified holding times.

REFERENCES

- American Society for Testing and Materials (ASTM), 2002, **Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations: D 6771-02**, 2002.
- U.S. EPA, Region 9, **Standard Operating Procedure for the Standard/Well-Volume Method for Collecting a Ground-Water Sample from Monitoring Wells for Site Characterization**. (Date not specified).
- U.S. EPA, Region 1, 1996, **Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells**: July 30, 1996.
- U.S. EPA, 2002, **Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers**: EPA 542-S-02-001, May 2002.

U.S. EPA. Region 4, 2007, **Groundwater Sampling Operating Procedure:** Document Number SESDPROC-301-R1, November 2007.