February 26, 2018

MEMORANDUM TO: File (Docket No. 040-09068, License SUA-1598)

FROM: John L. Saxton, Hydrogeologist
Uranium Recovery Licensing Branch
Division of Decommissioning, Uranium Recovery
and Waste Programs
Office of Nuclear Material Safety
and Safeguards

SUBJECT: LOST CREEK EAST AMENDMENT ATTACHMENT D6-6

By letter dated February 27, 2017, Lost Creek ISR, LLC submitted its Lost Creek East Amendment Application (ADAMS Accession No. ML17069A296). Attachment D6-6 "Technical Memorandum: Simulation and Assessment of Uranium in Situ Recovery from the KM Horizon, Lost Creek Project" of that submittal was in electronic form on an attached CD. The CD was placed on file in the Public Document Room rather than placed directly into ADAMS.

The purpose of this memorandum is to place the report into ADAMS and include it with the package referenced above for the application. The Technical Memorandum report has been in ADAMS; however, the reference is to Lost Creek's February 26, 2016 (ML16056A543) submittal rather than the February 27, 2017 submittal. The numeric groundwater flow model electronic files are not included with the report but available in the Public Document Room.

Technical Memorandum

To: Lost Creek, ISR, LLC.

From: Petrotek Engineering Corporation

Date: January 26, 2016

Subject: Simulation and Assessment of Uranium In Situ Recovery from the KM Horizon, Lost Creek Project

Executive Summary

A numerical model was developed to simulate In Situ Recovery (ISR) of uranium from the KM Horizon of the Lost Creek Project (LCP) in Sweetwater County, Wyoming. The focus of the model was on the demonstration of hydraulic control, both horizontally and vertically, of production and restoration fluids throughout mining.

The model contains eleven layers representing the hydrostratigraphic interval from the HJ Horizon down through the N Horizon, with a total thickness of approximately 550 feet. The KM Horizon was subdivided into three layers within the model to account for the heterogeneity that may be present within that hydrostratigraphic unit. The model was calibrated to static potentiometric conditions and two separate pumping tests conducted within the KLM Horizon.

A series of simulations were run using the calibrated model to assess potential hydraulic impacts of ISR from the KM Horizon. Wellfields were simulated in each of the three separate model layers that represent the KM Horizon (each of which comprise a unique distribution of hydraulic conductivity). This provides a high degree of variability in potential outcomes.

The simulated wellfields consist of a series of repeating 5-spot well patterns. The wellfield consists of a total of 9 well patterns arranged in a 3 by 3 square configuration consisting of 9 extraction wells and 16 injection wells. Each extraction well is simulated at a rate of 20 gpm during production. The injection wells were assigned values based on their location within the 5-spot pattern such that the total injection rate is 99 percent of the total extraction rate. This amounts to a 1 percent bleed (overproduction) in order to maintain an inward gradient through production. The simulated wellfields are substantially smaller than what would be utilized during actual production of the KM Horizon. The simulation of a smaller wellfield than what will be actually employed was done for computational efficiency, and to allow more focus on individual well pattern hydraulics and vertical movement of injectate.

Particle tracking was used to simulate the flowpaths of injectate throughout production and restoration. Results of the ISR simulations indicate that the maximum horizontal flare within the KM Horizon (as determined from the injectate flowpaths) was less than 115 ft from the edge of the wellfield. Horizontal flare is defined as the movement of injectate outside of the wellfield boundary, but within the production zone, during production operations. Vertical flare is the movement of injectate outside of the production zone (either upward or downward) during production operations.

The model simulations overestimate the total flare that will occur during ISR operations for the following reasons. First, as previously indicated, the simulated wellfields are smaller than what will be utilized during actual production of the KM Horizon. Horizontal flare has been demonstrated to be scale dependent (Lewis Water Consultants,1999). Smaller wellfields typically have a higher ratio of perimeter length to total area than do larger wellfields. This corresponds to a greater ratio of exterior injection wells to interior injection wells, which usually results in a higher simulated horizontal flare. The flare resulting from these simulations is anticipated to be higher than what will occur in actual operation because of the smaller size of the simulated wellfields. Secondly, for these simulations extraction and injection was maintained at the same ratio and rates, regardless of the hydraulic conductivity of the zone that the wells are completed in, or the response of the aquifer (drawdown or rise). During actual operations, the rates would be adjusted to avoid excessive drawdown or rise in individual wells during production or restoration. However, for purposes of this modeling demonstration, the scenarios that are simulated provide an opportunity to assess hydraulic impacts under extreme conditions. The simulated flare is greater than what would occur if the wells located in the areas of low permeability were adjusted to lower flow rates to prevent excessive drawdown or rise during production.

In each simulation, groundwater sweep (GWS) was effective in reversing the hydraulic gradient and altering the injectate flowpaths back toward the wellfield. None of the ISR simulations indicated vertical flare into the overlying HJ Horizon or the underlying L Horizons when operations were conducted under balanced flow conditions.

An excursion scenario was developed in which a portion of the K Shale was absent and an injection well was operating “out of balance” at twice the rate compared to balanced simulations. In this simulation, some injectate was forced into the underlying L Horizon during production. However, GWS was effective in recovering the excursion. The excursion simulations confirm that application of engineering controls should be adequate to successfully recover an excursion into the underlying aquifer.

Based on the modeling results, placement of L Horizon monitor wells should coincide with areas where the K shale is known or suspected to be thin or possibly absent. The

modeling demonstrates that it is difficult to simulate an excursion if there is a competent confining unit. The location of L Horizon monitor wells should be based on geologic interpretation of the K Shale, and not designed off a uniformly spaced grid. Placement of L Horizon monitor wells in areas where there is substantial shale/claystone thickness is unlikely to provide effective or efficient monitoring and should be avoided.

If the L Horizon is adequately monitored, no additional monitoring in the deeper M Horizon should be required. If an excursion to the L Horizon were to occur, it would be detected in the L Horizon monitor wells first. The probability of flare extending all the way through the L Horizon and the LM Shale and into the M Horizon (a vertical distance of over 100 feet) within the timeframes anticipated for production is very low.

Introduction

Lost Creek ISR, LLC (LC ISR) intends to extract uranium from the KM Horizon in the Lost Creek and Lost Creek East Project areas (LCP) using In Situ Recovery (ISR) mining. The LCP is located in Sweetwater County, in the northeastern portion of Great Divide Basin, Wyoming. LC ISR is currently producing uranium from the shallower HJ Horizon under a Source Materials License issued by the Nuclear Regulatory Commission and a Permit to Mine issued by the Wyoming Department of Environmental Quality.

Hydrologic testing has demonstrated some degree of vertical hydraulic communication between the KM Horizon and the underlying L and M Horizons. Petrotek Engineering Corporation (Petrotek) has developed a numerical model to simulate ISR mining of uranium from the KM Horizon to assess potential hydraulic impacts to the L and M Horizons. This report documents the development and results of the numerical modeling.

Purpose and Objectives

The numerical groundwater flow model was developed to support LC ISR in permitting, planning and operation of KM production within Resource Area 3 (RA3), which is considered to be representative of the entire LCP. The numerical model is used to assess potential impacts of ISR mining on the KM Horizon and underlying hydrostratigraphic units. Objectives of the numerical model include the following:

- simulate ISR mining of the KM Horizon within RA3;
- assess the movement of production and restoration fluids throughout ISR mining and restoration of the KM Horizon;
- evaluate the ability to hydraulically control those fluids under normal operating conditions; and
- evaluate the capability to recover an excursion to an underlying aquifer.

The model was developed to allow adequate discretization within the wellfields such that the impacts of individual wells can be discerned. This feature of the model will enable its use as a tool to assist LC ISR in the day-to-day operation of the ISR project.

Conceptual Model

LC ISR proposes to recover uranium from the KM Horizon within RA3 of the LCP. Uranium ISR mining is currently being successfully applied in the shallower HJ Horizon within Mine Unit 1. **Figure 1** shows the location of the two uranium production areas which partially overlap each other.

Hydrostratigraphy

Groundwater modeling is focused on the simulation of uranium ISR from the KM Horizon, and potential hydraulic impacts to underlying hydrostratigraphic units. The KM Horizon is a uranium-bearing interval within the Eocene-age Battle Spring Formation, and is the target production zone for RA3 of the LCP.

The hydrostratigraphic units within the Battle Spring Formation in the LCP that are of interest with respect to this modeling project are (in descending order):

- HJ Horizon(overlying aquifer),
- Sagebrush Shale (overlying confining unit),
- KM Horizon (production zone aquifer),
- K Shale (underlying confining unit),
- L Horizon (underlying aquifer),
- LM Shale,
- M Horizon,
- MN Shale, and
- N Horizon.

Figure 2 illustrates the vertical relationship of the hydrostratigraphic units included in the numerical model.

A summary description of these units is provided below. Description of unit thicknesses are based on geologic correlations and interpretations made by LC ISR geologists from electric logs of borings throughout the LCP. A summary of the geologic tops/picks used to generate the thicknesses of the hydrostratigraphic units included in the model is provided in **Attachment A**. The table does not include every boring that has been analyzed by LC ISR geologists, but provides a representative sampling of subsurface conditions, with an emphasis on the area of RA3.

The Production Zone evaluated in this modeling effort is the KM Horizon, which is a component of the composite KLM Horizon. The composite KLM Horizon is an informal

unit that comprises the KM Horizon, the L Horizon and the M Horizon. Previous hydrologic testing (Petrotek 2009a, 2013a and 2013b) has indicated some degree of hydraulic communication between the hydrostratigraphic units of the composite KLM Horizon.

Similar to the other horizons in the LCP, the KM Horizon consists of multiple sandstone units interbedded with mudstones. The KM Horizon averages approximately 115 feet in thickness within RA3. Previous hydrologic testing (Petrotek 2009a, 2013a and 2013b) has indicated some degree of hydraulic communication between the KM Horizon and underlying hydrostratigraphic units within the LCP.

The KM Horizon is bounded above by the confining unit identified as the Sagebrush Shale. The Sagebrush Shale is continuous throughout the LCP, and ranges from 3 to 40 feet thick within RA3. Similar to other shale units, the Sagebrush Shale commonly consists of a composite of multiple shales which complexly interbed with overlying and underlying sandstone units.

Above the Sagebrush Shale is the HJ Horizon, which represents the overlying aquifer in this study. The HJ Horizon consists of multiple sandstone units interbedded with mudstones. The HJ Horizon is continuous throughout the LCP and ranges from 100 to 150 feet thick, with an average thickness of approximately 120 feet. This unit is also the current Production Zone in Mine Unit 1, which partially overlaps RA3.

Beneath the KM Horizon is a low permeability unit identified as the K Shale. The K Shale is a sequence of interbedded shales/mudstones, silts and sands. The K Shale is continuous throughout RA3 and ranges from 2 to 38 feet thick. The average net shale thickness within the K Shale interval is 15 feet (2015 personal communication with LC ISR geologists). The K Shale is the confining layer that separates the underlying L Horizon and the Production Zone KM Horizon.

The underlying aquifer is designated as the L Horizon. The L Horizon consists of multiple sandstone units interbedded with mudstones. The total thickness of the L Horizon ranges from 40 to 110 feet, averaging approximately 80 feet within RA3. The L Horizon is continuous throughout RA3 and the LCP.

Underlying the L Horizon is a low permeability unit identified as the LM Shale. The LM Shale is a sequence of interbedded shales/mudstones, silts and sands. The LM Shale is continuous throughout RA3 and ranges from 3 to 45 feet thick, with typical thickness of 15 to 20 feet. The LM Shale is the confining layer that separates the L Horizon and the M Horizon.

The M Horizon is the deepest stratigraphic unit within the composite KLM Horizon. The M Horizon consists of multiple sandstone units interbedded with shales/mudstones. This unit is from 85 to 97 feet thick within RA3.

The MN Shale is a zone of interfingering layers of mudstone, siltstone, and shale that separates the M Horizon from the deeper N Horizon. It ranges from approximately 5 to 40 feet thick, with a typical thickness of about 10 to 20 feet.

Beneath the MN Shale is the N Horizon. Based on limited data, the total thickness of the N Horizon is approximately 100 feet.

Structure

Within the LCP, the Battle Spring Formation dips to the west at approximately three degrees. A series of normal faults are located within the LCP. The main fault, identified as the Lost Creek Fault, is oriented in a west-southwest to east-northeast direction that cuts across RA3. The main fault (identified as the Lost Creek Fault) bisects the northwestern portion of RA3, and is downthrown to the south, with displacement of approximately 60 to 70 feet. A subsidiary splay fault splits from the main fault to the south for a limited distance in the central portions of RA3 (**Figure 1**). Displacement on the splay fault is 20 feet or less.

Hydrology

LC ISR and Petrotek performed multiple hydrologic studies and tests to characterize the aquifer properties of the KM Horizon and the overlying and underlying hydrostratigraphic units. Some of the key reports describing these hydrologic studies include "Lost Creek Hydrologic Testing-KM Horizon Hydrologic Testing" (Petrotek 2009a), "Lost Creek Hydrologic Testing-Mine Unit 1 North and South Tests" (Petrotek 2009b), "Lost Creek Hydrologic Test, Composite KLM Horizon Regional Pump Test. October 2011" (Petrotek, 2013a), and "Lost Creek Hydrologic Test, Composite KLM Horizon 5-Spot Testing, October 2012" (Petrotek, 2013b).

Key findings of those studies are summarized below.

- Potentiometric data from the HJ, KM, L, and M Horizons indicate a west-southwest groundwater flow direction. **Figure 3** shows the potentiometric surface of the KM Horizon in October 2011.
  - There are insufficient data points in the N Horizon to make a determination of flow direction in that unit although it is assumed to be similar to that of the overlying hydrostratigraphic units.
- Horizontal hydraulic gradients are on the order of 0.004 to 0.007 ft/ft for the KM Horizon, 0.005 to 0.009 ft/ft for the HJ Horizon, and 0.004 to 0.006 ft/ft for the L and M Horizons.
- Vertical hydraulic gradients exist between the HJ, KM, L, M and N Horizons.
  - Potentiometric heads generally decrease with depth indicating a net downward vertical potential.

  - In most areas, the difference in potentiometric heads is greatest between the HJ Horizon and the deeper Horizons. The vertical hydraulic gradient between the HJ Horizon and the KM Horizon is typically from 0.1 to 0.3 ft/ft.
  - Potentiometric differences between the KM, L and M Horizons tend to be smaller, consistent with pumping test data that indicate vertical communication between these units. The vertical gradients between the KM Horizon and the L and M Horizons are from 0.02 and 0.1 ft/ft.
  - Based on two control points, the potentiometric heads in the N Horizon are approximately 5 feet lower than in the M Horizon.
- The Lost Creek fault acts as a partial barrier to groundwater flow within the HJ, KM, L and M Horizons.
  - The ability of the fault to impede groundwater flow appears to be greater in the HJ Horizon than in the KM Horizon, based on potentiometric data and pumping test results.
- Aquifer properties of the KM Horizon were estimated from the KM Horizon Regional Pump Test (Petrotek 2013a) and the 5-Spot Test (Petrotek 2013b).
  - Transmissivity of the KM Horizon ranges from 100 to 260 ft^2/d.
  - Hydraulic conductivity in the KM Horizon ranges from 0.9 to 2.2ft/d.
  - Storativity of the KM Horizon ranges from 3.5E-05 to 4.2E-04.
  - Notable drawdown response was observed in the underlying L and M Horizon observation wells during these tests. The aquifer properties for the KM Horizon were calculated assuming a non-leaky aquifer system (i.e., no contribution from anything other than the KM Horizon). Therefore, the values cited above for the KM Horizon should be considered as overestimates of the actual aquifer properties for that unit.
- Pumping tests demonstrate lateral hydraulic communication within the KM Horizon, with some restriction of flow across the Lost Creek Fault.
- Aquifer properties of the HJ Horizon were estimated from the Mine Unit 1 Hydrologic Tests (Petrotek 2009b).
  - Transmissivity of the HJ Horizon ranges from 50 to 130 ft^2/d.
  - Hydraulic conductivity of the HJ Horizon ranges from 0.4 to 1.1ft/d.
  - Storativity of the HJ Horizon ranges from 3.6 E-05 to 4.2 E-04.
- Pumping tests demonstrate lateral hydraulic communication within the HJ Horizon, with some restriction of flow across the Lost Creek Fault.
- Pumping tests demonstrate limited hydraulic communication between the KM Horizon and the overlying HJ Horizon, similar in magnitude to responses observed at other ISR facilities where engineering practices are successful in containing lixiviant within the Production Zone.

- Aquifer properties of the L, M and N Horizons were not determined directly as no pumping tests were conducted in those units. However, geologically these units appear very similar to the HJ and KM Horizons, and are assumed to have similar values of transmissivity, hydraulic conductivity and storativity.
- Pumping tests demonstrate quantifiable hydraulic communication between the KM Horizon and the underlying L and M Horizons.
    - Drawdown propagation decreases with depth below the KM Horizon.
- A 5-Spot hydrologic test in the KM Horizon, which included a nearly balanced extraction and injection condition (similar to what would occur in typical ISR), indicated minimal response in the underlying L and M Horizons.

There are no known sources of groundwater discharge, other than pumping wells, within the LCP. No direct recharge via infiltration of precipitation or streamflow to the HJ through N Horizons occurs within the LCP (there are a couple of shallower aquifers above the HJ Horizon). Recharge to the HJ through N Horizons occurs either from regional lateral flow within the specific units or from interflow between adjacent overlying or underlying units.

As previously indicated, the KM Horizon hosts uranium mineralization, and is the target Production Zone for RA3. Pumping tests have shown a notable degree of hydraulic communication between the KM, L and M Horizons.

Based on discussions with LC ISR, the typical completion interval for well patterns within RA3 will be 18 feet thick. Anticipated production rates will be 20 gallons per minute (gpm) per well pattern, all of which will be reinjected with the exception of an approximate net 1.0 percent bleed (overproduction).

Model Code

The model code used to simulate the hydraulic effects of ISR mining of the KM horizon isMODFLOW-2000 (Harbaugh et al 2000). MODFLOW-2000 is a public domain computer code developed by the U.S. Geological Survey that numerically solves the groundwater flow equation for a porous medium using a finite difference method. MODFLOW-2000 is an enhanced version of the widely used MODFLOW code that has been updated several times (McDonald and Harbaugh 1988, and Harbaugh and McDonald 1996). Like its predecessors, MODFLOW-2000 simulates groundwater flow using a block-centered, finite-difference approach that is capable of a wide array of boundary conditions. The code can simulate aquifer conditions as unconfined, confined, or a combination of the two. MODFLOW-2000 also supports variable thickness layers (i.e. variable aquifer bottoms and tops). Documentation of all aspects of the MODFLOW-2000 code is provided in the user manuals (Harbaugh and others 2000).

A particle-tracking code is utilized that readily incorporates information collected from the MODFLOW groundwater flow model. The code is MODPATH, Version 5 (Pollock, 1994), which is designed to use the output head files from MODFLOW to calculate particle velocity changes over time in three dimensions. MODPATH is used to provide computations of groundwater seepage velocities and groundwater flow directions at the site. MODPATH is also a public domain code that is well accepted in the scientific community. Full documentation of the MODPATH code is provided in the MODPATH users guide (Pollock 1994). Dispersion and diffusion are not examined as part of this modeling effort.

The pre/post-processor Groundwater Vistas (Environmental Simulations 2011) is used to assist with input of model parameters and output of model results. Groundwater Vistas serves as a direct interface with MODFLOW which enhances model processing. Groundwater Vistas provides an extensive set of tools for developing, modifying and calibrating numerical models and allows for ease of transition between the groundwater flow and particle tracking codes. Full description of the Groundwater Vistas program is provided in the "Guide to Using Groundwater Vistas, Version 6.0" (Environmental Simulations 2011).

Calibration of the models was accomplished using the model independent parameter estimation software PEST. PEST is a non-linear parameter estimation package based on weighted least squares and a robust implementation of the Gauss-Marquardt-Levenburg method. Full documentation of the PEST code is provided in the "PEST User Manual, 5^{th} Edition" (Doherty 2010).

Model Development

The primary objective of the model is to assess potential hydraulic impacts of ISR production from the KM Horizon on the underlying L and M Horizons. The model development focused on the vertical relationship between the KM Horizon and the underlying L, M and N Horizons within the area of the proposed KM Mine Unit (RA3). However, the overlying HJ Horizon and the deeper N Horizon were also included in the model development in order to assess any potential impacts to those units.

The model domain is rotated 45 degrees east of north to align the x-axis of the model with the predominant groundwater flow direction (to the southwest). The x-axis and y-axis model dimensions are 10,210 and 9,000 feet, respectively. The 5-Spot Test site is located in the center of the model domain. The extent of the model domain is illustrated on **Figure 4**.

The model grid was designed to provide adequate spatial resolution within the proposed KM Mine Unit in order to simulate response of the aquifer to typical extraction and

injection rates anticipated for ISR production of the KM Horizon. Cell dimensions within the vicinity of the 5-Spot Test are 6.25 feet by 6.25 feet. Cell dimensions are gradually increased to a maximum size of 100 feet by 100 feet near the edges of the model. The model consists of 208 rows and 294 columns with 11 layers and contains 672,672 cells.

The eleven layers of the model represent, from shallowest to deepest, the following:

- HJ Horizon,
- Sagebrush Shale,
- KM Horizon
    - (divided into three layers representing an upper, middle and lower portion of that unit),
- K Shale,
- L Horizon,
- LM Shale,
- M Horizon,
- MN Shale, and
- N Horizon.

Figure 2 shows the relationship of the model layers. Within the project area, the top and bottom elevation of each of the stratigraphic units included in the model are based on interpretations and correlations provided by LC ISR geologists. The geologic dips of the stratigraphic units are projected out to the limits of the model domain. It is assumed that each of the units included in the model extends out to the edge of the model domain (that there are no stratigraphic pinchouts). The top and bottom elevation of the KM Horizon across the model domain are shown on **Figures 5**, and **6**, respectively.

Boundary conditions imposed on a numerical model define the external geometry of the groundwater flow system being studied as well as internal sources and sinks. Descriptions of the types of boundary conditions that can be implemented with the MODFLOW code are found in McDonald and Harbaugh (1988). The general-head boundary (GHB) condition was used to represent groundwater flow into and out of the model domain along the perimeter of the model domain. GHBs were used to establish the hydraulic gradient for the HJ, KM, L, M, and N Horizons across the model domain. GHBs were used because the groundwater elevation at those boundaries can change in response to simulated stresses. The values of head assigned to the GHBs on the model were based on the projection of the potentiometric surface for each of those Horizons, as determined from the October 2011 water level measurements. GHBs are placed along the northeast and southwest boundaries of the model domain.

The well package of MODFLOW was used to simulate pumping from the KM Horizon during model calibration and production simulations. Rates and locations of simulated wells are described in the calibration and production simulation sections of this report.

Aquifer Properties

Aquifer properties that were considered in the development of the model, in addition to top and bottom elevation of the various modeled units, include hydraulic conductivity and storativity and porosity. MODFLOW-2000 utilizes the specific storage coefficient (which is defined as the storativity divided by the saturated thickness of the aquifer).

Hydraulic conductivity and storativity were estimated during the calibration process as described in the following section.

A uniform porosity of 25 percent was assumed, based on communication with LC ISR geologists. Porosity is only used in the calculation of groundwater velocity in the particle tracking function of MODPATH.

The faults within the LCP previously described are simulated within the KM model by the use of discrete hydrologic conductivity zones. The numeric values of these zones were varied as part of the calibration process as described below.

Calibration

Groundwater flow model calibration is an integral component of groundwater modeling applications. Calibration of a numerical groundwater flow model is the process of adjusting model parameters to obtain a reasonable match between field measured values and model predicted values of heads and fluxes (Woessner and Anderson 1992). The calibration procedure is generally performed by varying estimates of model parameters (hydraulic properties) and/or boundary condition values from a set of initial estimates until an acceptable match of simulated and observed water levels, drawdown and/or flux is achieved. Calibration can be accomplished using trial and error methods or automated techniques (often referred to as inverse modeling). The KM groundwater model was calibrated using a combination of trial and error, and inverse modeling methods (using PEST).

The adequacy of model calibration is judged by examining model residuals. A residual, as defined for use in this modeling report, is the difference between an observed water level measurement and the water level predicted by the model. The KM model was calibrated to both absolute groundwater elevations, as well as the net change in water levels measured during pumping tests (drawdown). The objective of model calibration should be the minimization of the residual mean, residual standard deviation, and residual sum of squares (RSS) (Duffield et al 1990). The mean residual is the arithmetic average of all the differences between observed and computed water levels.

A positive sign indicates that the model has under-predicted the observed drawdown level and a negative sign indicates over-prediction. The residual standard deviation quantifies the spread of the differences between observed and predicted drawdown around the mean residual. The ratio of residual standard deviation to the total head change across the model domain should be small, indicating the residual errors are only a small part of the overall model response (Woessner and Anderson 1992). The RSS is computed by adding the square of each residual and is another measure of overall variability. The overall objective during the calibration process is to minimize the residuals, and the statistics based on the residual, while maintaining aquifer properties within the range of reasonably expected values.

Calibration Simulations

The KM Horizon numerical model was calibrated to water level measurements collected at the site in October 2011 and drawdown data from two separate KM pumping tests, one conducted in October 2011 and the other in October 2012. Calibration of the groundwater model to multiple data sets and types increases the confidence that the model can adequately represent hydrologic conditions at the site.

The October 2011 measurement round represents the most complete water level data set collected at the site, and includes monitoring wells completed in the HJ, KM, L, M, and N Horizons. Water level measurements from 83 monitor wells were included in the calibration. The October 2011 water level data were used to calibrate the model to "steady state" groundwater flow conditions (non-pumping) in the HJ, KM, L, M, and N Horizons within the LCP. The October 2011 water level measurements were conducted prior to the regional KM hydrologic test described below.

Drawdown data from the regional Composite KLM Horizon hydrologic test conducted in October 2011 were also used to calibrate the model. For the 2011 Composite KLM Horizon test, well KPW-3 (completed in the KM Horizon) was pumped for a period of 4.9 days at an average rate of 70 gpm. Wells completed in the KM, HJ, L, M and N Horizons were monitored during the test. The total drawdown measured in 77 monitoring wells and in the pumping well were used as calibration targets. Details of that test are found in the report "Lost Creek Hydrologic Test, Composite KLM Horizon Regional Pump Test, October 2011" (Petrotek, 2013a). **Table 1** provides data for the wells used in the calibration of the steady state portion of the model and in the calibration of the model to the 2011 Composite KLM Horizon Test.

Additionally, the KM Horizon model was calibrated to drawdown data from the 5-Spot Hydrologic Test conducted in October 2012. Well 5S-KM3 (completed in the upper portion of the KM Horizon) was pumped for 3.1 days at an average rate of 28.5 gpm.

Wells completed in the HJ, KM, L, M and N Horizons were monitored during the test. Because there were a number of relatively closely spaced wells that were monitored during the 5 Spot Test, the model grid was minimized in that portion of the model (with cell sizes of 6.25 ft by 6.25 ft). This allowed for better resolution of the flow field and drawdown resulting from the 5-Spot pumping test. The total drawdown measured in 8 monitor wells and the pumping well were used as calibration targets. Details of that test are found in the report "Lost Creek Hydrologic Test, Composite KLM Horizon 5-Spot Testing, October 2011" (Petrotek, 2013b). **Table 2** provides data for the wells used in the calibration of the model to the Composite KLM Horizon 5-Spot Test.

The calibration simulation was set up with four stress periods. The initial period represents groundwater flow within the Composite KLM Horizon (and the overlying HJ Horizon and underlying N Horizon) under steady-state (non-pumping) conditions. The second stress period simulates the October 2011 regional Composite KLM Horizon hydrologic test. The third period represents an equilibration period, where water levels were allowed to return to steady state conditions. The fourth stress period represents the 5-Spot KM extraction test conducted in October 2012.

Each of the model layers were assigned discrete zones of hydraulic conductivity (**Table 3).** Increased discretization (i.e. a larger number of zones) was utilized in the model layers where there were more water level measurements (i.e., where there were more monitoring wells). This allowed for greater flexibility during parameter estimation in fitting the simulated values to the actual observed measurements. The model layers representing the production zone and overlying and underlying aquifers (HJ, KM, L, and M Horizons) were subdivided into numerous hydraulic conductivity units (generally between 10 and 20 zones). The model layers representing the confining units (Sagebrush Shale, K Shale, L-M Shale and the M-N Shale) were only assigned a few zones because there were no observations (water level measurements) in any of those layers. No wells are completed in those units. The N horizon was also only assigned a few discrete hydraulic conductivity zones as there are only two wells completed in that interval.

As previously indicated, the KM Horizon averages approximately 115 feet in thickness within RA3 and consists of multiple sandstone units interbedded with mudstones. As is typical in many uranium roll front deposits, mineralization within the KM Horizon is present in stacked ore zones. During ISR production, well patterns will be completed over discrete intervals of typically 15 to 20 feet. In order to allow for a more representative simulation of mining of the KM Horizon using ISR (wherein wellfields would only be completed over a portion of the total KM Horizon thickness), the KM Horizon was subdivided into three separate layers. To represent the vertical heterogeneity that would be expected in a hydrostratigraphic interval characterized by

interbedded sands and mudstones, the hydraulic conductivity zones within the three layers of the KM Horizon were allowed to vary independently during calibration. The heterogeneity simulated in the model provides a reasonable representation of subsurface conditions exhibited in borehole logs.

It should also be noted that the extraction well and the four injection wells used in the 5-Spot Test (Petrotek 2013b) were all completed in only the upper portion of the KM Horizon. Subdividing the KM Horizon into 3 distinct layers allowed for a more representative calibration to the 5-Spot Test.

The faults were represented as discrete hydraulic conductivity zones in each of the model layers. Evidence from the water level measurements and pumping tests indicates that the transmissive nature of the faults varies with depth and hydrostratigraphic interval. For example, the main Lost Creek Fault that bisects Mine Unit 1 is a greater barrier to groundwater flow in the HJ Horizon than in the KM Horizon (Petrotek 2013a).

A total of 113 hydraulic conductivity zones were included in the model. **Figures 7** through **9** show the final distribution and values of hydraulic conductivity following completion of model calibration for the 3 layers representing the KM Horizon. **Table 3** summarizes the layer and value for each hydraulic conductivity zone.

The storage coefficient was also set up as separate zones within the model. However, initial attempts at calibration revealed that the parameter estimation process was not very sensitive to the storage coefficient. Therefore, a single value was used in each of the layers with the exception of the layers representing the KM Horizon (Layers 3, 4 and 5). A separate zone was assigned in the vicinity of the two pumping wells in each of those layers. **Table 4** summarizes the layer and value for each storage coefficient zone.

Calibration Results

The calibration simulation was set up to replicate the pumping rate and duration for each of the two pumping tests previously described. The drawdown in the pumping wells and observation wells at the end of each of the two pumping tests were used as calibration targets.

Calibration was achieved by first comparing field-measured (observed) water levels in the observation/monitoring wells with heads predicted by MODFLOW-2000 for the same wells under simulated steady state conditions of the HJ, KM, L, M and N aquifers. Then, the model results were compared to the final drawdown at the end of the October 2011 and 2012 pumping tests. Initial trial and error methods were used to provide a generalized “match” to the water level and drawdown observations. PEST was used to optimize the calibration for each of the three simulated conditions (steady state and two pumping tests). The hydraulic conductivity zones, and GHB heads were adjusted until

the best fit to the average potentiometric surface observed in the monitor wells was achieved.

The potentiometric surface of the steady state portion of the final calibration simulations for the HJ, KM, L and M Horizons are shown on **Figures 10** through **13**. The potentiometric surface for the N Horizon is not shown because there are only two wells completed in that hydrostratigraphic interval. Calibration residuals for the steady state targets for each of the Horizons are shown on the figures. A plot of the observed versus simulated heads for all of the steady state targets is shown on **Figure 14**. Calibration statistics from the steady state calibration simulation are listed in **Table 5**.

The simulated drawdown in the KM Horizon at the end of the October 2011 KM Regional test and the end of the 2012 5-Spot Test are shown on **Figures 15** and **16**, respectively. The difference between the simulated and observed drawdown values at the target locations are also shown on the figures. One of the wells monitored during the 5 Spot Test had more than twice as much drawdown as other observation wells that were a similar distance from the pumping well (well M-UKM1, **Table 7**). Extensive efforts to match the anomalous drawdown at the well were unsuccessful. Rather than skew the calibration to fit the single anomalous observation at the expense of the hundreds of other observations used in the overall calibration, the decision was made to weight that drawdown target much lower than the other drawdown observations. A plot of the observed versus simulated drawdown for the October 2011 and October 2012 pumping tests are shown on **Figures 17** and **18**, respectively. Calibration statistics from the October 2011 KM regional Test and the 2012 5-Spot Test simulation are listed in **Table 6** and **7**, respectively.

The calibration simulation provides a reasonably good match to each of the three target sets. The residual mean, the difference between the observed and simulated target value, was generally small for each target. The input and output files for the calibration simulation are provided electronically in **Attachment B**.

ISR Production/Restoration Simulations

The primary objective of this modeling effort is to assess potential hydraulic impacts of ISR from the KM Horizon on the overlying and underlying aquifers. The previously calibrated model was modified in order to simulate ISR scale production and restoration operations. The initial condition for the ISR simulations was based on the potentiometric surface determined from the steady state portion of the calibration simulation. The hydraulic conductivity, specific storage and the GHB heads were adjusted in the calibration simulation to provide a reasonable match to potentiometric surface data representative of steady-state conditions and to drawdown data from two separate

pumping tests. The calibrated model was then used to simulate ISR production and restoration from the KM Horizon.

The simulated wellfields consist of a series of repeating 5-spot well patterns. The well package of MODFLOW was used to simulate extraction and injection in the 5-spot well patterns of the wellfields. The wellfield consists of a total of 9 well patterns arranged in a 3 by 3 square configuration consisting of 9 extraction wells and 16 injection wells (**Figure 19**). The distance from the extraction well to each of the injection wells is approximately 70 ft., and the distance between extraction wells in each well pattern is approximately 100 ft.

Note that the simulated wellfield is substantially smaller than what would be utilized during actual production of the KM Horizon. In fact, a single header house in RA3 would include more than double the number of wells that are simulated in these models (and the entire wellfield would be comprised of multiple header houses). The simulation of a smaller wellfield than what will be actually employed was done for computational efficiency, and to allow more focus on individual well pattern hydraulics. One downside to this approach is that wellfield flare (the area contacted by lixiviant that is outside of the wellfield footprint) is somewhat scale dependent. Smaller wellfields generally show higher apparent wellfield flare than larger ones (Lewis Water Consultants 1999). This is true because wellfield flare tends to occur predominately along the outer edges of the wellfield, where the hydraulic control is not as strong and the injection into the outermost injection wells is more likely to move, at least temporarily, outside of the wellfield footprint. In general, smaller wellfields have a higher ratio of perimeter length to total area than do larger wellfields. This corresponds to a greater ratio of exterior injection wells to interior injection wells, which usually results in a higher simulated wellfield flare.

As previously described, in the calibration simulation the grid size was smallest in the area of the 5-Spot Test (6.25 ft. by 6.25 ft.). In order to allow adequate discretization within the wellfields such that the impacts of individual wells can be discerned, the finer grid size in the vicinity of the 5-Spot Test was expanded slightly. This was accomplished by splitting several of the rows and columns in the model in the vicinity of the 5-Spot Test. As a result, the model domain increased to a total of 238 rows and 320 columns. However, the total dimensions of the x-axis and y-axis of the model (10,210 and 9,000 feet, respectively) remained the same as for the calibration simulation. This allowed for placement of the entire 9 well pattern wellfield within the finer grid portion of the model.

Multiple simulations were run in which the wellfield was placed in either the upper (layer 3), middle (layer 4), or lower (layer 5) portion of the KM Horizon. Each of the simulations provided a different set of conditions with respect to overlying and underlying (and

lateral) conditions relative to the wellfield. For the simulation of a wellfield in the upper KM Horizon, the overlying hydrostratigraphic unit is the Sagebrush Shale and the lower hydrostratigraphic unit is the middle KM Horizon. For the simulation of a wellfield in the middle KM Horizon, the overlying hydrostratigraphic unit is the upper KM Horizon and the lower hydrostratigraphic unit is the lower KM Horizon. The simulation of the wellfield in the lower KM Horizon represents an upper boundary of the middle KM Horizon and a lower bounding unit of the K Shale. Because the hydraulic conductivity zone values are different in each of the three layers of the KM Horizon, each simulation represents variable hydrologic conditions for ISR operations. The relative position of the 9 well pattern wellfield relative to RA3 is shown on **Figure 19**.

Each extraction well is simulated at a rate of 20 gpm during production. The injection wells were assigned values based on their location within the 5-spot pattern such that the total injection rate is 99 percent of the total extraction rate. This amounts to a 1 percent bleed (overproduction) in order to maintain an inward gradient through production. The rates for the extraction/injection wells during production are summarized below.

- Extraction - 20.0 gpm
- Interior Injection - 19.8 gpm
- Exterior Side Injection - 9.9 gpm
- Exterior Corner Injection - 4.95 gpm

Based on discussions with LC ISR personnel, production is anticipated to continue for each well pattern until 50 pore volumes (PVs) are recovered. A pore volume (PV) for purpose of determining the duration of production is calculated as the area inside of a well pattern multiplied by the completion thickness, multiplied by the effective porosity. Each of the well patterns has dimensions of approximately 100 feet by 100 feet, with a thickness of 18 feet and an effective porosity of 25 percent. Therefore a single PV is calculated as:

1 PV =100ft x 100ft x 18ft x 0.25 = 45,000 ft^3 = 45,000 ft^3 x 7.48 gal/ft^3 = 336,600 gallons,

and

50 PV = 336,600 gal x 50 = 16,830,000 gallons.

The duration of production, at the simulated rate of 20 gpm per pattern, is calculated as:

16,830,000 gal ÷ 20 gpm = 841,500 minutes = 841,500 min ÷ 1,440 min/day= 584.4 days.

The production period for each simulation was run for 585 days.

The simulated production period of 585 days was immediately followed by simulation of aquifer restoration. LC ISR has indicated that restoration at RA3 will include groundwater sweep (GWS) for an equivalent of 1/3 of a PV followed by reverse osmosis (RO) treatment and reinjection for 6 PVs. For purposes of this modeling effort, only GWS was simulated, although for a total of 4 PV instead of 1/3 PV. The longer simulation of GWS than is actually planned provides a better representation of the extended period of restoration (and maintenance of an inward hydraulic gradient) that will occur with the inclusion of RO.

The GWS extraction rate was simulated at 10 gpm per extraction well (half of the production extraction rate). Using the same PV calculation as previously results in a restoration time as follows:

4 PV=4 x 336,600 gal ÷ 10 gpm=134,640 minutes=134,640 min ÷ 1,440 min/day=93.5 days.

The restoration period for each simulation was rounded up to 100 days.

Particle tracking is utilized to assess the simulated movement of production and restoration fluids during ISR operations. The MODPATH code is used to simulate the movement of particles (Pollock 1994). Particles are placed at each of the injection wells at multiple depth intervals within the layer of injection. The starting position of the particles in the model cells with injection wells are in the middle of the layer and at the 0.3 and 0.7 fractional portion of the layer. (For example, if a layer was 30 feet thick, then the particles are released at 9 feet, 15 feet and 21 feet from the bottom of the layer).

ISR Simulation Results

A series of simulations were run to assess potential hydraulic impacts of ISR from the KM Horizon. Simulating distinct wellfields in the three separate model layers that represent the KM Horizon (each of which comprise a unique distribution of hydraulic conductivity), provides a high degree of variability in potential outcomes.

Upper KM Horizon ISR Simulation

One ISR simulation includes a wellfield in the upper KM Horizon (layer 3 of the model). In this simulation, the overlying hydrostratigraphic unit is the Sagebrush Shale (layer 2) and the lower hydrostratigraphic unit is the middle KM Horizon (layer 4). During the production period, the total extraction from the 9 pattern wellfield is 180 gpm. Total injection during the production period is 178.2 gpm, for a net 1 percent bleed. During GWS, each of the extraction wells are simulated at a rate of 10 gpm for a total wellfield recovery rate of 90 gpm. The injection wells are not pumped during simulation of GWS.

Figure 20 shows the simulated drawdown within the upper KM Horizon in the vicinity of the wellfield at the end of production. The pattern of drawdown appears very irregular with relatively large changes in water levels occurring in the southeast corner of the wellfield and comparatively smaller changes to the northwest. The drawdown pattern is more readily understood when the hydraulic conductivity zones for this model layer in the wellfield area also shown (**Figure 21**). The area with the largest net change in water levels coincide with the zones of considerably lower hydraulic conductivity values. In actual field conditions, the operator would recognize that the wells completed in this low permeability area would be unable to sustain the 20 gpm production/injection rates that were planned for this wellfield and would reduce the flow accordingly. However, for purposes of this modeling demonstration, the scenario that is simulated provides an opportunity to assess hydraulic impacts under extreme conditions.

In the upper KM Horizon ISR simulation, the extraction well showing the greatest impact at the end of production has over 125 feet of drawdown (**Figure 20**). The injection well with the largest net change shows a rise of almost 300 feet. At the end of GWS, most of the wellfield shows over 60 feet of drawdown (**Figure 22**).

Particle tracking is used to identify flowpaths of injectate as the fluids move from the injection well toward the extraction wells. **Figure 23** indicates injectate flowpaths in the upper KM Horizon through the production phase. The figure indicates that some particles near the southeast portion of the wellfield (in the area of very low permeability) appear to be moving away from the wellfield at the end of production. Essentially all of the particles that have moved outside of the wellfield outline during production originated from injection wells located along the outer edge of the simulated wellfield. As previously described, the small size of the simulated wellfield results in a larger than anticipated horizontal flare (movement of particles outside of the footprint of the wellfield). If a larger wellfield were simulated, the ratio of exterior injection wells to interior injection wells would be smaller, resulting in a relative reduction in the horizontal flare factor. The horizontal flare factor is the ratio of total area contacted by lixiviant within the production zone to the area inside the footprint of the wellfield.

The maximum distance traveled by any particle outside of the wellfield is approximately 100 feet. The effectiveness of GWS in recovering those particles that moved outside of the wellfield within the upper KM Horizon during production is shown on **Figure 24**. The hydraulic gradient around the entire perimeter of the wellfield is inward toward the wellfield. This figure only shows the continuation of flowpaths of particles that were not captured by the extraction wells during production. During GWS, each of the particles are moving back toward the wellfield.

Within the middle KM Horizon there is a net drawdown of 0.5 to 7 feet within the footprint of the upper KM Horizon wellfield at the end of production (**Figure 25**). There are several particles that have migrated from the upper KM Horizon into the middle KM Horizon during production (**Figure 25**). However, almost all of the particles are moving inward to the wellfield as they are still within the capture zone of the extraction wells. **Figure 26** shows a cross-sectional view (along row 115 of the model) of the particle tracking at the end of production. One particle flowpath skims the upper surface of the lower KM Horizon. **Figure 27** shows a cross-sectional view at the end of the simulated GWS of the particles that were still active (not captured by extraction wells) after completion of production. Almost all of the particles have moved back into the upper KM Horizon wellfield footprint at the end of the simulated GWS. At no time during production or GWS did any particles enter into the overlying Sagebrush Shale.

Middle KM Horizon ISR Simulation

An ISR simulation was run that includes a wellfield placed in the middle KM Horizon (layer 4 of the model). In this simulation, the overlying hydrostratigraphic unit is the upper KM Horizon and the lower hydrostratigraphic unit is the lower KM Horizon. Extraction and injection rates were identical to the upper KM Horizon ISR simulation previously described.

The simulated drawdown within the middle KM Horizon in the vicinity of the wellfield at the end of production is illustrated in **Figure 28**. The pattern of drawdown indicates relatively larger changes in water levels occurring in the southeast portion of the wellfield and comparatively smaller changes to the west. As was the case for the upper KM Horizon simulation, the hydraulic conductivity is substantially higher in the west-northwest portion of the wellfield in this model layer. In the middle KM Horizon ISR simulation, the extraction well showing the greatest impact at the end of production has approximately 90 feet of drawdown (**Figure 28**). Some of the interior injection wells have over 60 feet of rise in water levels at the end of production.

Particle tracking is used to identify injectate flowpaths in the middle KM Horizon during production (**Figure 29**). Some particles along the southeast edge of the wellfield appear to be moving away from the wellfield at the end of production. Again, that area coincides with the simulation of lower permeability units. The maximum distance traveled at the end of production is approximately 110 feet outside of the wellfield. **Figure 30** shows the particle traces after the 100 days of GWS. As in the previous simulation, this figure only shows the flowpaths for particles that were not captured by extraction wells during the production simulation. In every case, the particles are moving back toward the wellfield.

For these simulations, extraction and injection was maintained at the same ratio and rates, regardless of the hydraulic conductivity of the zone that the wells are completed in, or the response of the aquifer (drawdown or rise). During actual operations, the rates would be adjusted to avoid excessive drawdown or rise in individual wells during production or restoration. However, as was the case for the upper KM simulations, for purposes of this modeling demonstration, the scenario that is simulated provides an opportunity to assess hydraulic impacts under extreme conditions. The horizontal flare is greater than what would occur if the wells located in the areas of low permeability were adjusted to lower rates to prevent excessive drawdown or rise during production.

Hydraulic impacts to the overlying upper KM Horizon during production of the middle KM Horizon are shown on **Figure 31**. The maximum drawdown in the upper KM Horizon is less than 8 feet of hydraulic head and the maximum rise is less than 1 foot. Particle tracking indicates some injectate migrates from the middle KM Horizon into the upper KM Horizon during production (**Figure 31**). However, all of the particles are moving inward to the wellfield by the end of production as they are within the capture zone of the extraction wells.

Hydraulic impacts to the underlying lower KM Horizon during production of the middle KM Horizon are shown on **Figure 32**. The net change in water levels within the lower KM Horizon is less than a few feet at the end of production. A few particles move into the lower KM Horizon during production southeast of the wellfield, but only cover a very limited area (**Figure 32**).

The effect of GWS following production from the middle KM Horizon wellfield is shown in cross-sectional view of the particle tracking (**Figure 33**). Only particles that were not captured by extraction wells at the end of production are shown on the figure. The particle tracks are generally limited to the middle and upper KM Horizon Layers, with a very minor intrusion into the lower KM Horizon. No particles move into the underlying K Shale or the overlying Sagebrush Shale during production or GWS.

Lower KM Horizon ISR Simulation

An ISR simulation was run that includes a wellfield in the lower KM Horizon (layer 5 of the model). In this simulation, the overlying hydrostratigraphic unit is the middle KM Horizon and the lower hydrostratigraphic unit is the K Shale. Extraction and injection rates were identical to the upper KM Horizon ISR simulation that was previously described.

The simulated hydraulic impacts within the lower KM Horizon indicate relatively larger changes in water levels occurring in the east side of the wellfield and comparatively smaller changes to the southwest (**Figure 34**). This is the result of a slightly higher

hydraulic conductivity zone present in the southwest portion of the wellfield in this model layer. In the lower KM Horizon ISR simulation, the extraction well showing the greatest impact at the end of production has approximately 140 feet of drawdown (**Figure 34**). Some of the interior injection wells have over 130 feet of rise in water levels at the end of production.

Injectate flowpaths in the lower KM Horizon at the end of the production indicate that some particles along each side of the wellfield appear to be moving away from the wellfield at the end of production (**Figure 35**). The maximum distance traveled at the end of production is approximately 105 feet outside of the wellfield. **Figure 36** shows the particle traces after the 100 days of GWS. All of the particles that were not already captured during production are moving back toward the wellfield during GWS.

Hydraulic impacts to the overlying middle KM Horizon at the end of production from the lower KM Horizon are shown on **Figure 37**. The maximum drawdown in the middle KM Horizon is less than 3 feet of hydraulic head and the maximum rise is less than 4 foot. Particles have migrated from the lower KM Horizon into the middle KM Horizon along the north and southeast sides of the wellfield during production (**Figure 37**). However, all of the particles are moving inward to the wellfield and are within the capture zone of the extraction wells.

Within the K Shale, the net change in water levels is generally less than 10 feet at the end of production from the lower KM Horizon (**Figure 38**). A few particles move into the K Shale during production but only cover a very limited area (**Figure 38**).

The effect of GWS following production from the lower KM Horizon wellfield is shown in cross-sectional view of the particle tracking (**Figure 39**). Only particles that were not captured by extraction wells at the end of production are shown on the figure. The particle tracks are generally limited to the lower and middle KM Horizon Layers, with a very minor intrusion into the K Shale. All particles are moving toward the lower KM Horizon wellfield. No particles move into the underlying L Horizon or the overlying upper KM Horizon during production or GWS.

The input and output files for each of the three production simulations are provided electronically in **Attachment A**.

Excursion Simulations

One of the stated objectives of this modeling effort is to evaluate the capability to recover an excursion to an underlying aquifer. In each of the previous production/restoration simulations there was no indication of an excursion into either the overlying HJ Horizon or the underlying L Horizon. It is less likely that an excursion into

the HJ Horizon would occur under normal operating conditions, based on the large head differences between that unit and the KM Horizon and the regional extent and integrity of the Sagebrush Shale. Furthermore, there is existing capability to contain an excursion from the KM Horizon to the HJ Horizon with the existing wellfield network already in place for ISR mining of the HJ Horizon. Therefore, no additional evaluation of recovery of an excursion from the KM Horizon to the HJ Horizon is conducted in this investigation.

A separate simulation was developed to evaluate if an excursion into the L Horizon from KM Horizon production could be effectively recovered. In the calibrated model, the vertical hydraulic conductivity of the K Shale in the vicinity of the KM Horizon wellfields was relatively high for a shaley unit (at 0.146 ft/d). Nevertheless, the production simulations using the calibrated model were unable to create an excursion to the L Horizon under typical operating conditions. There was some excursion into the K Shale under the simulation of the wellfield in the lower portion of the KM Horizon, but the extent was minimal and was restricted to the upper most portion of the K Shale.

In order to simulate an excursion into the L Horizon, a scenario was constructed in which a portion of the K Shale directly beneath the KM Horizon wellfield was given the same hydraulic conductivity values as the L Horizon. In effect, this simulated the absence of a confining unit between the L Horizon and KM Horizon. **Figure 40** shows the hydraulic conductivity zone distribution in the K Shale for this simulation and the projection of the KM Horizon wellfield. Additionally, the simulation was run “out of balance” wherein the most southern injection well was run at twice the rate as in the previous simulations (10 gpm vs. 5 gpm).

Injectate flowpaths indicate an excursion into the L Horizon directly east of the “out of balance” well during production (**Figure 41**). However, note that the particles that have moved into the L Horizon during the excursion simulation are moving toward the wellfield. Although the particles have moved out of the production zone, they are still within the capture zone of the wellfield extraction wells and would eventually be drawn back into the wellfield (assuming production continued for a sufficient period of time). Following production, a simulation was run using the same GWS recovery rates as in the previous simulations (9 wells extracting at 10 gpm each for 100 days) to determine if that would be sufficient to recover the excursion. The results of the particle tracking are shown in cross-sectional view (**Figure 42**). Based on examination of the MODPATH output files, at the end of the simulated GWS all of the particles have either migrated back into the KM Horizon (layer 5) or into the K Shale (layer 6). No particles remain in the L Horizon (layer 7).

A second recovery scenario was simulated in which the “out of balance” well was used during GWS, extracting at a rate of 10 gpm. Results of that simulation indicate that all of the excursion particles that were in the L Horizon during production have been pulled back up into the KM Horizon or very near the top of the K Shale by the end of GWS (**Figure 43**).

The excursion simulation demonstrates that if an excursion were to occur, recovery can be accomplished using rates that are typical for GWS. Conversion of existing injection wells to extraction wells during recovery will increase the effectiveness of the recovery.

The input and output files for the excursion simulations are provided electronically in **Attachment B**.

Summary

A numerical model was developed to simulate ISR of uranium from the KM Horizon of the Lost Creek Project in Sweetwater County Wyoming. The focus of the model was on the demonstration of hydraulic control, both horizontally and vertically, of production and restoration fluids throughout mining. The model was initially calibrated to static potentiometric conditions and two separate pumping tests conducted within the KLM Horizon.

The model contains eleven layers representing the hydrostratigraphic interval from the HJ Horizon down through the N Horizon, with a total thickness of approximately 550 feet. The parameter estimator code PEST (Doherty 2010) was coupled with the USGS MODFLOW-2000 (Harbaugh et al 2000) groundwater flow code to calibrate the model to observed drawdown data from a regional KM Horizon pumping test and a 5-spot pumping test.

The KM Horizon was subdivided into three layers within the model to account for the heterogeneity that may be present within that hydrostratigraphic unit. Calibration of the model resulted in a large range of hydraulic conductivity values within the KM Horizon layers.

A series of simulations were run using the calibrated model to assess potential hydraulic impacts of ISR from the KM Horizon. Wellfields were simulated in each of the three separate model layers that represent the KM Horizon (each of which comprise a unique distribution of hydraulic conductivity). This provided a high degree of variability in potential outcomes.

Each wellfield was designed as a series of repeating 5-spot well patterns that contained nine extraction wells and sixteen injection wells. The extraction wells were simulated at a rate of 20 gpm. Injection rates varied depending on the position of the injection well

relative to the well patterns. Production was simulated with an approximate net 1 percent bleed (overproduction) for the entire wellfield. Production was simulated for a period of 585 days.

The simulated wellfields are substantially smaller than what would be utilized during actual production of the KM Horizon. The simulation of a smaller wellfield than what will be actually employed was done for computational efficiency, and to allow more focus on individual well pattern hydraulics and vertical movement of injectate. However, horizontal flare has been demonstrated to be scale dependent (Lewis Water Consultants,1999). Smaller wellfields generally show higher apparent horizontal flare than larger ones. Horizontal flare occurs predominately along the outer edges of the wellfield. Smaller wellfields typically have a higher ratio of perimeter length to total area than do larger wellfields. This corresponds to a greater ratio of exterior injection wells to interior injection wells, which usually results in a higher simulated horizontal flare. The horizontal flare resulting from these simulations is anticipated to be higher than what will occur in actual operation because of the smaller size of the simulated wellfields.

Restoration was simulated using GWS (extraction only). GWS was simulated for 100 days with nine extraction wells, each operating at 10 gpm.

Particle tracking (using the USGS code MODPATH) was used to monitor the flowpaths of injectate throughout production and GWS.

Results of the ISR simulations indicate that the maximum horizontal flare within the KM Horizon (as determined from the injectate flowpaths) was less than 115 ft from the edge of the wellfield. For these simulations, extraction and injection was maintained at the same ratio and rates, regardless of the hydraulic conductivity of the zone that the wells are completed in or the response of the aquifer (drawdown or rise). During actual operations, the rates would be adjusted to avoid excessive drawdown or rise in individual wells during production or restoration. For purposes of this modeling demonstration, the scenarios that are simulated provide an opportunity to assess hydraulic impacts under extreme conditions. The simulated flare is greater than what would occur if the wells located in the areas of low permeability were adjusted to lower rates to prevent excessive drawdown or rise during production.

In each case (simulation of wellfields in the upper, middle and lower portion of the KM Horizon), GWS was effective in reversing the hydraulic gradient and altering the injectate flowpaths back toward the wellfield.

There was some vertical flare between the KM Horizon subunits during production. However, GWS was generally effective in pulling the injectate back into the producing zone.

The geologic heterogeneity and complexity that is common to ISR deposits was simulated in the model through the use of multiple layers and multiple hydraulic conductivity units within the KM Horizon. However, there are numerous smaller scale low permeability units throughout the KM Horizon that are not accounted for in the scale of the model. The additional layering of low permeability units will further limit vertical flare during production of the KM Horizon.

None of the ISR simulations indicated vertical flare into the overlying HJ Horizon or the underlying L Horizons when operations were conducted under balanced flow conditions.

An excursion scenario was developed in which a portion of the K Shale was absent and an injection well was operating “out of balance” at twice the rate compared to balanced simulations. In this simulation, some injectate was forced into the underlying L Horizon during production.

Following production, a simulation was run using the same GWS recovery rates as in the previous simulations to determine if that would be sufficient to recover the excursion. At the end of the simulated GWS, all of the particles either migrated back into the KM Horizon or into the K Shale. No particles remained the L Horizon.

An additional recovery simulation was run wherein the “out of balance” injection well was used as an extraction well during GWS. That well was also simulated at 10 gpm. This increased the hydraulic gradient between the excursion area and the wellfield. Results of the enhanced GWS simulation indicated more rapid and more efficient capture of the flare than in the previous GWS simulation. These simulations confirm that application of engineering controls should be adequate to successfully recover an excursion into the underlying aquifer. The rate of recovery is generally proportional to the changes in hydraulic gradients that are applied.

Although not specifically included in the modeling of the KM Horizon, some recommendations regarding monitoring of the underlying aquifers are provided. Placement of L Horizon monitor wells should coincide with areas where the K Shale is known or suspected to be thin or possibly absent. As demonstrated in the modeling, it is difficult to simulate an excursion if there is a competent confining unit, even if the vertical hydraulic conductivity is relatively high (as might be the case for a silty K Shale unit instead of a shaley unit). The location of L Horizon monitor wells should be based on geologic interpretation of the K Shale, and not designed based on a uniformly spaced grid. Placement of L Horizon monitor wells in areas where there is substantial shale/claystone thickness would be unwarranted and is unlikely to provide consequential monitoring.

If the L Horizon is adequately monitored, no additional monitoring in the deeper M Horizon should be required. Based on the modeling, the likelihood of vertical flare reaching the L Horizon appears small. If an excursion to the L Horizon were to occur, it would be detected in the L Horizon monitor wells first. The probability of flare extending all the way through the L Horizon and the LM Shale and into the M Horizon (a vertical distance of over 100 feet) within the timeframes anticipated for production is very low.

References

Doherty, J.E. 2010. *PEST Model-Independent Parameter Estimation, User Manual: 5th Edition*. Prepared by Watermark Numerical Computing.

Doherty, J.E., M.N. Fienen, and R.J.Hunt, 2010. *Approaches to Highly Parameterized Inversion: Pilot Point Theory, Guidelines and Research Directions.* Scientific Investigations Report 2010-5168, U.S. Geological Survey, Reston, VA.

Duffield, G.M., D.R. Buss, and D.E. Stephenson. 1990. Velocity prediction errors related to flow model calibration uncertainty, *In*: *Calibration and Reliability in Groundwater Modeling* (K. Kovar, ed.), IAHS Publication 195, pp. 397-406.

Environmental Simulations, Inc. 2011. *Guide to Using Groundwater Vistas, Version 6*. pp 213. Prepared by Environmental Simulations, Inc., Reinholds, VA.

Harbaugh, A. W., and M.G. McDonald. 1996. *User's documents for MODFLOW-96, an update to the U.S. Geological Survey modular finite difference ground-water flow model*. Open File Report 96-485. U.S. Geological Survey,Reston, VA.

Harbaugh, A.W, E.R. Banta, M.C. Hill and M. G. McDonald. 2000. MODFLOW-2000.*The U.S. Geological Survey Modular Ground-Water Model-User Guide to Modularization Concepts and the Ground-Water Flow Process*. Open File Report 00-92l U.S. Geological Survey, Reston, VA.

Lewis Water Consultants 1999. *Draft Evaluation and Simulation of Wellfield Restoration at the RAMC Smith Ranch Facility*. Prepared for Rio Algom Mining Corporation, October 1999.

McDonald, M.G., and A.W. Harbaugh. 1988. *MODFLOW, A Modular Three-Dimensional Finite Difference Flow Model*. Techniques of Water-Resources Investigations, Book 6, Chapter A1. U.S. Geological Survey.

Petrotek Engineering Corporation, 2009a. *Lost Creek Hydrologic Testing, KM Horizon Testing.* Prepared for Lost Creek ISR, LLC, November 2009.

Petrotek Engineering Corporation, 2009b. *Lost Creek Hydrologic Testing, Mine Unit 1, North and South Tests.* Prepared for Lost Creek ISR, LLC, October2009.

Petrotek Engineering Corporation, 2013a. *Lost Creek Hydrologic Test, Composite KLM Horizon Regional Pump Test, October 2012.* Prepared for Lost Creek ISR, LLC, April 2013.

Petrotek Engineering Corporation, 2013b. *Lost Creek Hydrologic Test, Composite KLM Horizon 5-Spot Testing, October 2012.* Prepared for Lost Creek ISR, LLC, April 2013.

Pollock, D.W. 1994. *Users Guide for MODPATH/MODPATH-PLOT, Version 3: A particle tracking post-processing package for MODFLOW, the U.S. Geological Survey finite-difference ground-water flow model*. Open-File Report 94-464. U.S. Geological Survey, Reston, VA.

Woessner, W.W. and M.P. Anderson. 1992. *Applied Groundwater Modeling: Simulation of Flow and Advective Transport*. Academic Press. 381 pp.

Table 1. Well Information, 2011 KM Regional Test and Water Level Monitoring, Lost Creek Uranium ISR Project

Well	Type of Well	Completion Zone	MP Elev (ft amsl)	Easting (NAD83) (feet)	Northing (NAD83) (feet)	Screened Interval (ft bgs)	Casing ID (in)	Screen Length (feet)
5S-HJ1	Overlying Obs. Well	HJ Horizon	6947.19	2214013	595593	460-480	4.5	20
HJMP-105	Overlying Obs. Well	HJ Horizon	6937.40	2211252	595778	425-465	4.5	40
HJMP-108	Overlying Obs. Well	HJ Horizon	6952.08	2211786	596015	400-440	4.5	40
HJMP-109	Overlying Obs. Well	HJ Horizon	6939.73	2212215	595535	478-508	4.5	30
HJT-101	Overlying Obs. Well	HJ Horizon	6937.56	2210880	595314	437-477	4.5	40
HJT-102	Overlying Obs. Well	HJ Horizon	6939.15	2211206	595401	390-420	4.5	30
HJT-103	Overlying Obs. Well	HJ Horizon	6938.22	2211500	595374	423-453	4.5	30
HJT-104	Overlying Obs. Well	HJ Horizon	6940.15	2211973	595596	410-460	4.5	50
M-103A	Overlying Obs. Well	HJ Horizon	6946.00	2214017	594642	364-378, 395-408, 414-434, 440-465	4.5	72
M-104	Overlying Obs. Well	HJ Horizon	6942.11	2213540	594556	368-382, 400-415, 415-426, 437-453	4.5	56
M-109	Overlying Obs. Well	HJ Horizon	6921.72	2211177	594662	379-391, 403-423	4.5	30
M-111	Overlying Obs. Well	HJ Horizon	6909.59	2210267	594443	370-379, 390-409, 416-429, 445-460	4.5	56
M-113	Overlying Obs. Well	HJ Horizon	6928.01	2209307	594502	396-406, 417-439, 447-463, 472-480	4.5	56
M-114	Overlying Obs. Well	HJ Horizon	6930.75	2208939	594825	410-420, 429-449, 465-485	4.5	50
M-115	Overlying Obs. Well	HJ Horizon	6939.10	2208876	595312	428-451	4.5	23
M-117	Overlying Obs. Well	HJ Horizon	6944.80	2209305	596139	435-453, 461-480	4.5	37
M-119	Overlying Obs. Well	HJ Horizon	6948.65	2210263	596294	432-450	4.5	18
M-121	Overlying Obs. Well	HJ Horizon	6951.71	2211196	596586	393-404, 436-455, 468-491	4.5	51
M-123	Overlying Obs. Well	HJ Horizon	6951.85	2212163	596638	422-444, 465-495	4.5	52
M-125	Overlying Obs. Well	HJ Horizon	6947.76	2212967	596102	367-397, 404-419	4.5	45
M-127	Overlying Obs. Well	HJ Horizon	6947.66	2213929	595946	408-418, 435-450, 450-471, 480-495	4.5	61
MP-101	Overlying Obs. Well	HJ Horizon	6942.02	2213872	595185	420-438	4.5	18
MP-102	Overlying Obs. Well	HJ Horizon	6941.02	2213296	595391	408-458	4.5	50
MP-103	Overlying Obs. Well	HJ Horizon	6935.48	2212706	595372	370-400	4.5	30
MP-104	Overlying Obs. Well	HJ Horizon	6939.85	2212004	595507	423-463	4.5	40
MP-108	Overlying Obs. Well	HJ Horizon	6937.94	2210879	595460	405-435	4.5	30
MP-111	Overlying Obs. Well	HJ Horizon	6936.28	2209948	595352	391-410	4.5	19
MP-113	Overlying Obs. Well	HJ Horizon	6923.19	2209858	594941	447-466	4.5	19
UKMO-101	Overlying Obs. Well	HJ Horizon	6942.32	2212406	595647	465-490	4.5	25
UKMO-103	Overlying Obs. Well	HJ Horizon	6952.11	2212820	596261	409-439	4.5	30

Table 2. Well Information, 2012 5-Spot Test, Lost Creek Uranium ISR Project

Well ID	Well Type	Completion Zone	Easting (NAD83)	Northing (NAD83)	TOC Elev (ft amsl)	Drilled TD (ft bgs)	Cased Depth (ft bgs)	Casing ID (in)	Screen Interval (ft bgs)	Screen Length (feet)
5S-HJ1	Obs. Well	HJ Horizon	2,214,013	595,593	6,945.83	480	460	4.5	460-480	20
5S-KM3	Recovery Well	KM Horizon	2,213,986	595,579	6,945.87	540	520	4.5	520-540	20
5S-KM1	Inj/Obs. Well	KM Horizon	2,213,950	595,640	6,946.20	540	525	4.5	525-545	20
5S-KM2	Inj/Obs. Well	KM Horizon	2,214,046	595,610	6,946.02	540	520	4.5	520-540	20
M-UKM1	Inj/Obs. Well	KM Horizon	2,214,017	595,516	6,945.22	550	520	4.5	520-540	20
KPW-1A	Inj/Obs. Well	KM Horizon	2,213,927	595,550	6,947.58	540	520	5	519-539 575-610	20 35
5S-KM4	Obs. Well	KM Horizon	2,213,955	595,563	6,945.59	540	520	4.5	520-540	20
KMU-1	Obs. Well	L Horizon	2,214,011	595,543	6,946.00	740	650	4.5	650-675	25
M-M1	Obs. Well	M Horizon	2,213,989	595,526	6,945.82	780	750	4.5	750-770	20
5S-N1	Obs. Well	N Horizon	2,213,940	595,615	6,946.29	900	850	4.5	850-870	20

NAD83 - North American Datum, 1982-Wyoming State Plane, West Central-feet
TOC Elev - top of casing elevation
TD - total depth
ft amsl - feet above mean sea level
ft bgs - feet below ground surface
in - inches

Table 1. Well Information, 2011 KM Regional Test and Water Level Monitoring, Lost Creek Uranium ISR Project

Well	Type of Well	Completion Zone	MP Elev (ft amsl)	Easting (NAD83) (feet)	Northing (NAD83) (feet)	Screened Interval (ft bgs)	Casing ID (in)	Screen Length (feet)
KPW-3	PZ Pump Well	KM Horizon	6940.17	2213891	595227	515-550, 565-590	5.5	60
HJMU-109	PZ Obs. Well	KM Horizon	6939.60	2212225	595540	524-574	4.5	50
HJMU-110	PZ Obs. Well	KM Horizon	6948.02	2212005	595900	492-537	4.5	45
KMP-1	PZ Obs. Well	KM Horizon	6936.26	2216968	594503	430-450, 460-475, 490-505	4.5	50
KMP-2	PZ Obs. Well	KM Horizon	7016.47	2216654	599180	525-545, 550-560, 570-590	4.5	50
KMP-3A	PZ Obs. Well	KM Horizon	6966.18	2214149	596543	500-530, 545-565	4.5	50
KMP-4	PZ Obs. Well	KM Horizon	6971.19	2211256	597607	580-600	4.5	20
KMP-5	PZ Obs. Well	KM Horizon	6916.21	2210070	594057	525-554, 560-585	4.5	54
KPW-1A	PZ Obs. Well	KM Horizon	6947.58	2213927	595550	520-565, 575-610	4.5	80
KPW-2	PZ Obs. Well	KM Horizon	6936.50	2210879	595477	500-507, 526-545, 555-590	4.5	60
LC17M	PZ Obs. Well	KM Horizon	6937.18	2212869	595542	529-565	4.5	36
LC20M	PZ Obs. Well	KM Horizon	6950.78	2211684	596034	511-543	4.5	32
LC24M	PZ Obs. Well	KM Horizon	6944.60	2212886	595906	478-531	4.5	53
M-KM1	PZ Obs. Well	KM Horizon	6951.56	2215130	595555	505-520, 550-580	4.5	45
M-KM2	PZ Obs. Well	KM Horizon	6946.90	2213993	594514	505-530, 565-580	4.5	40
M-KM3A	PZ Obs. Well	KM Horizon	6945.74	2214543	595505	510-550, 580-605	4.5	65
MU-101	PZ Obs. Well	KM Horizon	6941.08	2213855	595183	520-540	4.5	20
MU-102	PZ Obs. Well	KM Horizon	6941.86	2213286	595382	525-555	4.5	30
MU-103	PZ Obs. Well	KM Horizon	6935.83	2212706	595380	525-565	4.5	40
MU-104	PZ Obs. Well	KM Horizon	6939.77	2212006	595493	550-580	4.5	30
MU-106	PZ Obs. Well	KM Horizon	6944.19	2211479	595964	500-550	4.5	50
MU-107	PZ Obs. Well	KM Horizon	6937.53	2210977	595802	500-540	4.5	40
MU-109	PZ Obs. Well	KM Horizon	6934.35	2210941	595221	525-545	4.5	20
MU-110	PZ Obs. Well	KM Horizon	6940.98	2210162	595639	520-540	4.5	20
MU-112	PZ Obs. Well	KM Horizon	6938.31	2209564	595529	515-535	4.5	20
MU-113	PZ Obs. Well	KM Horizon	6925.41	2209839	594942	530-550	4.5	20
M-UKM1	PZ Obs. Well	KM Horizon	6946.51	2214017	595516	520-540	4.5	20
UKMP-101	PZ Obs. Well	KM Horizon	6941.97	2212410	595633	547-577	4.5	30
UKMP-103	PZ Obs. Well	KM Horizon	6954.34	2212808	596263	496-536	4.5	40
UKMU-103	PZ Obs. Well	KM Horizon	6952.21	2212808	596251	558-588	4.5	30

Table 1. Well Information, 2011 KM Regional Test and Water Level Monitoring, Lost Creek Uranium ISR Project

Well	Type of Well	Completion Zone	MP Elev (ft amsl)	Easting (NAD83) (feet)	Northing (NAD83) (feet)	Screened Interval (ft bgs)	Casing ID (in)	Screen Length (feet)
KMU-2	PZ Obs. Well	L Horizon	6952.99	2215179	595572	625-650	4.5	25
KMU-3	PZ Obs. Well	L Horizon	6965.36	2214220	596506	630-650	4.5	20
KMU-4	PZ Obs. Well	L Horizon	6943.22	2211051	595488	605-635	4.5	30
M-L1	PZ Obs. Well	L Horizon	6941.45	2213855	595210	650-670	4.5	20
M-L2	PZ Obs. Well	L Horizon	6946.59	2214551	595530	655-675	4.5	20
M-L3	PZ Obs. Well	L Horizon	6934.90	2212651	595362	660-670, 680-690	4.5	20
M-L4	PZ Obs. Well	L Horizon	6944.86	2213937	594454	640-665	4.5	25
M-L5	PZ Obs. Well	L Horizon	6945.26	2211589	595995	630-650	4.5	20
M-M1	PZ Obs. Well	M Horizon	6947.34	2213989	595526	750-770	4.5	20
M-M2	PZ Obs. Well	M Horizon	6941.97	2213830	595194	725-745	4.5	20
M-M3	PZ Obs. Well	M Horizon	6947.75	2214552	595550	750-770	4.5	20
M-M4	PZ Obs. Well	M Horizon	6945.79	2214044	594453	725-745	4.5	20
M-M5	PZ Obs. Well	M Horizon	6952.97	2215196	595540	730-760	4.5	30
M-M6A	PZ Obs. Well	M Horizon	6964.46	2214200	596525	715-730	4.5	15
M-M7	PZ Obs. Well	M Horizon	6933.45	2212691	595346	745-770	4.5	25
M-M8	PZ Obs. Well	M Horizon	6947.71	2211634	596001	720-740	4.5	20
M-N1	Underlying Obs. Well	N Horizon	6942.42	2213777	595217	825-850	4.5	25
5S-N1	Underlying Obs. Well	N Horizon	6947.66	2213940	595615	850-870	4.5	20

Table 3. Hydraulic Conductivity Zones, KM Horizon Model, Lost Creek Uranium ISR Project

Zone Number	Kx	Kz	Model Layer	Zone Number	Kx	Kz	Model Layer
	(ft/d)	(ft/d)			(ft/d)	(ft/d)	
1	9.786E-01	9.200E-02	1	58	4.335E-02	1.084E-02	2
2	2.970E+00	3.213E-01	1	59	1.000E+01	1.634E-02	5
3	7.028E-01	1.001E-02	1	60	1.000E+00	1.000E-01	Not Used
4	1.647E+00	6.038E-01	1	61	1.000E+00	1.000E-01	Not Used
5	5.176E+00	8.000E-01	1	62	7.600E-05	2.100E-05	Not Used
6	1.735E+00	4.000E-02	1	63	1.571E+00	8.258E-03	11
7	5.991E-01	3.032E-02	1	64	4.600E+00	5.233E-04	5
8	9.471E-01	1.109E-02	1	65	4.068E+00	3.941E-01	7
9	2.704E+00	2.249E-02	1	66	1.169E+00	7.583E-04	7
10	2.952E+00	1.693E-01	1	67	2.464E-03	1.158E-01	1
11	6.515E-02	1.000E-01	1	68	3.000E-01	3.472E-01	4
12	4.846E-02	2.992E-01	1	69	8.130E-01	4.585E-01	4
13	5.819E-01	2.009E-01	1	70	1.816E-02	2.662E-04	4
14	9.122E-02	6.408E-03	All except 1, 2	71	2.778E+00	2.284E+00	4
15	2.916E-03	1.253E-02	All except 1, 2	72	9.160E-01	1.127E-01	4
16	6.503E-01	1.506E-01	11	73	1.708E+00	1.728E-02	4
17	6.306E+00	2.000E-02	11	74	8.119E-02	6.995E-04	4
18	4.832E-02	8.810E-01	10	75	1.624E-02	1.362E+00	4
19	4.688E-02	1.094E-06	10	76	1.617E+00	6.792E-04	4
20	3.597E-01	6.014E-02	8	77	3.740E+00	9.649E-02	4
21	2.023E+00	2.179E-01	8	78	7.117E+00	2.641E-02	4
22	2.329E-03	3.165E-03	6	79	4.147E+00	1.670E-03	4
23	1.118E-01	1.468E-01	6	80	1.000E+00	1.000E-01	Not Used
24	7.288E-05	9.597E-07	2	81	4.661E-01	1.957E-01	3
25	7.758E-05	1.553E-04	2	82	5.050E-01	6.541E-01	3
26	9.971E-03	2.465E-06	9	83	1.111E+00	6.901E-06	3
27	1.287E-01	1.256E-03	9	84	1.877E+00	3.245E+00	3
28	5.733E-01	8.115E-06	9	85	7.893E-01	1.366E-01	3
29	6.006E-02	5.358E-01	9	86	6.897E-01	8.049E-04	3
30	7.049E-01	1.098E-02	9	87	6.776E-01	2.547E-05	3
31	3.957E-01	1.517E-03	9	88	5.496E-02	9.606E-01	3
32	3.324E+00	9.856E-05	9	89	6.487E-01	4.219E-03	3
33	2.176E-01	3.072E-04	9	90	5.941E-03	2.507E-01	2
34	1.866E+00	8.435E-05	9	91	5.730E+00	1.906E-01	3
35	3.623E+00	2.242E-01	9	92	1.000E+01	3.557E-02	3
36	8.951E-01	3.321E-04	9	93	3.080E+00	2.581E-03	3
37	2.235E+00	3.121E-01	7	94	1.337E+00	7.896E-02	5
38	3.188E-01	6.373E-01	7	95	1.023E+00	4.626E-02	5
39	1.528E+00	8.569E-03	7	96	1.551E+00	7.499E-02	5
40	3.060E-01	6.688E-01	7	97	4.267E-01	4.326E-02	5
41	6.862E-02	1.385E-01	7	98	1.339E+00	1.296E-01	4
42	6.591E-02	8.601E-01	7	99	1.205E+00	1.995E-02	4
43	1.000E+01	4.120E-02	7	100	7.518E-01	4.930E-03	4
44	9.768E-01	5.046E-01	7	101	6.759E-01	5.000E+00	4
45	3.469E+00	4.401E-01	7	102	5.655E+00	5.000E+00	4
46	1.000E+01	8.647E-03	7	103	1.878E+00	8.861E-02	3
47	7.614E+00	2.935E-01	7	104	4.795E-02	1.997E-02	3
48	5.926E-01	3.938E-01	5	105	1.766E+00	1.296E-01	3
49	7.737E-01	4.954E-01	5	106	4.457E-01	5.864E-04	3
50	6.111E-01	8.257E-06	5	107	1.000E+01	5.000E+00	3
51	3.035E+00	2.099E+00	5	108	7.779E+00	4.011E-01	3
52	7.662E-01	9.502E-02	5	109	5.187E+00	5.000E+00	3
53	4.516E-01	3.012E-01	5	110	1.436E-03	1.076E-03	3
54	8.406E-01	1.298E-05	5	111	8.573E-01	7.291E-02	3
55	2.863E-02	1.552E+00	5	112	5.891E-03	9.993E-04	3
56	6.826E-01	7.327E-04	5	113	2.639E+00	9.912E-04	3
57	3.458E+00	5.834E-02	5				

ft/d - feet/day

Kx - horizontal hydraulic conductivity

Kz - vertical hydraulic conductivity

Table 4. Specific Storage Coefficient Zones, KM Horizon Model, Lost Creek Uranium ISR Project

Zone Number	Specific Storage	Model Layer
1	5.10E-05	11
2	1.10E-06	10
3	4.80E-06	1
4	1.00E-08	3, 4, 5
5	3.90E-06	5
6	8.40E-07	2
7	3.80E-08	7
8	1.30E-06	6
9	1.00E-07	8
10	1.00E-08	3
11	1.00E-08	4
12	1.00E-08	5
13	2.50E-06	3

Specific storage units are in ft^{-1}

Table 5. Calibration Targets and Statistics, Steady State Simulation, Lost Creek Uranium ISR Project

Name	X-coordinate	Y-coordinate	Model Layer	Observed	Computed	Residual
	(ft)	(ft)		(ft amsl)	(ft amsl)	(ft)
5S-N1	2213940	595615	11	6737.69	6737.88	-0.19
M-N1	2213777	595217	11	6737.50	6737.09	0.41
M-M1	2213989	595526	9	6742.87	6745.52	-2.65
M-M2	2213830	595194	9	6742.64	6743.81	-1.17
M-M3	2214552	595550	9	6748.25	6747.74	0.51
M-M4	2214044	594453	9	6742.63	6742.92	-0.29
M-M5	2215196	595540	9	6748.64	6748.24	0.40
M-M6A	2214200	596525	9	6755.38	6754.75	0.63
M-M7	2212691	595346	9	6738.60	6740.60	-2.00
M-M8	2211634	596001	9	6744.79	6745.70	-0.91
M-WC9	2211051	595488	9	6737.84	6741.92	-4.08
M-KM1	2215130	595555	4	6757.24	6757.35	-0.11
M-KM2	2213993	594514	4	6753.59	6750.48	3.11
M-KM3A	2214543	595505	4	6756.07	6753.19	2.88
KPW-2	2210879	595477	4	6742.73	6743.47	-0.74
KPW-3	2213891	595227	4	6753.10	6750.87	2.23
LC20M	2211684	596034	4	6748.35	6747.11	1.24
MU-103	2212706	595380	4	6750.70	6750.05	0.65
M-UKM1	2214017	595516	4	6754.93	6751.09	3.84
KMP-3A	2214149	596543	4	6759.88	6759.67	0.21
HJMU-109	2212225	595540	4	6749.33	6749.46	-0.13
HJMU-110	2212005	595900	4	6749.03	6748.19	0.84
KMP-1	2216968	594503	4	6765.66	6766.68	-1.02
KMP-2	2216654	599180	4	6787.08	6788.28	-1.20
KMP-4	2211256	597607	4	6749.56	6750.57	-1.01
KMP-5	2210070	594057	4	6730.78	6734.09	-3.31
KPW-1A	2213927	595550	4	6752.98	6750.90	2.08
LC17M	2212869	595542	4	6751.13	6750.33	0.80
LC24M	2212886	595906	4	6753.36	6752.70	0.66
MU-101	2213855	595183	4	6753.38	6750.88	2.50
MU-102	2213286	595382	4	6752.06	6750.65	1.41
MU-104	2212006	595493	4	6746.82	6747.96	-1.14
MU-106	2211479	595964	4	6747.39	6746.25	1.14
MU-107	2210977	595802	4	6744.31	6744.14	0.17
MU-109	2210941	595221	4	6741.65	6742.29	-0.64
MU-110	2210162	595639	4	6739.73	6740.89	-1.16
MU-112	2209564	595529	4	6738.56	6739.03	-0.47
MU-113	2209839	594942	4	6737.56	6735.73	1.83
UKMP-101	2212410	595633	4	6750.03	6751.62	-1.59
UKMP-103	2212808	596263	4	6754.60	6752.52	2.08
UKMU-103	2212808	596251	4	6752.65	6752.50	0.15
KMU-1	2214011	595543	7	6751.35	6750.59	0.76
KMU-2	2215179	595572	7	6754.95	6756.58	-1.63
KMU-3	2214220	596506	7	6757.56	6757.56	0.00
KMU-4	2211051	595488	7	6742.96	6742.12	0.84
M-L1	2213855	595210	7	6749.94	6749.63	0.31
M-L2	2214551	595530	7	6752.31	6752.65	-0.34
M-L3	2212651	595362	7	6745.71	6746.74	-1.03

Table 5. Calibration Targets and Statistics, Steady State Simulation, Lost Creek Uranium ISR Project

Name	X-coordinate	Y-coordinate	Model Layer	Observed	Computed	Residual
	(ft)	(ft)		(ft amsl)	(ft amsl)	(ft)
M-L4	2213937	594454	7	6748.19	6748.46	-0.27
M-L5	2211589	595995	7	6744.77	6745.62	-0.85
HJMP-105	2211252	595778	1	6768.03	6767.73	0.30
HJMP-109	2212215	595535	1	6764.13	6761.32	2.81
HJT-101	2210880	595314	1	6764.76	6764.42	0.34
HJT-103	2211500	595374	1	6748.52	6749.24	-0.72
HJT-104	2211973	595596	1	6769.57	6767.62	1.95
M-104	2213540	594556	1	6759.46	6763.27	-3.81
M-109	2211177	594662	1	6745.07	6743.92	1.15
M-111	2210267	594443	1	6737.85	6739.20	-1.35
M-113	2209307	594502	1	6735.82	6734.82	1.00
M-114	2208939	594825	1	6742.37	6746.34	-3.97
M-115	2208876	595312	1	6753.40	6753.05	0.35
M-117	2209305	596139	1	6758.59	6759.57	-0.98
M-119	2210263	596294	1	6764.25	6765.12	-0.87
M-121	2211196	596586	1	6770.29	6770.15	0.14
M-123	2212163	596638	1	6772.47	6774.31	-1.84
M-125	2212967	596102	1	6773.88	6774.82	-0.94
M-127	2213929	595946	1	6772.48	6773.28	-0.80
MP-102	2213296	595391	1	6761.40	6765.59	-4.19
MP-104	2212004	595507	1	6755.20	6757.01	-1.81
MP-111	2209948	595352	1	6759.37	6760.43	-1.06
MP-113	2209858	594941	1	6737.58	6737.75	-0.17
UKMO-101	2212406	595647	1	6763.88	6763.37	0.51
UKMO-103	2212820	596261	1	6775.56	6774.86	0.70
LC26M	2216523	595537	1	6784.57	6783.62	0.95
5S-HJ1	2214013	595593	1	6772.89	6771.03	1.86
MP-101	2213872	595185	1	6771.00	6767.23	3.77
M-103A	2214017	594642	1	6769.24	6766.41	2.83
M-128	2214350	595698	1	6775.45	6773.36	2.09
HJMP-108	2211786	596015	1	6770.83	6770.84	-0.01
HJT-102	2211206	595401	1	6767.45	6764.95	2.50
MP-108	2210879	595460	1	6767.39	6765.04	2.35
HJ-WC1	2214149	596542	1	6777.58	6778.49	-0.91
HJ-WC2	2215129	595554	1	6774.95	6776.27	-1.32

Residual Mean	0.055
Absolute Residual Mean	1.33
Residual Std. Deviation	1.71
Sum of Squares	242.6
Min. Residual	-4.19
Max. Residual	3.84
Number of Observations	83.0
Range in Observations	56.3
Scaled Residual Std. Deviation	0.030
Scaled Absolute Residual Mean	0.024
Scaled Residual Mean	0.001

Table 6. Calibration Targets and Statistics, 2011 KM Regional Test, Lost Creek Uranium ISR Project

Well ID	X-coordinate	Y-coordinate	Model Layer	Observed Drawdown	Simulated Drawdown	Residual
	(ft)	(ft)		(ft)	(ft)	(ft)
5S-HJ1	2214013	595593	1	0.70	1.12	-0.42
HJMP-105	2211252	595778	1	0.00	0.22	-0.22
HJMP-109	2212215	595535	1	0.10	0.98	-0.88
HJT-101	2210880	595314	1	0.10	0.29	-0.19
HJT-102	2211206	595401	1	0.00	0.42	-0.42
HJT-103	2211500	595374	1	1.10	1.15	-0.05
HJT-104	2211973	595596	1	0.20	0.82	-0.62
M-103A	2214017	594642	1	0.80	0.35	0.45
M-104	2213540	594556	1	1.70	0.38	1.32
M-109	2211177	594662	1	1.00	0.13	0.87
M-111t	2210267	594443	1	0.60	0.06	0.54
M-113	2209307	594502	1	0.40	0.04	0.36
M-114	2208939	594825	1	0.10	0.25	-0.15
M-115	2208876	595312	1	0.00	0.11	-0.11
M-117	2209305	596139	1	0.00	0.07	-0.07
M-119	2210263	596294	1	0.00	0.08	-0.08
M-121	2211196	596586	1	0.00	0.12	-0.12
M-123	2212163	596638	1	0.10	0.20	-0.10
M-125	2212967	596102	1	0.10	0.30	-0.20
M-127	2213929	595946	1	0.40	0.91	-0.51
MP-101	2213872	595185	1	0.80	0.79	0.01
MP-102	2213296	595391	1	1.40	0.94	0.46
MP-103	2212706	595372	1	1.50	0.94	0.56
MP-104	2212004	595507	1	1.60	0.79	0.81
MP-108	2210879	595460	1	0.10	0.23	-0.13
MP-111	2209948	595352	1	0.00	0.11	-0.11
MP-113	2209858	594941	1	0.60	0.07	0.53
UKMO-101	2212406	595647	1	0.20	1.01	-0.81
UKMO-103	2212820	596261	1	0.10	0.27	-0.17
HJMU-109	2212225	595540	4	23.00	22.18	0.82
HJMU-110	2212005	595900	4	2.60	3.31	-0.71
KMP-1	2216968	594503	4	8.20	6.78	1.42
KMP-2	2216654	599180	4	0.30	0.54	-0.24
KMP-3	2214149	596543	4	3.50	4.28	-0.78
KMP-4	2211256	597607	4	0.70	1.24	-0.54
KMP-5	2210070	594057	4	3.30	3.15	0.15
KPW-1A	2213927	595550	4	33.80	35.97	-2.17
KPW-2	2210879	595477	4	1.80	2.06	-0.26
KPW-3	2213891	595227	4	112.30	114.35	-2.05
LC17M	2212869	595542	4	34.00	32.61	1.39
LC20M	2211684	596034	4	2.30	2.65	-0.35
LC24M	2212886	595906	4	3.60	3.48	0.12
M-KM1	2215130	595555	4	21.20	19.45	1.75
M-KM2	2213993	594514	4	33.90	33.34	0.56
M-KM3A	2214543	595505	4	26.90	26.99	-0.09
MU-101	2213855	595183	4	50.20	48.83	1.37
MU-102	2213289	595391	4	40.30	37.36	2.94
MU-103	2212706	595380	4	29.30	30.45	-1.15

Table 6. Calibration Targets and Statistics, 2011 KM Regional Test, Lost Creek Uranium ISR Project

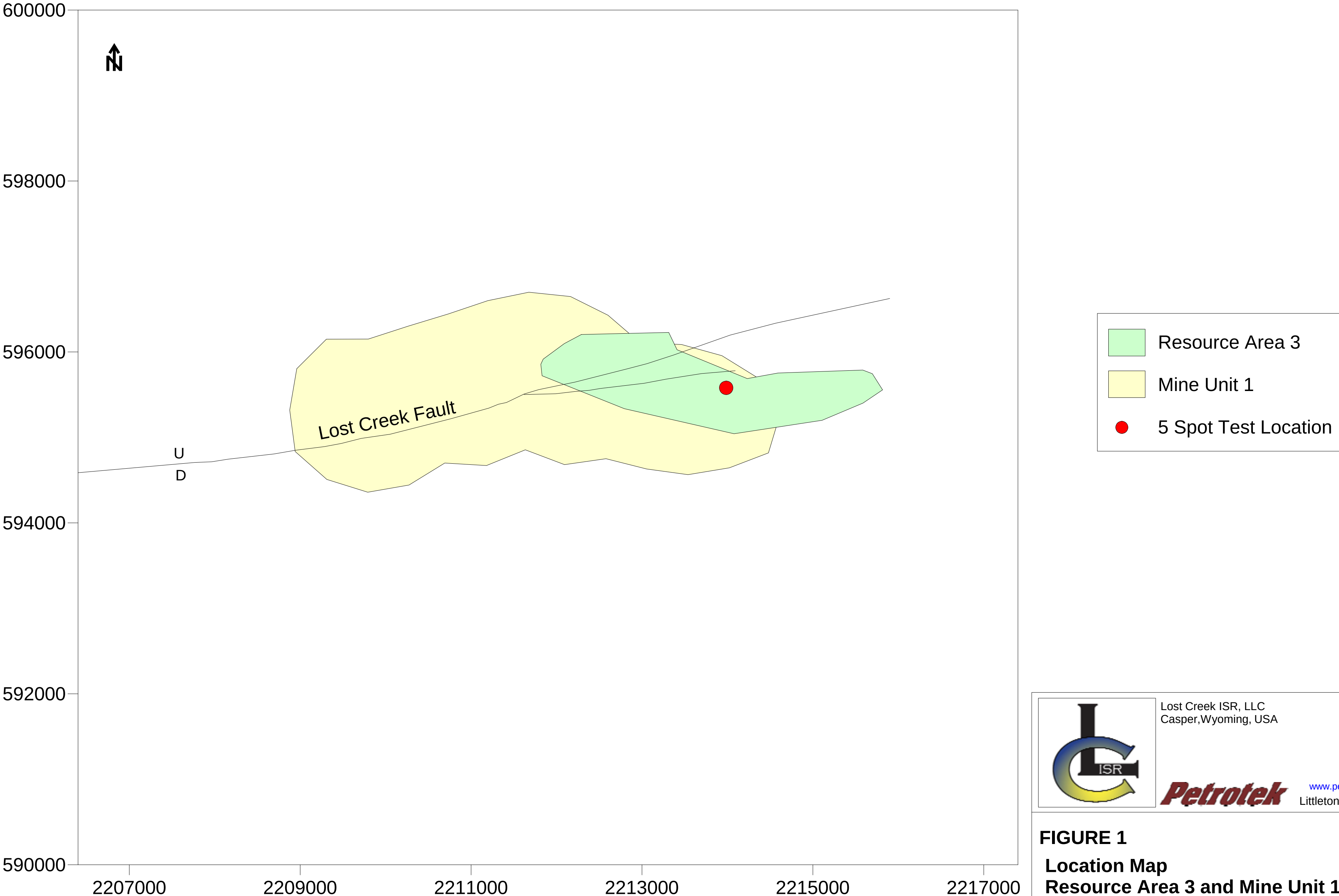
Well ID	X-coordinate	Y-coordinate	Model Layer	Observed Drawdown	Simulated Drawdown	Residual
	(ft)	(ft)		(ft)	(ft)	(ft)
MU-104	2212006	595493	4	7.10	9.66	-2.56
MU-106	2211479	595964	4	2.20	2.48	-0.28
MU-107	2210977	595802	4	1.90	1.97	-0.07
MU-109	2210941	595221	4	3.50	3.31	0.19
MU-110	2210162	595639	4	0.80	1.28	-0.48
MU-112	2209564	595529	4	0.90	1.00	-0.10
MU-113	2209839	594942	4	3.00	2.30	0.70
M-UKM1	2214017	595516	4	33.20	32.41	0.79
UKMP-101	2212410	595633	4	4.50	4.51	-0.01
UKMP-103	2212808	596263	4	3.20	3.01	0.19
UKMU-103	2212801	596244	4	3.20	3.03	0.17
KMU-1	2214011	595543	7	18.40	18.26	0.14
KMU-2	2215179	595572	7	16.40	12.05	4.35
KMU-3	2214220	596506	7	4.00	4.40	-0.40
KMU-4t	2211051	595488	7	2.10	1.99	0.11
M-L1	2213855	595210	7	15.30	17.06	-1.76
M-L2	2214551	595530	7	14.80	14.55	0.25
M-L3	2212651	595362	7	14.20	12.83	1.37
M-L4	2213937	594454	7	11.80	13.37	-1.57
M-L5	2211589	595995	7	2.30	2.02	0.28
M-M1	2213989	595526	9	5.10	6.10	-1.00
M-M2	2213830	595194	9	5.80	4.98	0.82
M-M3	2214552	595550	9	8.40	7.73	0.67
M-M4	2214044	594453	9	4.10	4.14	-0.04
M-M5	2215196	595540	9	7.20	5.09	2.11
M-M6A	2214200	596525	9	2.40	2.32	0.08
M-M7	2212691	595346	9	2.90	2.55	0.35
M-M8	2211634	596001	9	2.20	1.92	0.28
5S-N1	2213940	595615	11	0.40	0.17	0.23
M-N1	2213777	595217	11	0.40	0.15	0.25

Residual Mean	0.100
Absolute Residual Mean	0.663
Residual Std. Deviation	1.00
Sum of Squares	79.33
Min. Residual	-2.56
Max. Residual	4.35
Number of Observations	78
Range in Observations	112.3
Scaled Residual Std. Deviation	0.0089
Scaled Absolute Residual Mean	0.0059
Scaled Residual Mean	0.0009

Table 7. Calibration Targets and Statistics, 2012 5-Spot Test, Lost Creek Uranium ISR Project

Well ID	X-coordinate	Y-coordinate	Model	Observed Drawdown	Simulated Drawdown	Target Weight	Weighted Residual
	(ft)	(ft)		(ft)	(ft)		(ft)
5S-KM3	2213986	595577	3	116.20	115.36	1	0.84
5S-KM1	2213950	595640	3	29.40	26.00	1	3.40
5S-KM2	2214046	595610	3	37.20	36.79	1	0.41
M-UKM-1	2214017	595516	3	61.20	59.21	0.1	1.99
5S-KM4	2213955	595563	3	30.30	30.71	1	-0.41
KMU-1	2214011	595543	7	6.10	7.67	1	-1.57
M-M1	2213989	595526	9	1.10	2.10	1	-1.00
5S-N1	2213940	595615	11	0.00	0.03	1	-0.03
5S-HJ1	2214013	595593	1	0.00	0.47	1	-0.47
KPW-1A	2213927	595550	3	23.20	25.95	1	-2.75

Residual Mean	0.040
Absolute Residual Mean	1.29
Residual Std. Deviation	1.67
Sum of Squares	27.82
Min. Residual	-2.75
Max. Residual	3.40
Number of Observations	10
Range in Observations	116.2
Scaled Residual Std. Deviation	0.0143
Scaled Absolute Residual Mean	0.0111
Scaled Residual Mean	0.0003



Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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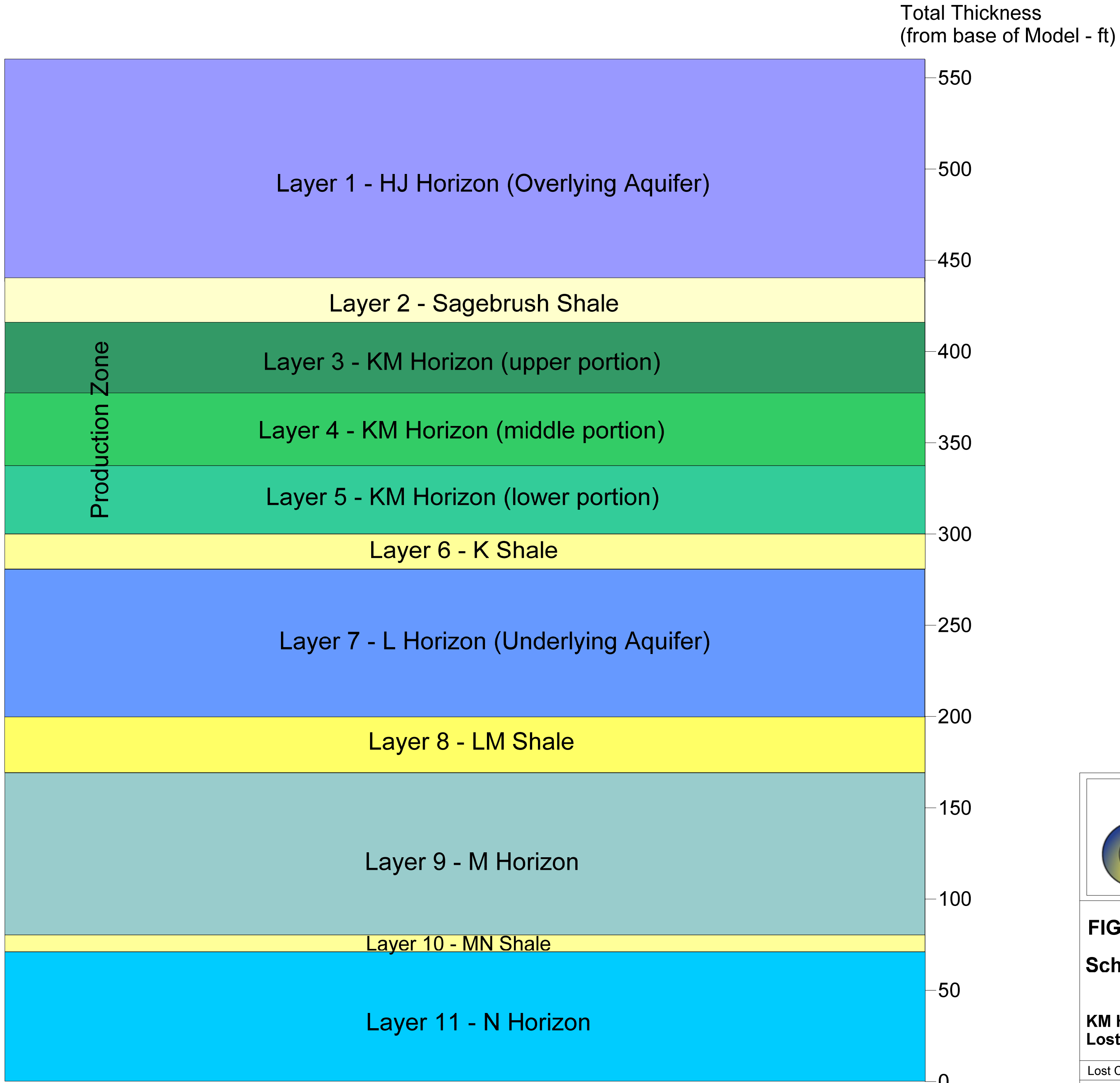
FIGURE 1

Location Map
Resource Area 3 and Mine Unit 1

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC	Drawn By: EPL
Issued /Revised: 12.15.15	
Drawing No.: Figure 1	



Vertical Layer Thickness is Approximated
(No Horizontal Scale)

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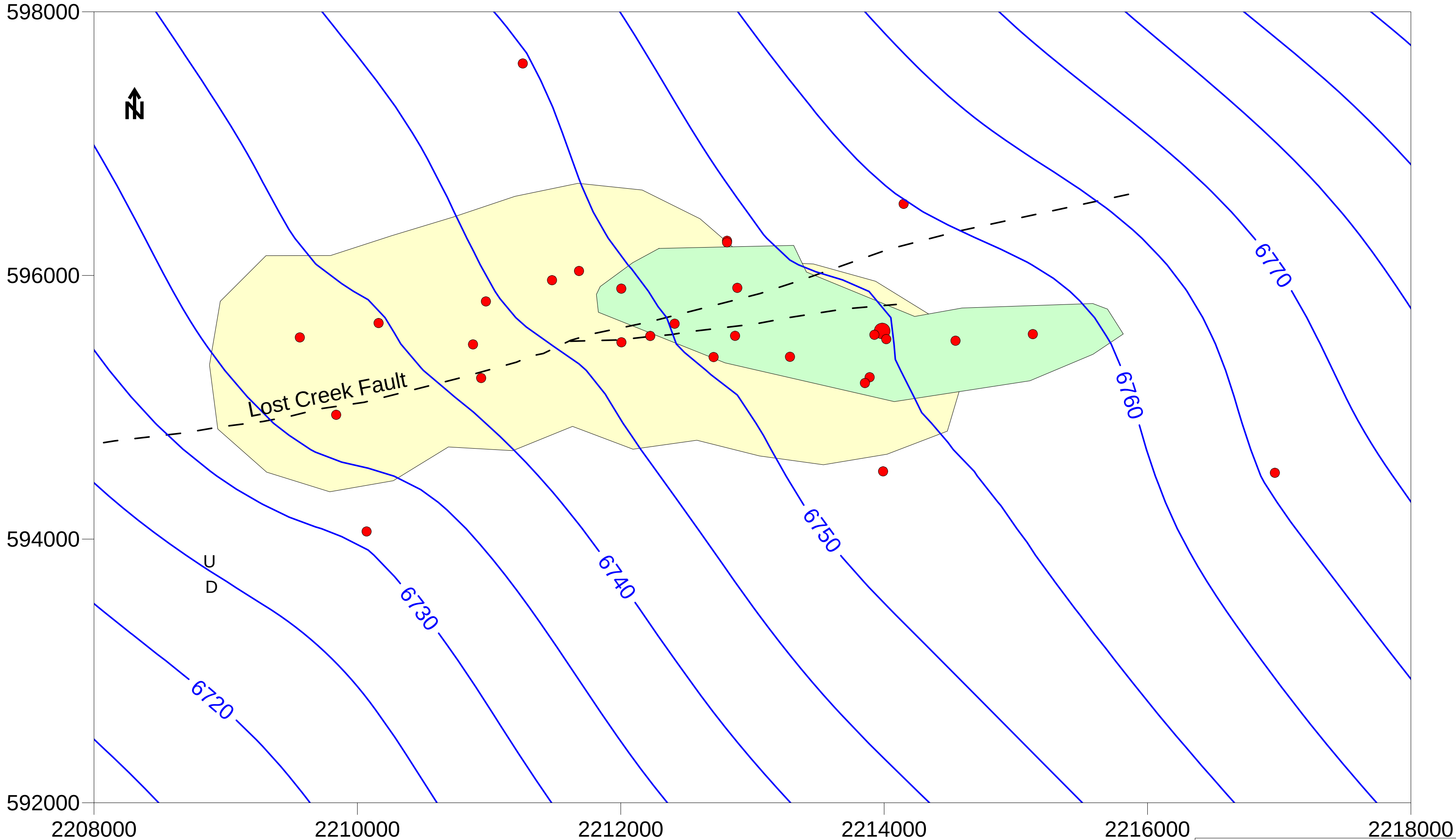
FIGURE 2

Schematic of KM Horizon Model Layers

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC	Drawn By: EPL
Issued /Revised: 12.15.15	
Drawing No.: Figure 2	



Resource Area 3

Mine Unit 1

KM Horizon Monitoring Wells

Potentiometric Surface (feet above mean sea level, contour interval = 5 feet)

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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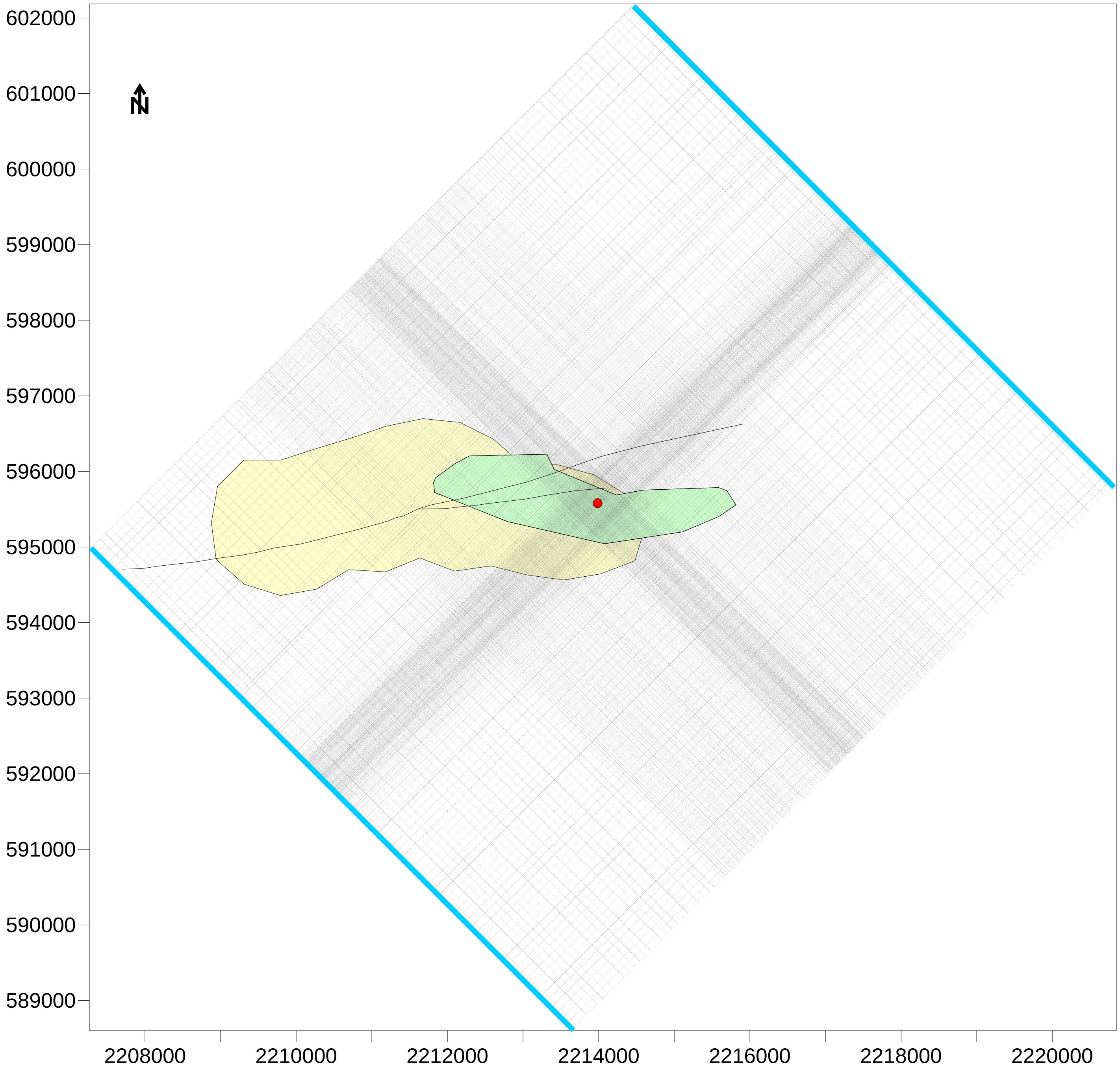
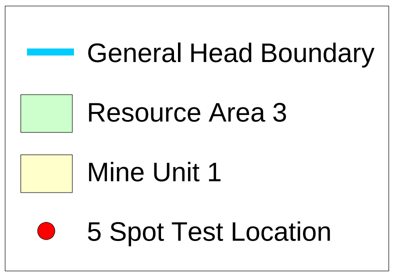
FIGURE 3

Potentiometric Surface KM Horizon, October 2011

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC	Drawn By: EPL
Issued /Revised: 12.15.15	
Drawing No.: Figure 3	





Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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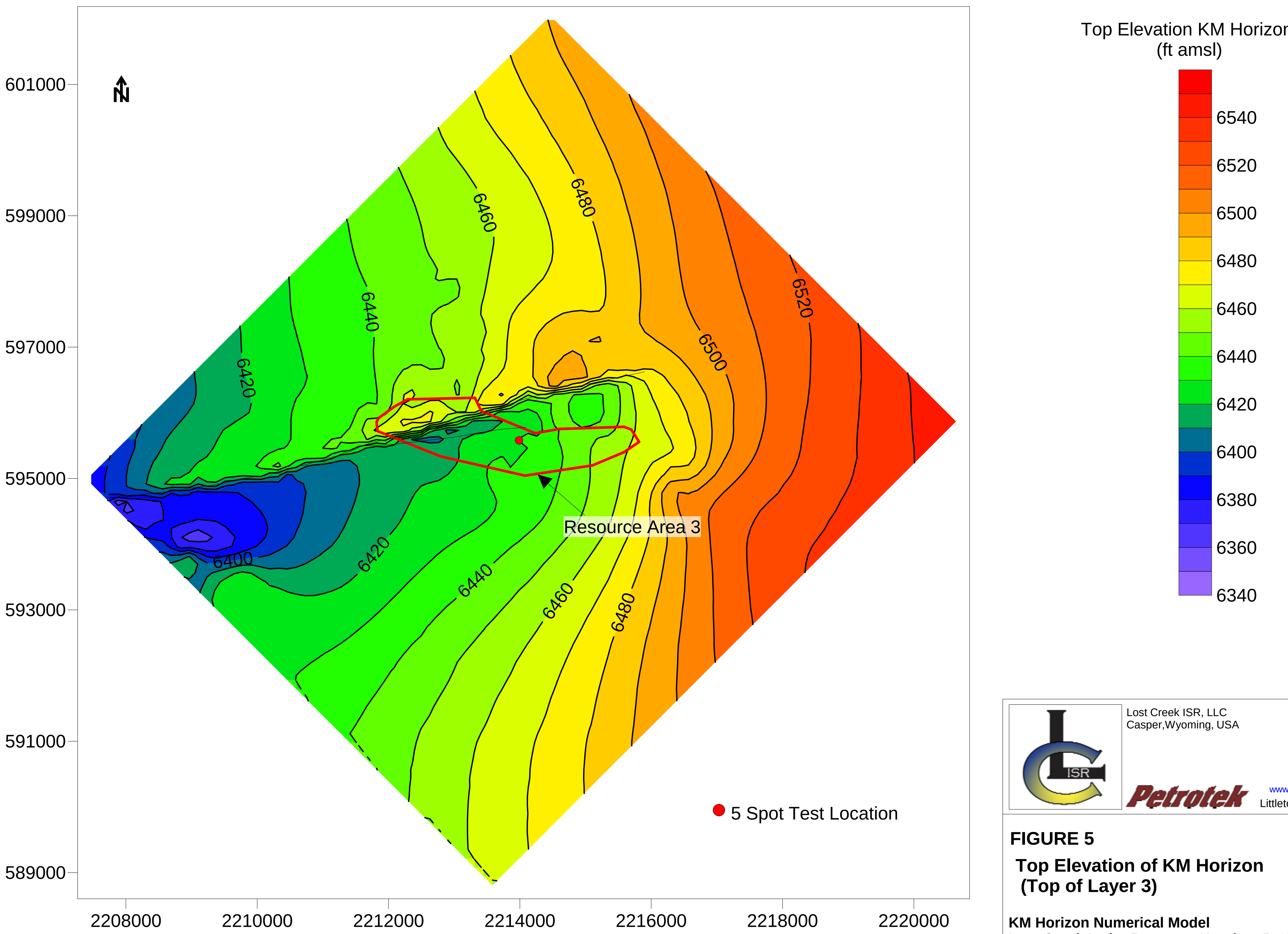
FIGURE 4

Model Domain and Grid

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC	Drawn By: EPL
Issued /Revised: 12.15.15	
Drawing No.: Figure 4	



Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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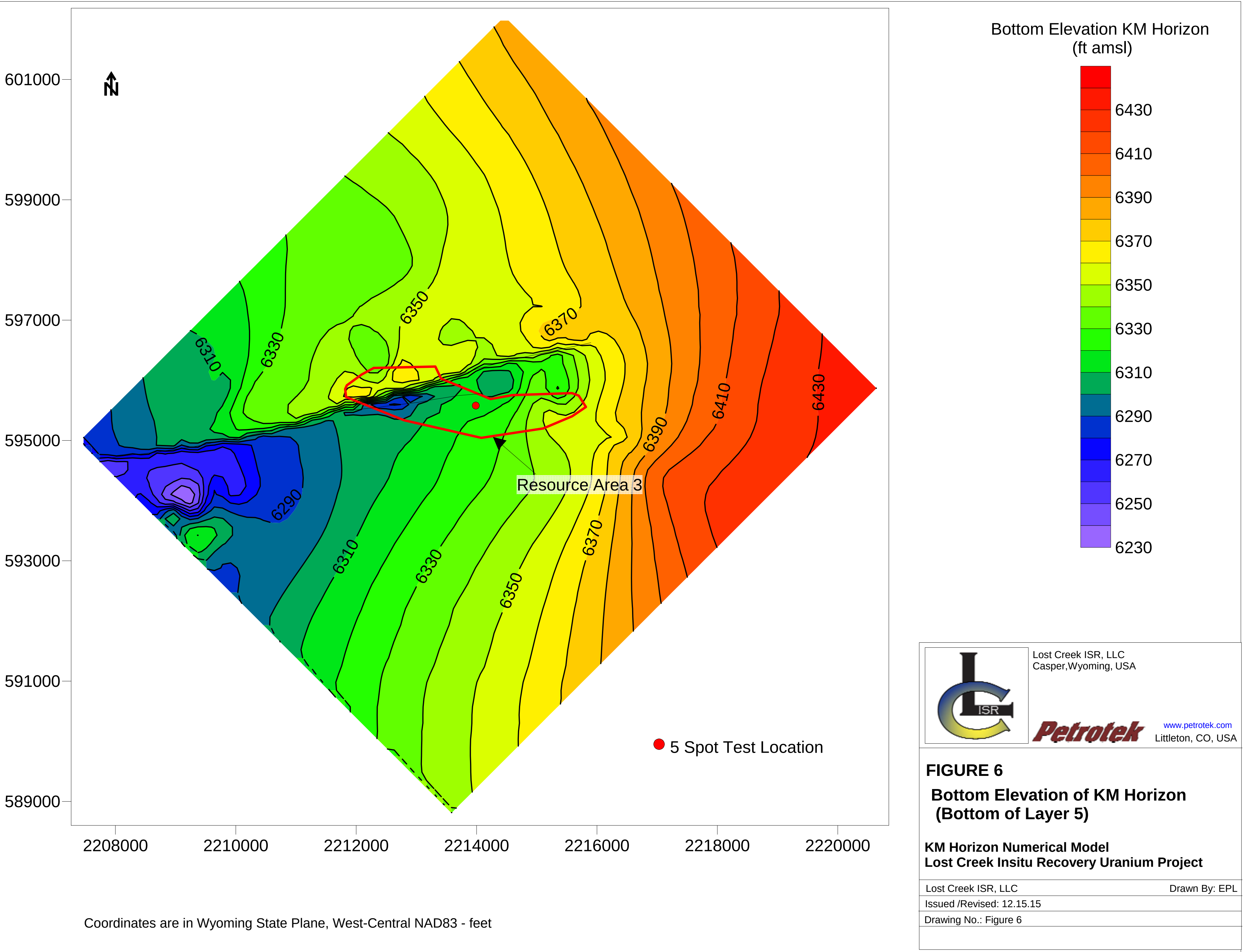
FIGURE 5

Top Elevation of KM Horizon (Top of Layer 3)

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC	Drawn By: EPL
Issued /Revised: 12.15.15	
Drawing No.: Figure 5	



Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 6

Bottom Elevation of KM Horizon (Bottom of Layer 5)

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC	Drawn By: EPL
Issued /Revised: 12.15.15	
Drawing No.: Figure 6	

Hydraulic Conductivity- ft/d

Zone	Horizontal K	Vertical K
14	9.200e-002	2.000e-002
15	8.300e-003	2.000e-002
81	0.343	0.217
82	0.517	0.464
83	0.932	3.000e-005
84	1.940	1.960
85	1.250	9.200e-002
86	1.250	1.200e-003
87	0.614	9.240e-005
88	2.500e-002	0.820
89	0.989	2.400e-003
91	3.370	0.151
92	5.000	3.600e-002
93	5.000	2.500e-003
103	2.000	8.000e-002
104	5.000e-002	2.000e-002
105	1.500	0.100
106	0.250	1.000e-002
107	5.500	0.800
108	11.00	0.400
109	4.700	1.000
110	1.000e-002	1.000e-003
111	0.900	0.100
112	1.000e-002	1.000e-003
113	6.000	1.000e-003

0 1000 2000
feet

Model grid is rotated 45 degrees

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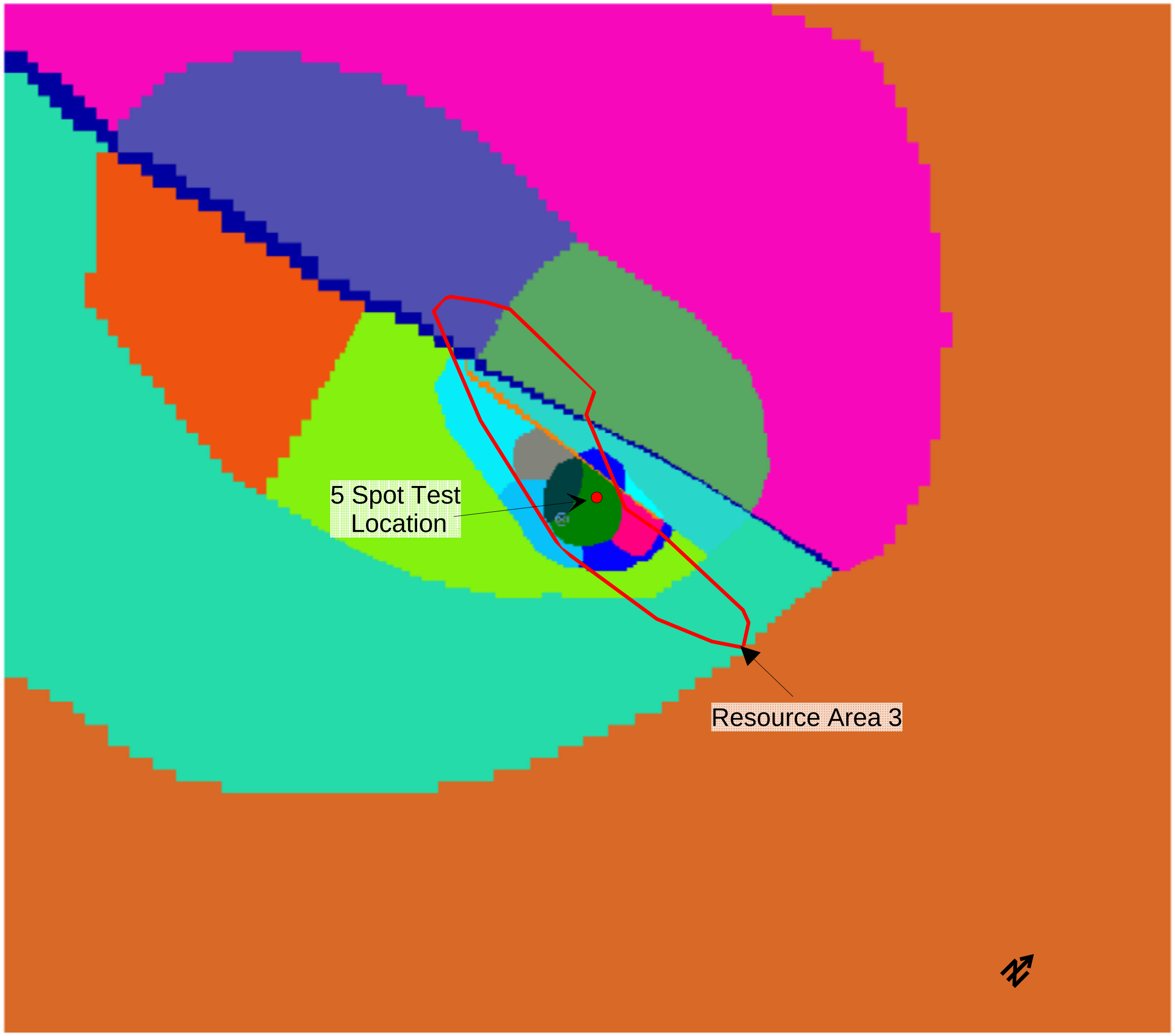
FIGURE 7

Hydraulic Conductivity Zones (upper KM Horizon - Layer 3)

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project



Hydraulic Conductivity- ft/d

Zone	Horizontal K	Vertical K
14	9.200e-002	2.000e-002
15	8.300e-003	2.000e-002
68	0.330	0.360
69	0.750	0.444
70	0.100	2.900e-004
71	2.580	1.240
72	1.180	8.300e-002
73	1.280	8.100e-003
74	0.300	8.600e-004
75	1.700e-002	0.930
76	3.500	1.800e-003
77	2.140	8.700e-002
78	5.000	2.300e-002
79	10.00	1.650e-003
98	1.400	0.130
99	1.400	2.000e-002
100	1.500	5.000e-003
101	0.700	0.700
102	3.500	3.000

0 1000 2000
feet

Model grid is rotated 45 degrees

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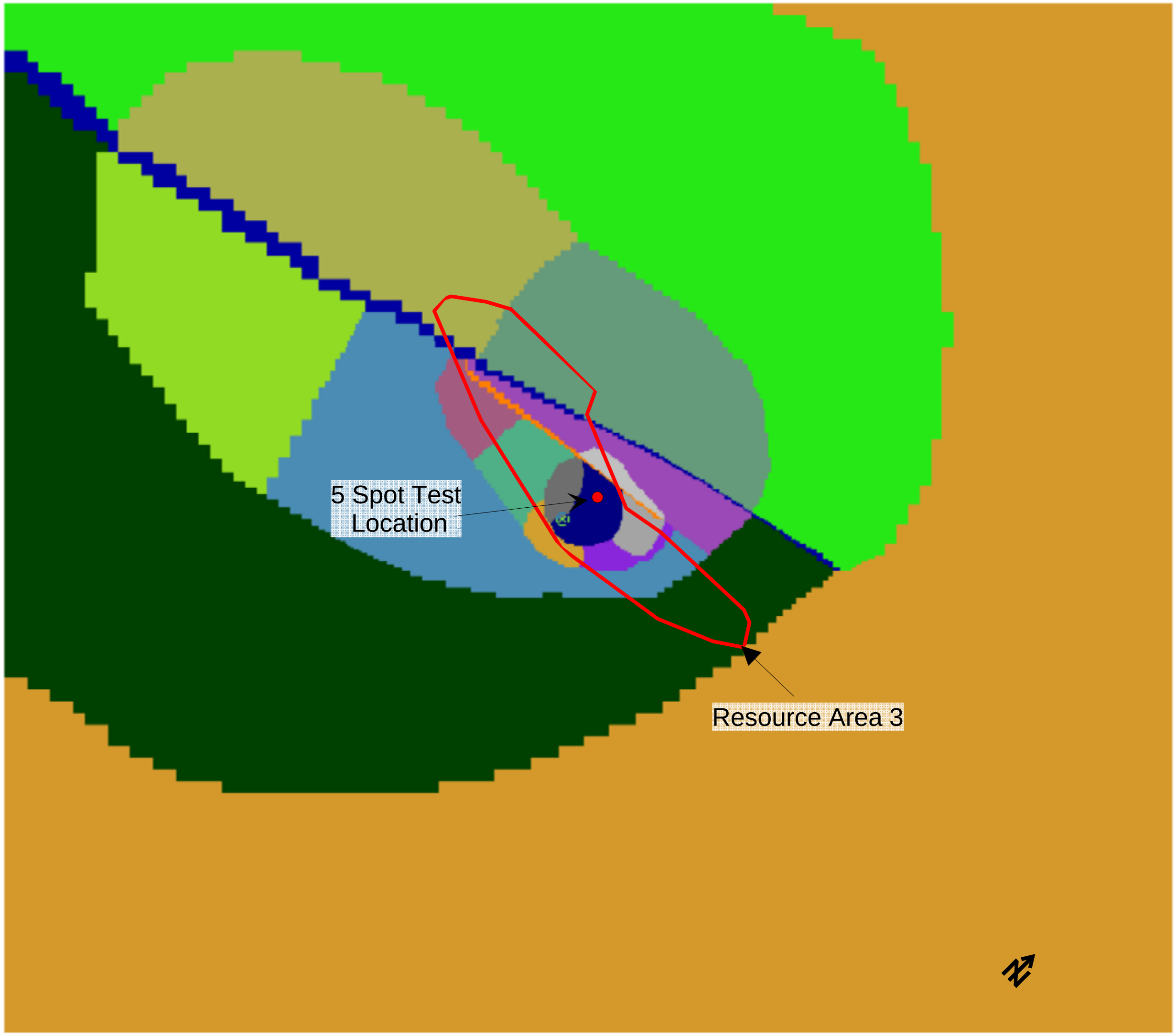
FIGURE 8

Hydraulic Conductivity Zones (middle KM Horizon - Layer 4)

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project



Hydraulic Conductivity- ft/d

Zone	Horizontal K	Vertical K
14	9.200e-002	2.000e-002
15	8.300e-003	2.000e-002
48	0.580	0.433
49	0.660	0.389
50	1.020	3.180e-005
51	2.260	1.850
52	0.650	7.000e-002
53	0.800	0.260
54	0.660	7.400e-005
55	2.300e-002	1.190
56	1.050	1.100e-003
57	2.310	7.300e-002
59	5.000	1.440e-002
64	7.280	5.200e-004
94	1.500	8.000e-002
95	1.500	5.000e-002
96	3.000	4.000e-002
97	0.800	0.100

0 1000 2000
feet

Model grid is rotated 45 degrees

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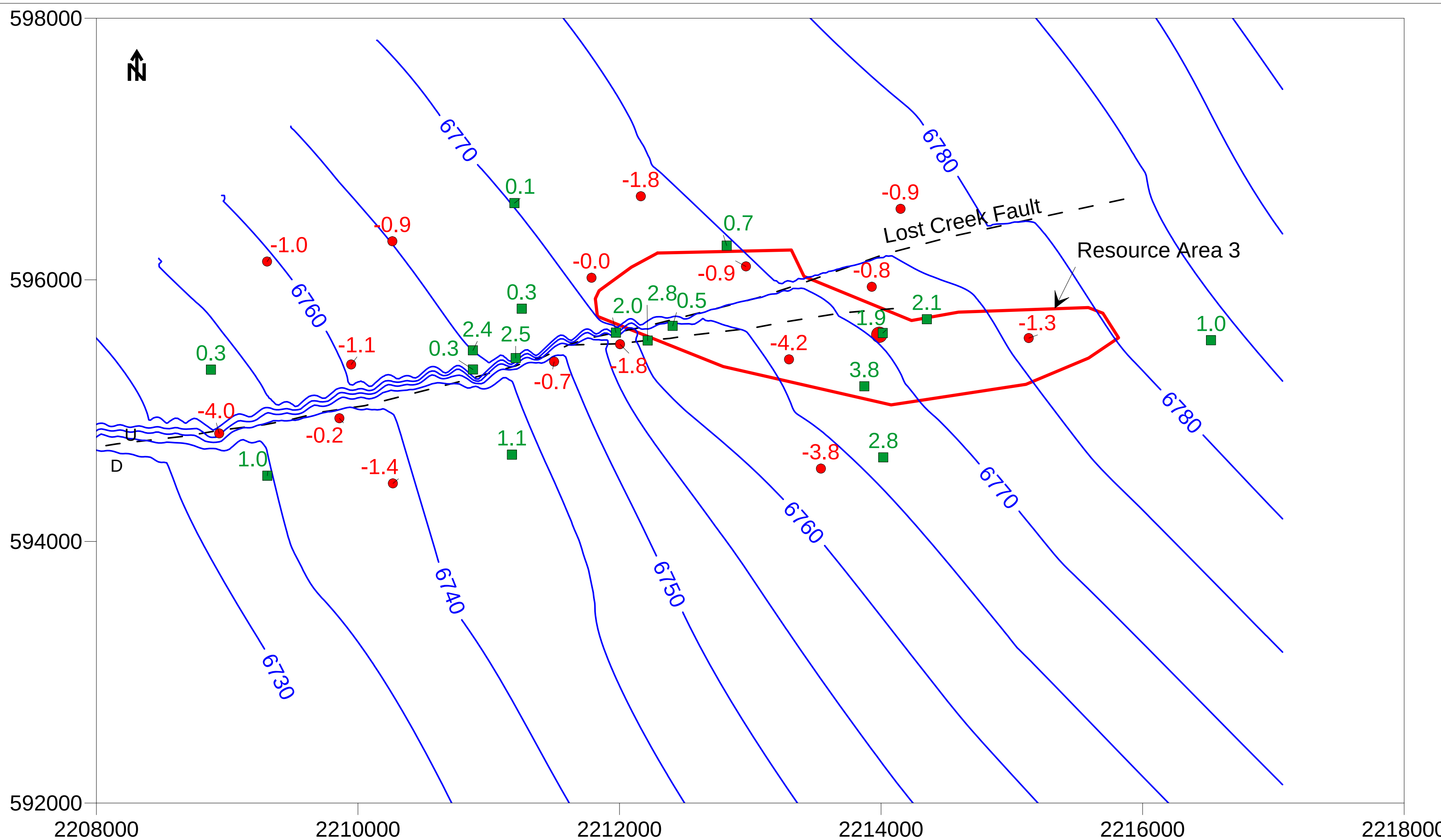
FIGURE 9

Hydraulic Conductivity Zones (lower KM Horizon - Layer 5)

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project



Potentiometric Surface (feet above mean sea level, contour interval = 5 feet)

HJ Horizon Monitoring Wells

-1.4 ● Negative Residual (ft)

1.1 ■ Positive Residual (ft)

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 10

Potentiometric Surface, with Residuals
HJ Horizon (Layer 1)
Steady State Calibration Simulation

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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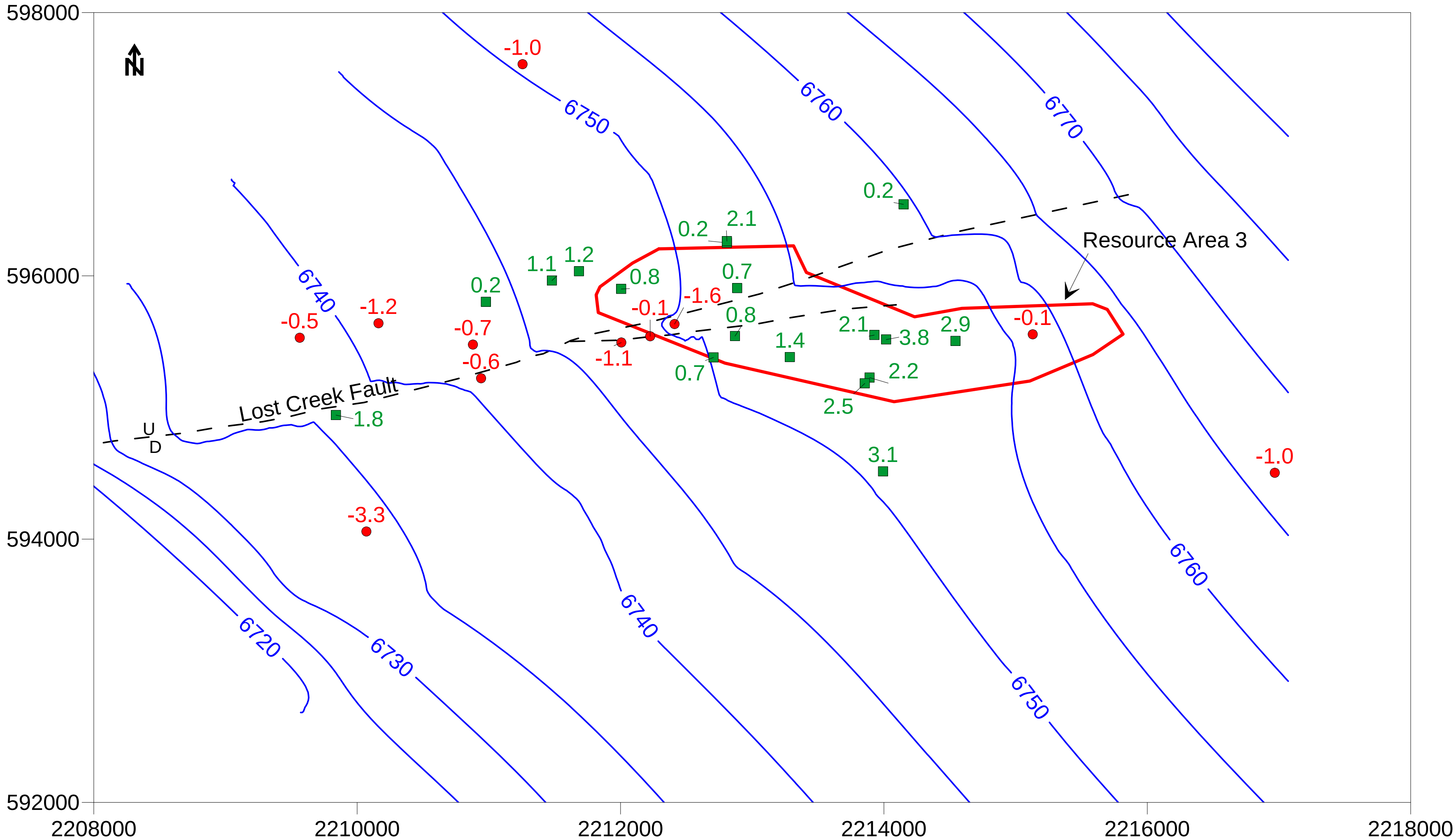
Issued /Revised: 12.15.15	
Drawing No.: Figure 10	



Potentiometric Surface (feet above mean sea level, contour interval = 5 feet)

KM Horizon Monitoring Wells

-1.4 ● Negative Residual (ft)

1.1 ■ Positive Residual (ft)

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 11

Potentiometric Surface, with Residuals
KM Horizon (Layer 4)
Steady State Calibration Simulation

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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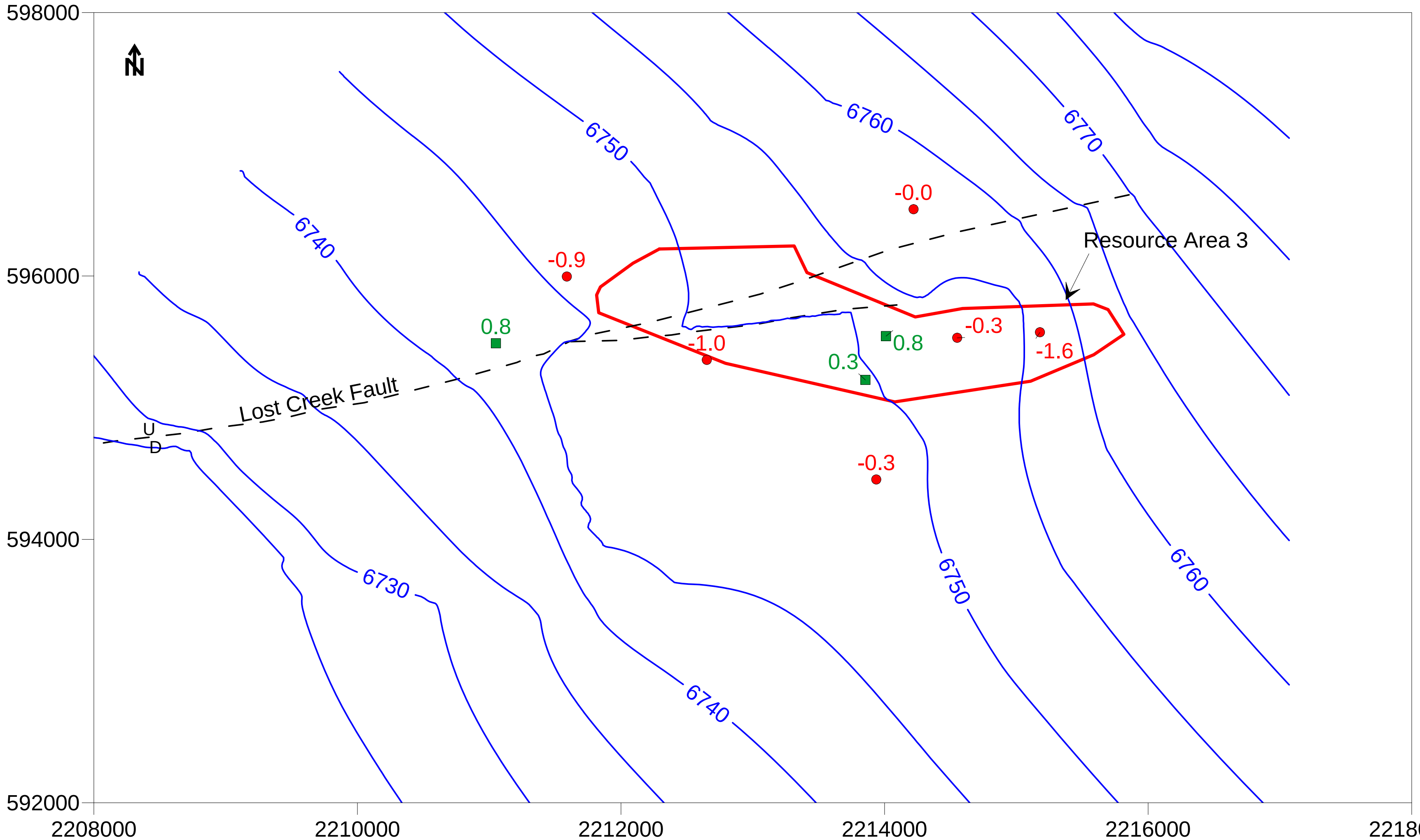
Issued /Revised: 12.15.15	
Drawing No.: Figure 11	



Potentiometric Surface (feet above mean sea level, contour interval = 5 feet)

L Horizon Monitoring Wells

-1.4 Negative Residual (ft)

1.1 Positive Residual (ft)

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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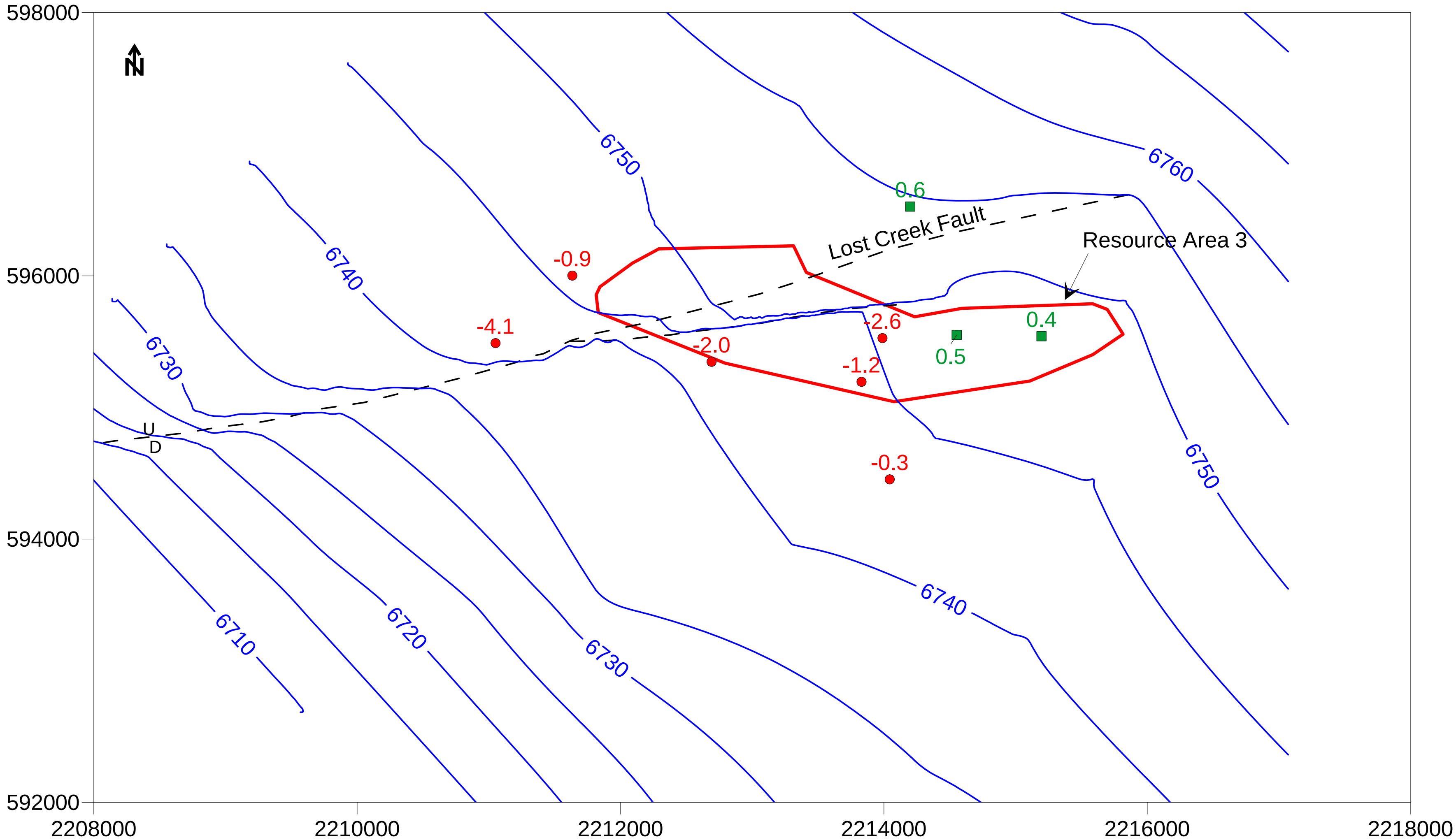
FIGURE 12
Potentiometric Surface, with Residuals
L Horizon (Layer 7)
Steady State Calibration Simulation
KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC — Drawn By: EPL
Issued /Revised: 12.15.15
Drawing No.: Figure 12



Potentiometric Surface
(feet above mean sea level,
contour interval = 5 feet)

M Horizon Monitoring Wells

-1.4 ● Negative Residual (ft)

1.1 ■ Positive Residual (ft)

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 13
Potentiometric Surface, with Residuals
M Horizon (Layer 9)
Steady State Calibration Simulation
KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC	Drawn By: EPL
Issued /Revised: 12.15.15	
Drawing No.: Figure 13	

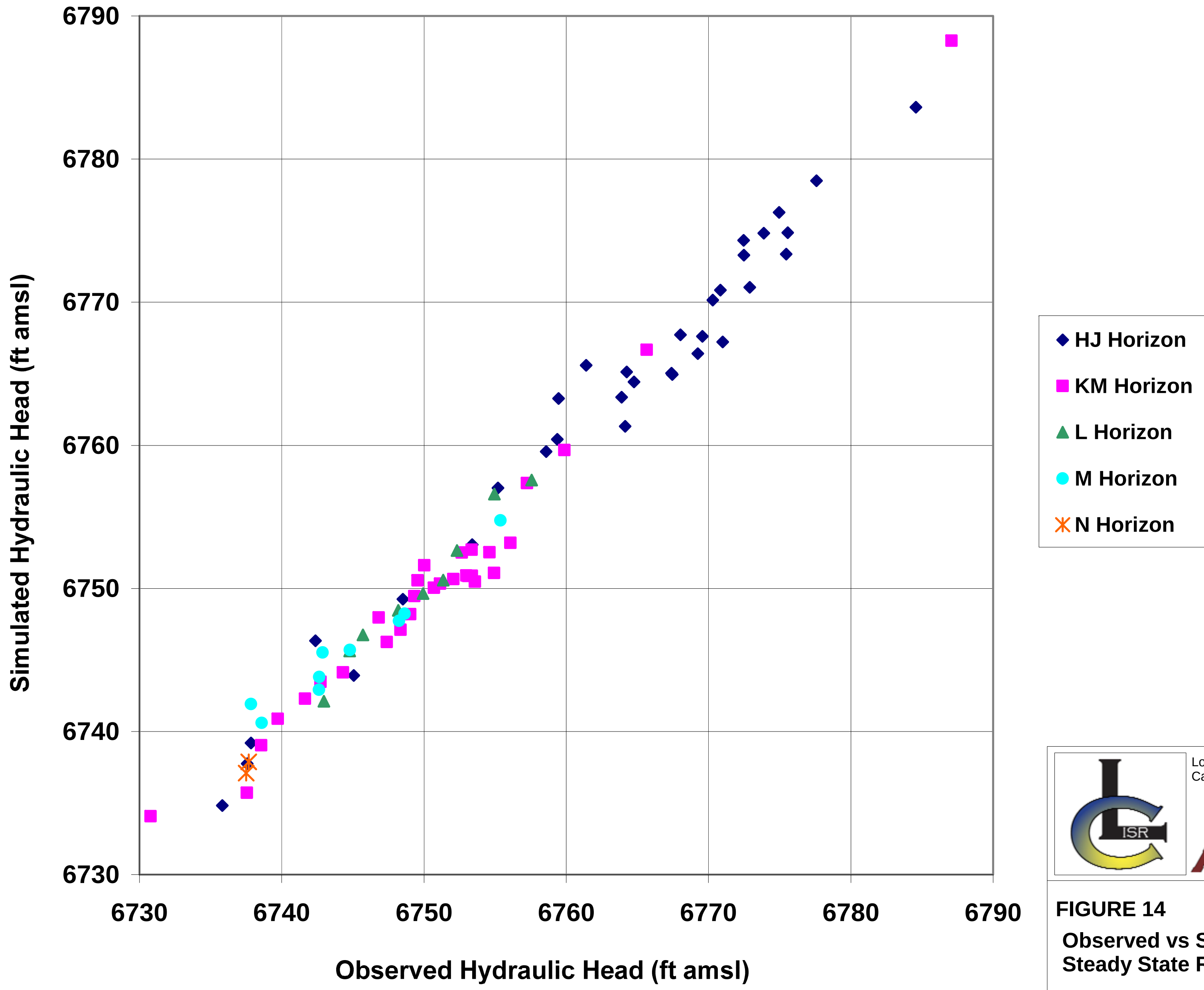

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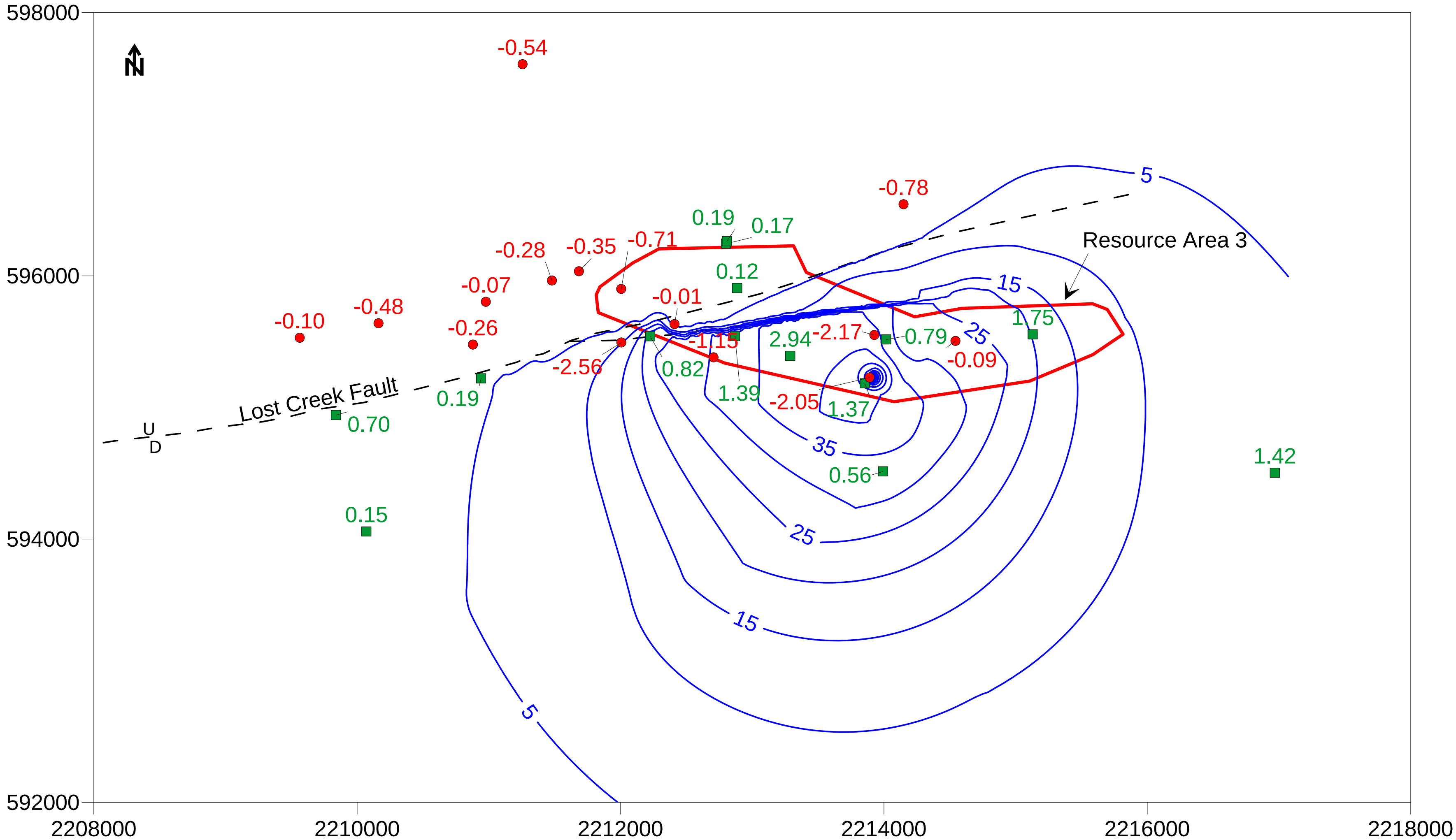
FIGURE 14

Observed vs Simulated Heads
Steady State Recharge Calibration

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC	Drawn By: EPL
Issued /Revised: 12.15.15	
Drawing No.: Figure 14	



Drawdown (feet)
contour interval = 5 feet

KM Horizon Monitoring Wells

-1.4 Negative Residual (ft)

1.1 Positive Residual (ft)

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 15
Simulated Drawdown, with Residuals
Regional KLM Test, KM Horizon (Layer 4)
Pumping Test Calibration Simulation

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC	Drawn By: EPL
Issued /Revised: 12.15.15	
Drawing No.: Figure 15	

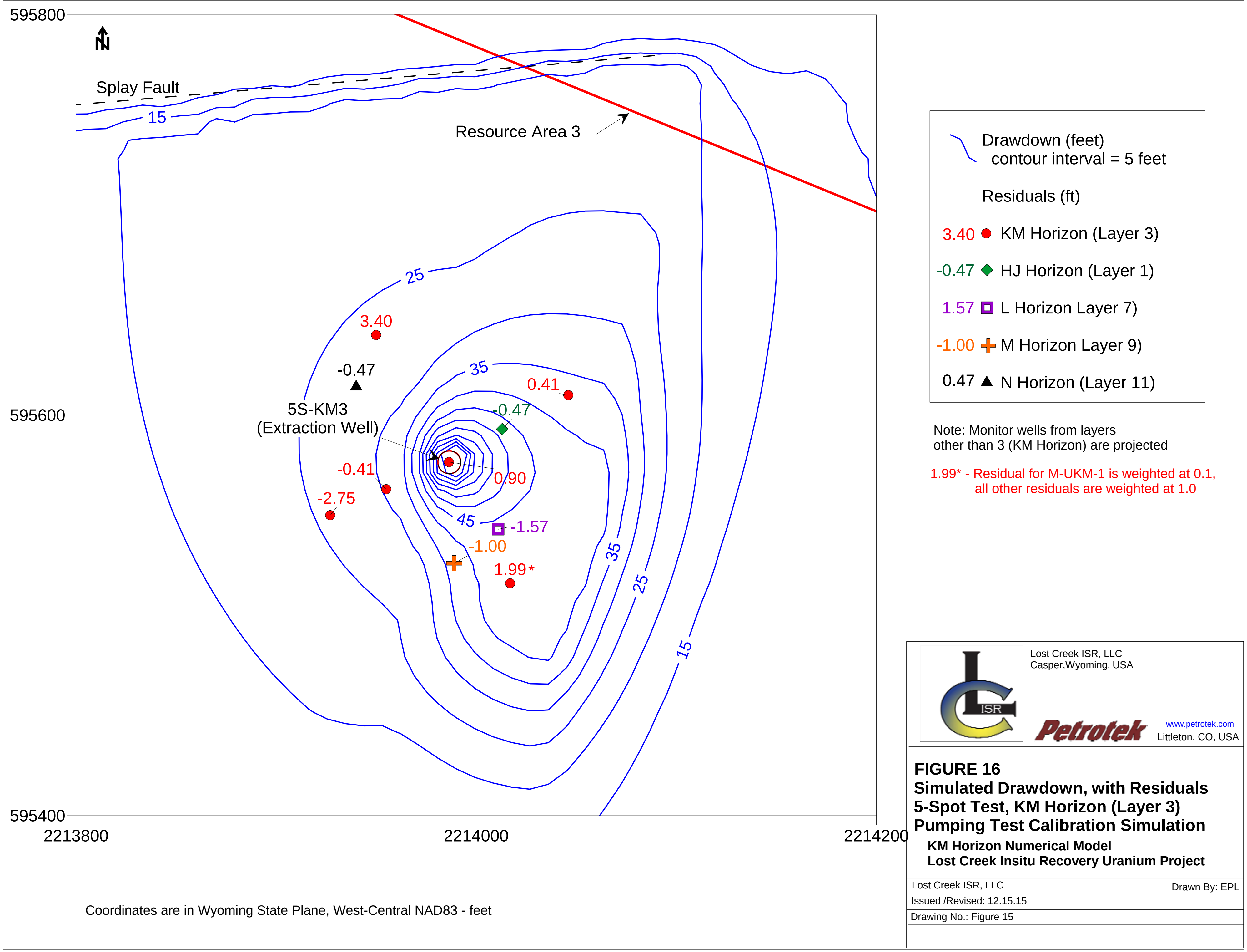

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FIGURE 16
Simulated Drawdown, with Residuals
5-Spot Test, KM Horizon (Layer 3)
Pumping Test Calibration Simulation
KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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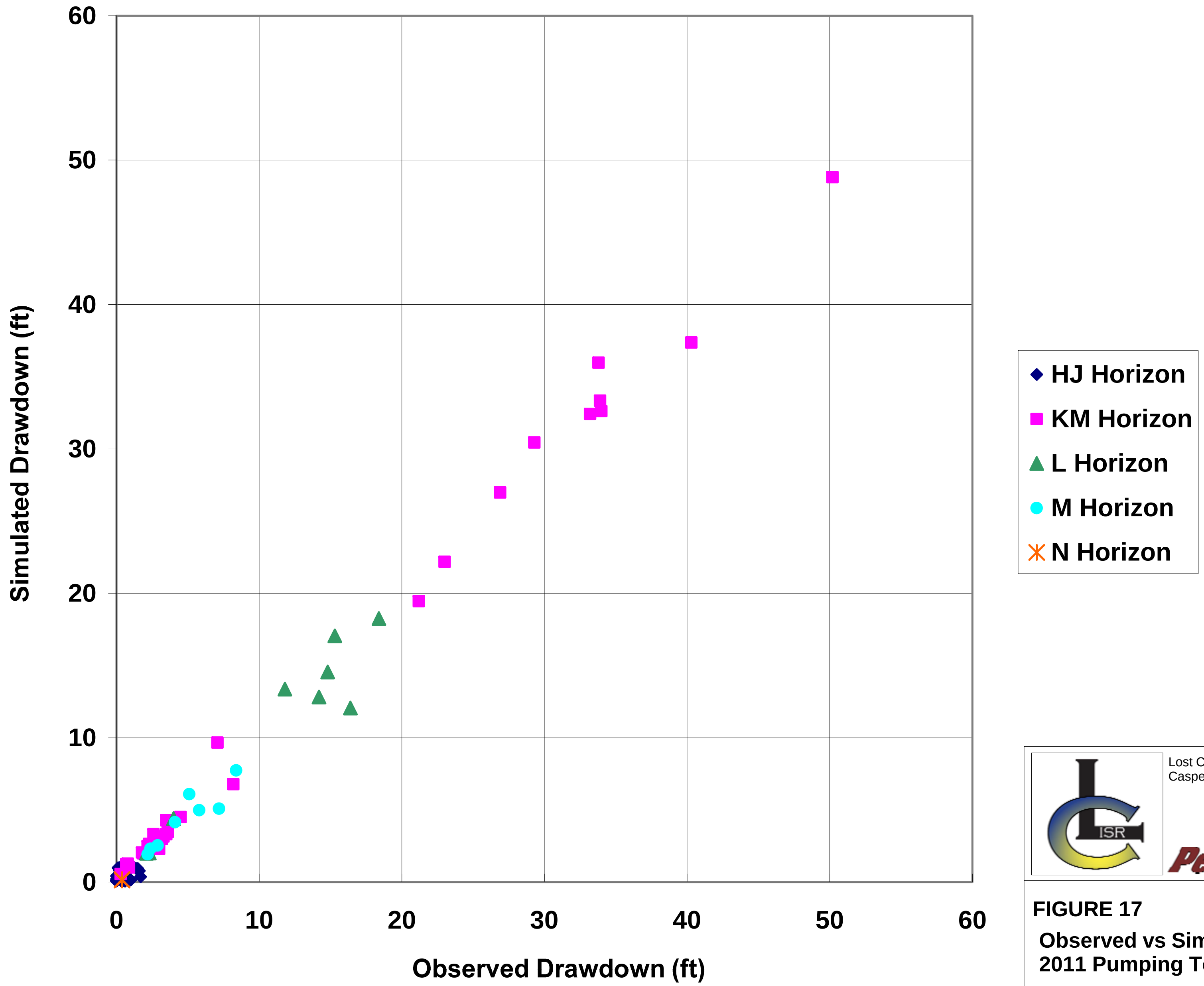
Drawing No.: Figure 15



*The pumping well (5PW-3) is not shown on the graph
Observed drawdown for that well was 112.3 ft,
simulated drawdown was 114.3 ft

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FIGURE 17

Observed vs Simulated Drawdown
2011 Pumping Test Calibration

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC	Drawn By: EPL
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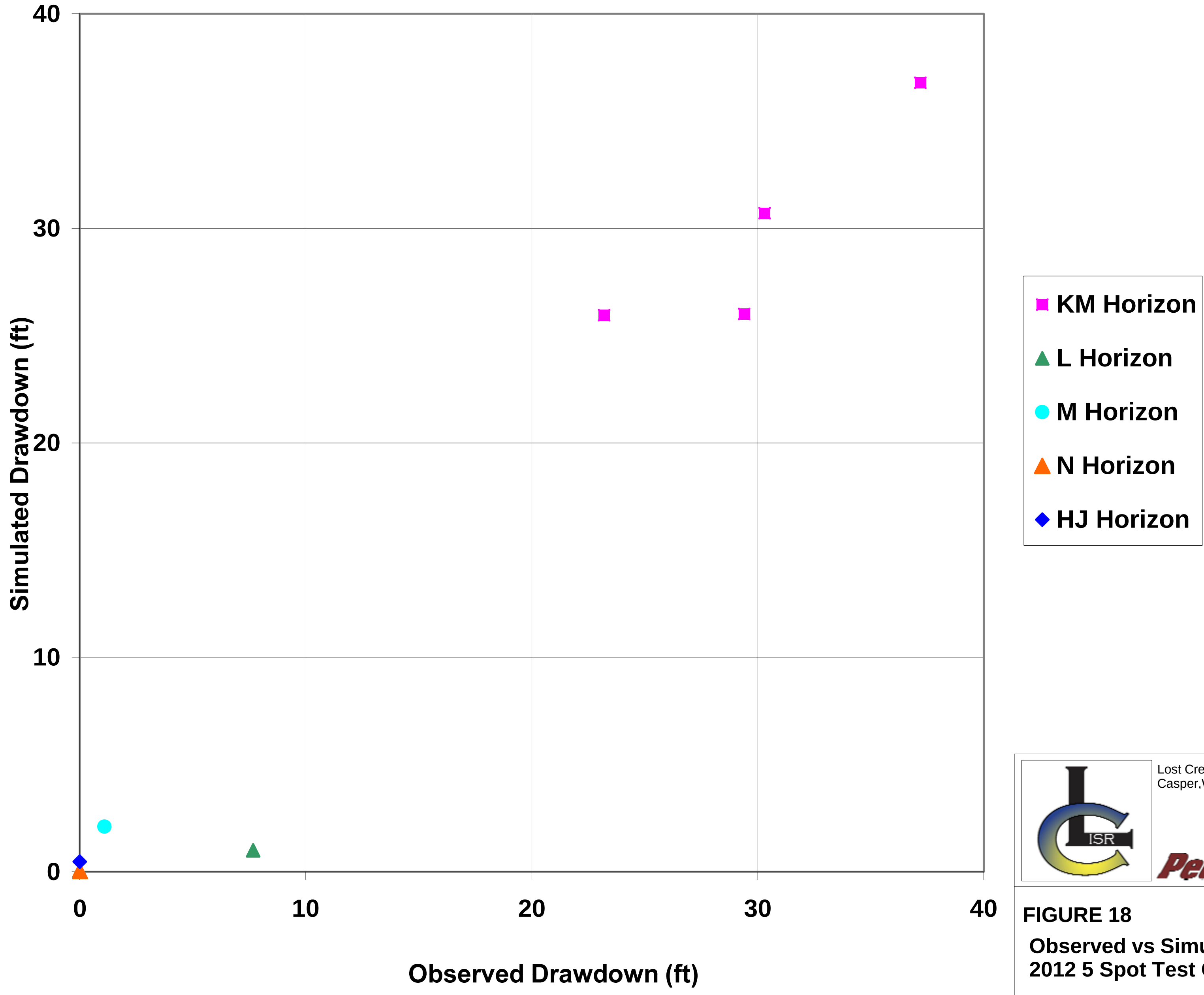
Drawing No.: Figure 17	



*The pumping well (5S-KM3) is not shown on the graph
Observed drawdown in that well was 116.2 ft,
simulated drawdown was 115.3 ft.

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FIGURE 18

Observed vs Simulated Drawdown
2012 5 Spot Test Calibration

KM Horizon Numerical Model
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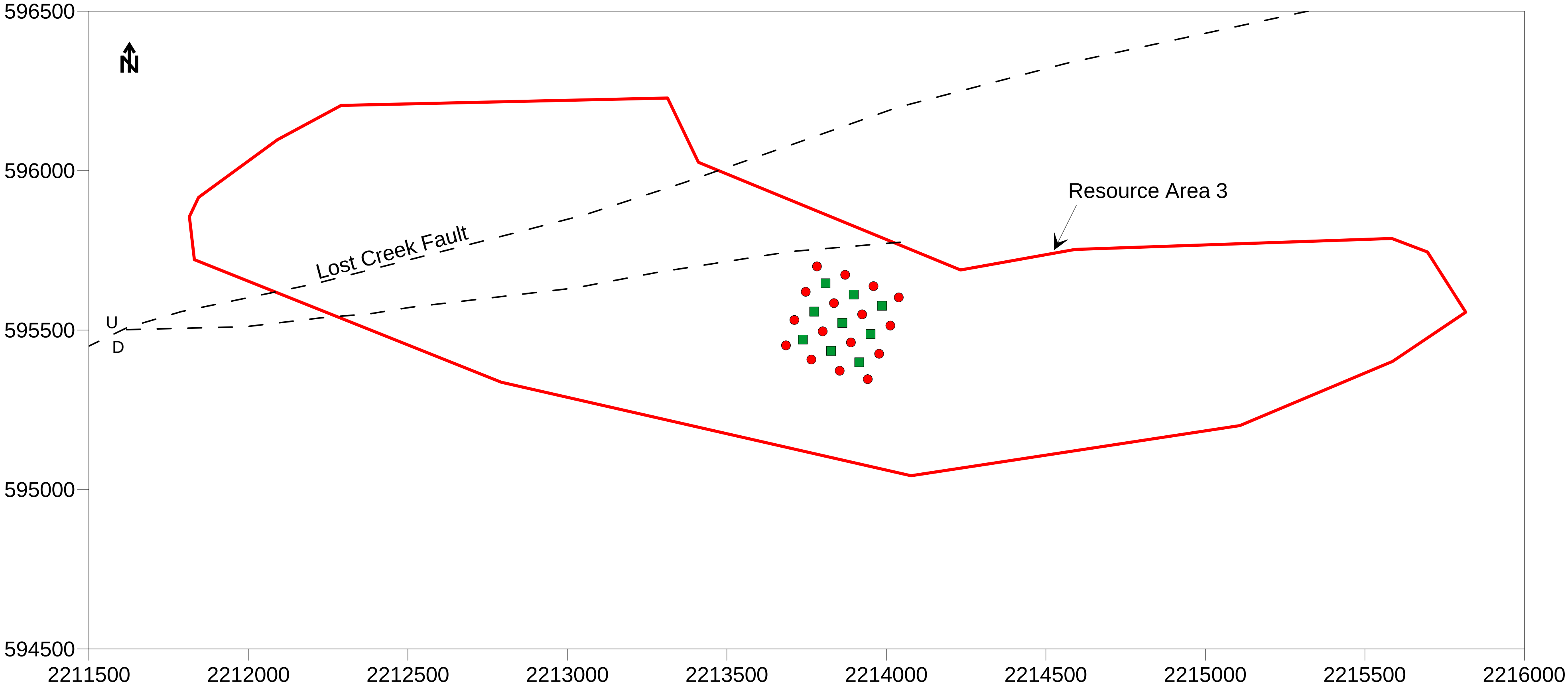
Drawing No.: Figure 18	



KM Horizon Wells

- Injection Wells
- Extraction Wells

Note: Simulations are run with a wellfield in either Layer 3, 4 or 5 of the model. Layers represent upper, middle and lower portions of KM Horizon. Simulated wellfield locations are for demonstrative purposes and do not necessarily coincide with actual mineralized zones. See report text for explanation.

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 19
Simulated Wellfield Location
KM Horizon (Layers 3, 4 or 5)
ISR Simulations

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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Drawing No.: Figure 19

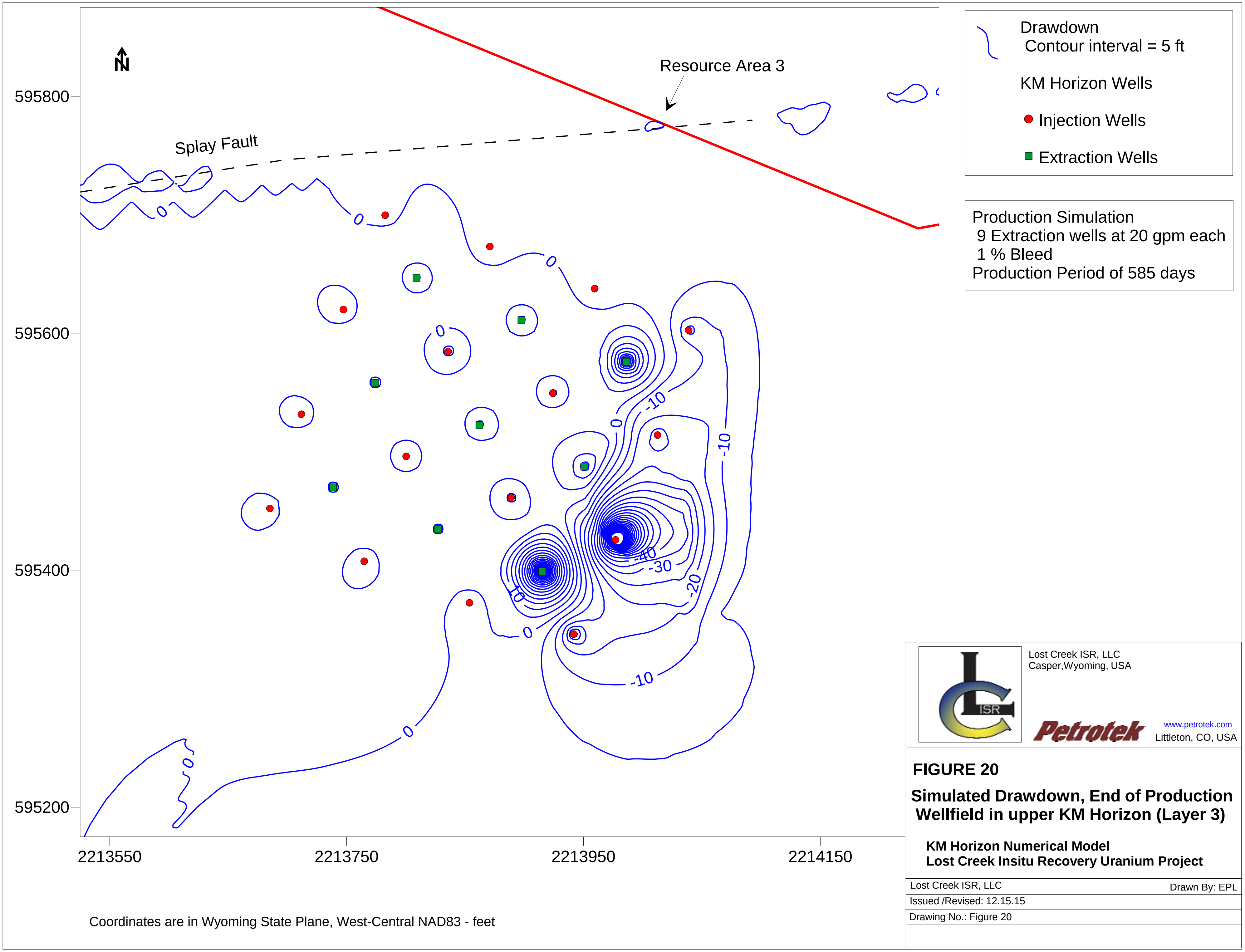
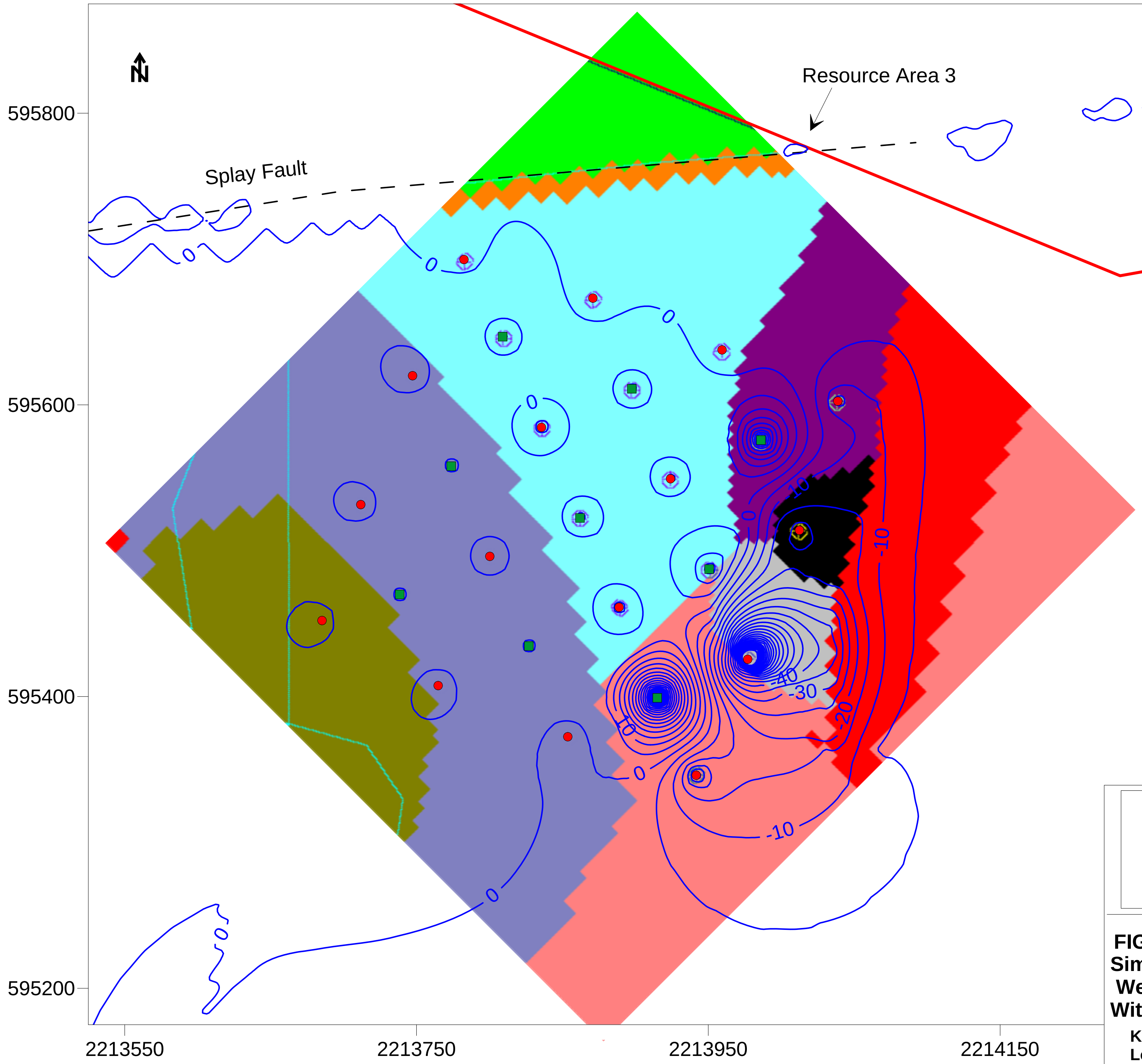


FIGURE 20

Simulated Drawdown, End of Production Wellfield in upper KM Horizon (Layer 3)



Drawdown
Contour interval = 5 ft

KM Horizon Wells

- Injection Wells
- Extraction Wells

Production Simulation
9 Extraction wells at 20 gpm each
1 % Bleed
Production Period of 585 days

Hydraulic Conductivity Zones (ft/d)

Zone	Kx	Kv
15	0.582	0.200
103	1.878	0.886
106	0.446	0.001
107	10.000	5.000
108	7.779	0.401
109	5.187	5.000
110	0.001	0.001
111	0.857	0.073
112	0.059	0.001
113	2.639	0.001

*Hydraulic conductivity zones only illustrated over portion of the model domain

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 21
Simulated Drawdown, End of Production Wellfield in upper KM Horizon (Layer 3) With Hydraulic Conductivity Zones

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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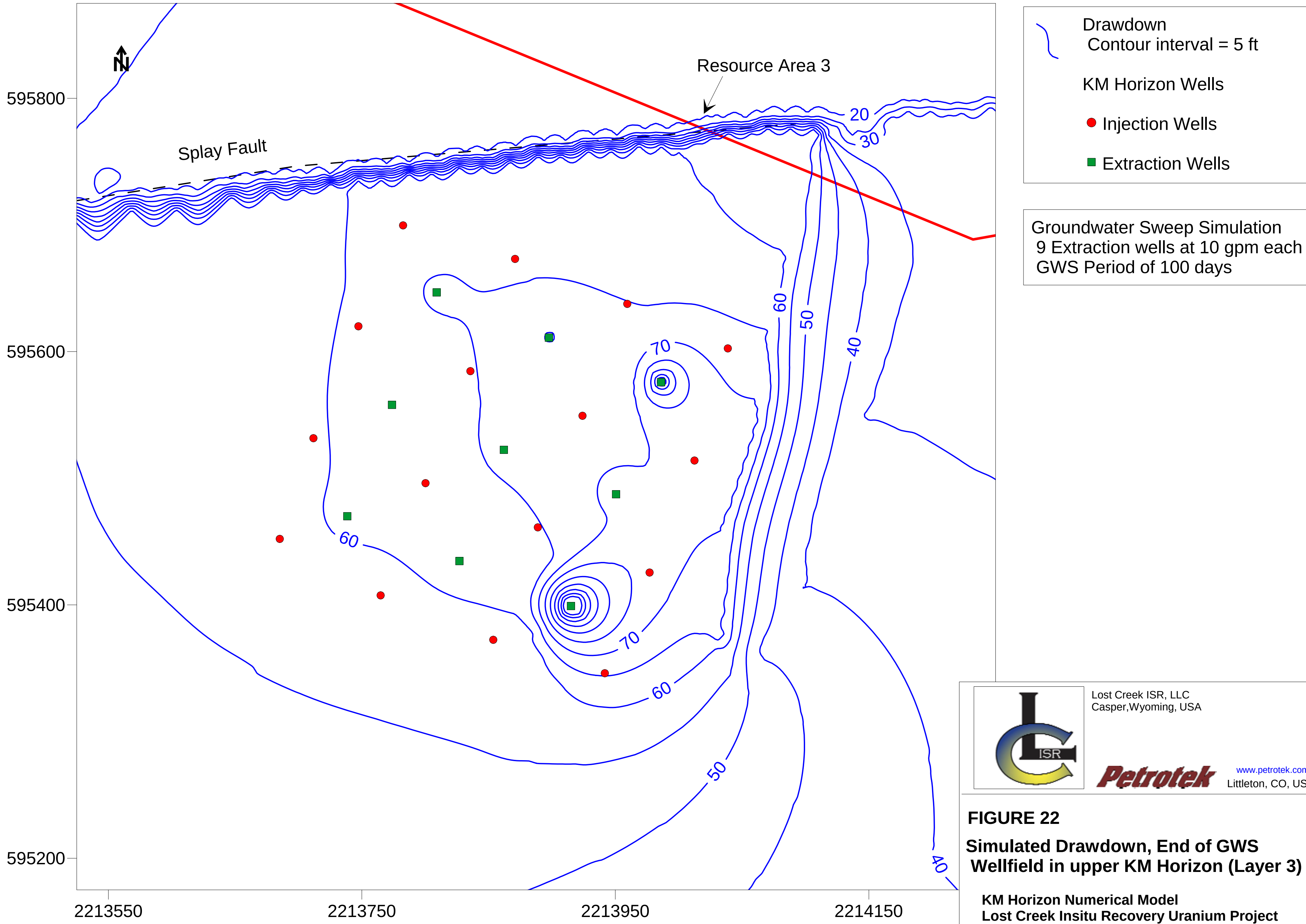
Issued /Revised: 12.15.15
Drawing No.: Figure 21



Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 22

Simulated Drawdown, End of GWS Wellfield in upper KM Horizon (Layer 3)

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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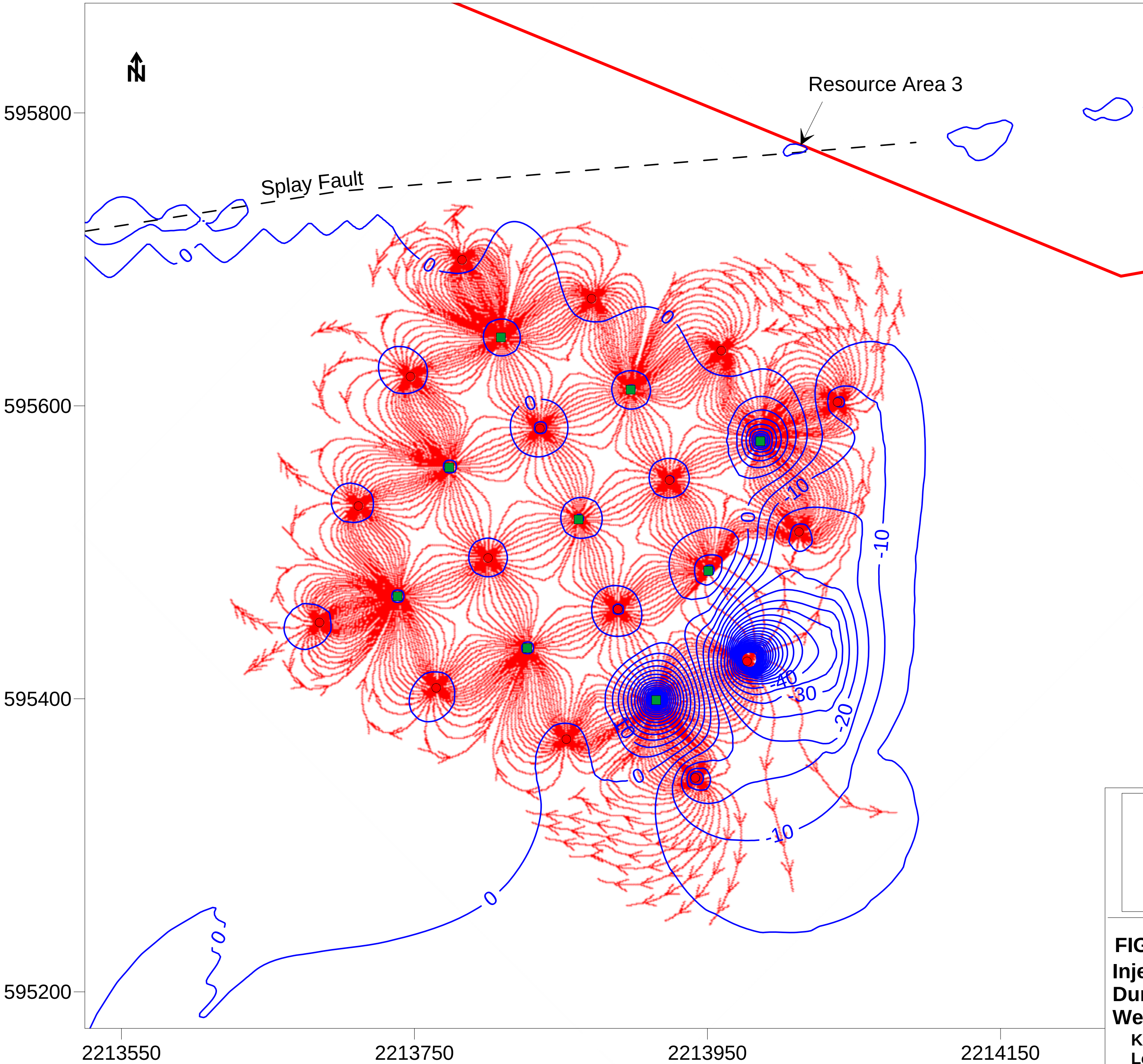
Drawing No.: Figure 22	



Drawdown
Contour interval = 5 ft

KM Horizon Wells

Injection Wells

Extraction Wells

Production Simulation
9 Extraction wells at 20 gpm each
1 % Bleed
Production Period of 585 days

Arrows point in direction of flow.
Arrows mark 120 day travel time

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 23

Injectate Flowpaths in upper KM Horizon During Production
Wellfield in upper KM Horizon (Layer 3)
KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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Issued /Revised: 12.15.15
Drawing No.: Figure 23

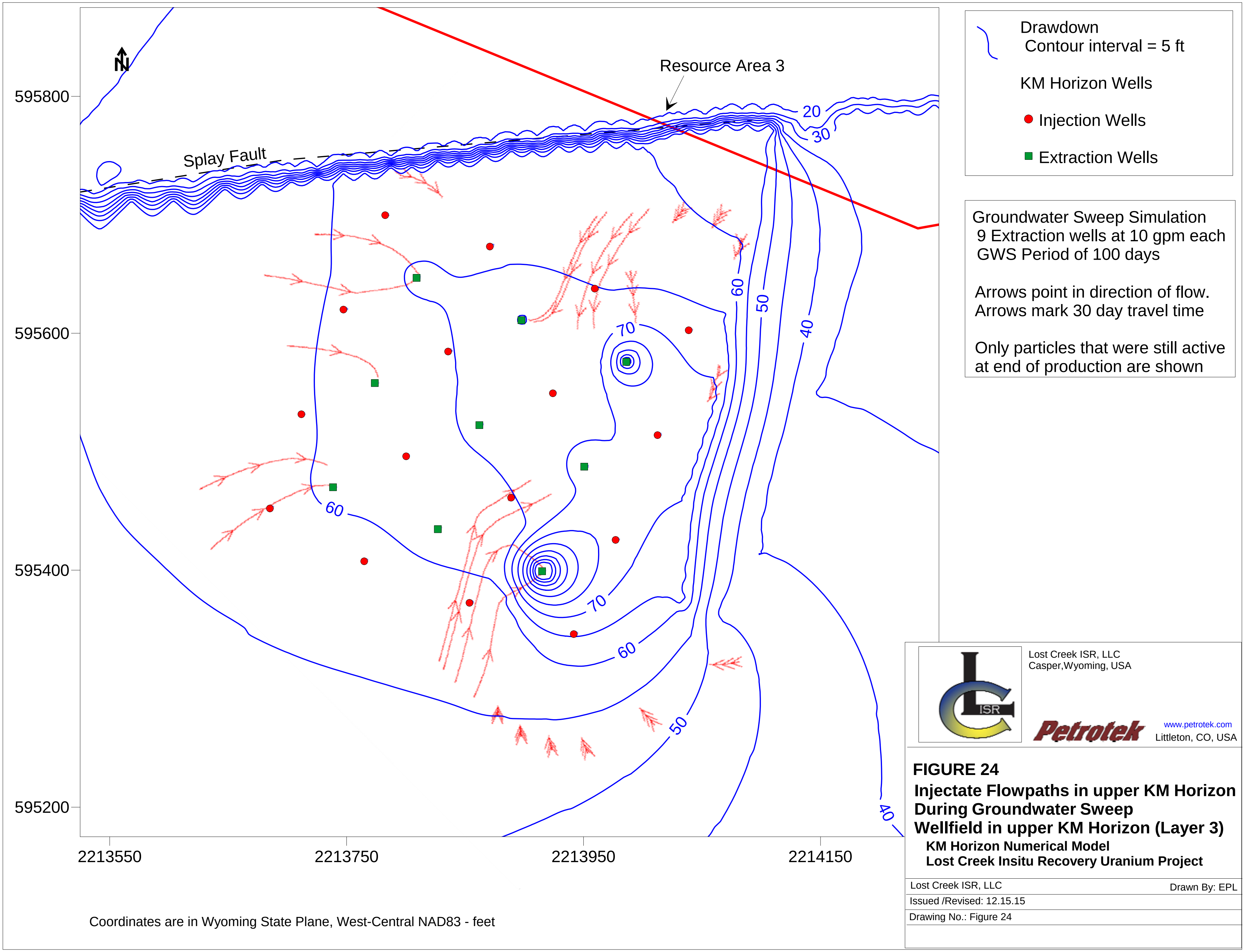

FIGURE 24

Injectate Flowpaths in upper KM Horizon During Groundwater Sweep Wellfield in upper KM Horizon (Layer 3)

KM Horizon Numerical Model

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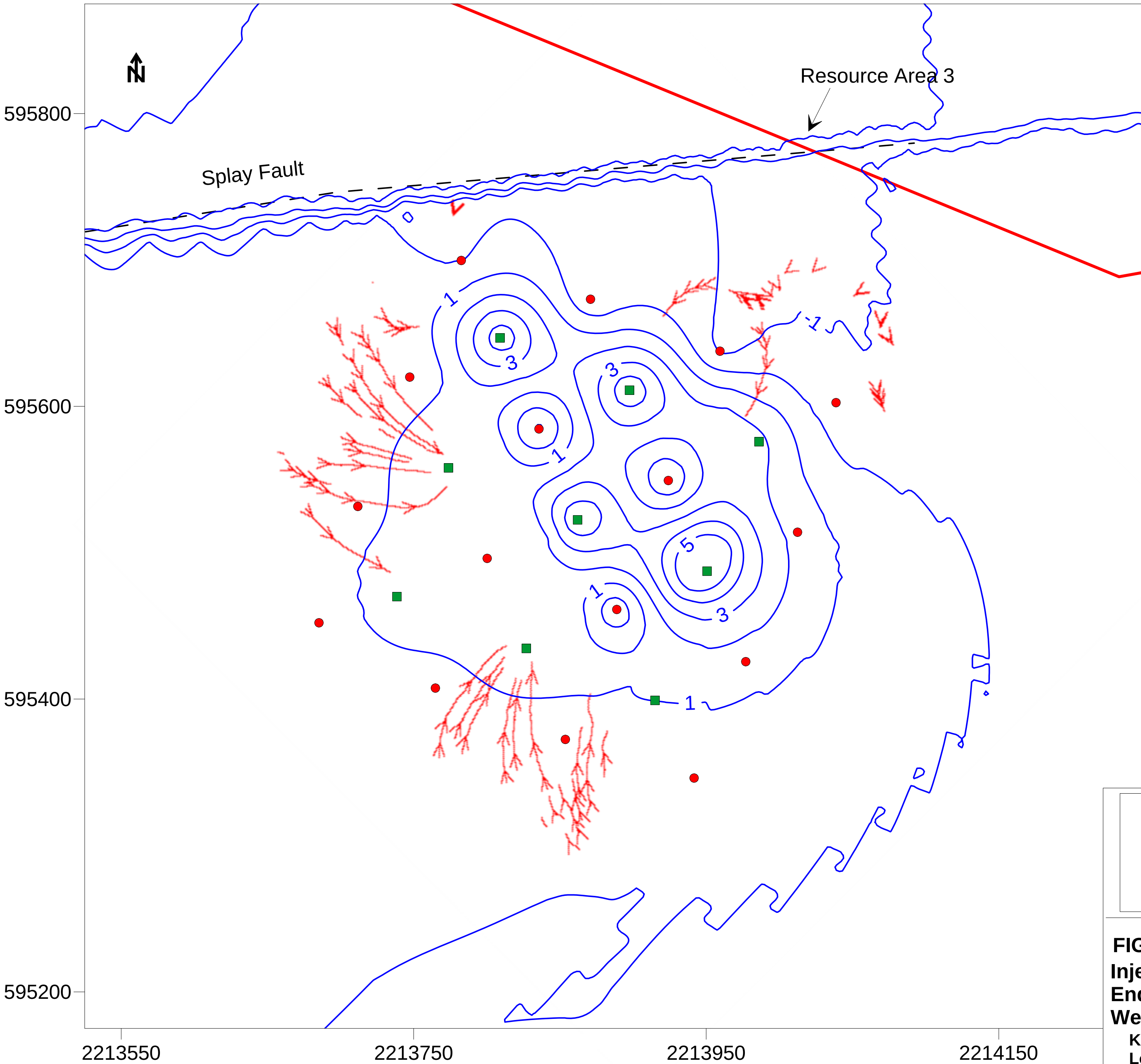
Drawing No.: Figure 24



Drawdown
Contour interval = 1 ft

KM Horizon Wells

Injection Wells

Extraction Wells

Production Simulation
All wells in upper KM Horizon.
9 Extraction wells at 20 gpm each.
1 % Bleed
Production Period of 585 days

Arrows point in direction of flow.
Arrows mark 120 day travel time

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 25

Injectate Flowpaths in middle KM Horizon
End of Production
Wellfield in upper KM Horizon (Layer 3)

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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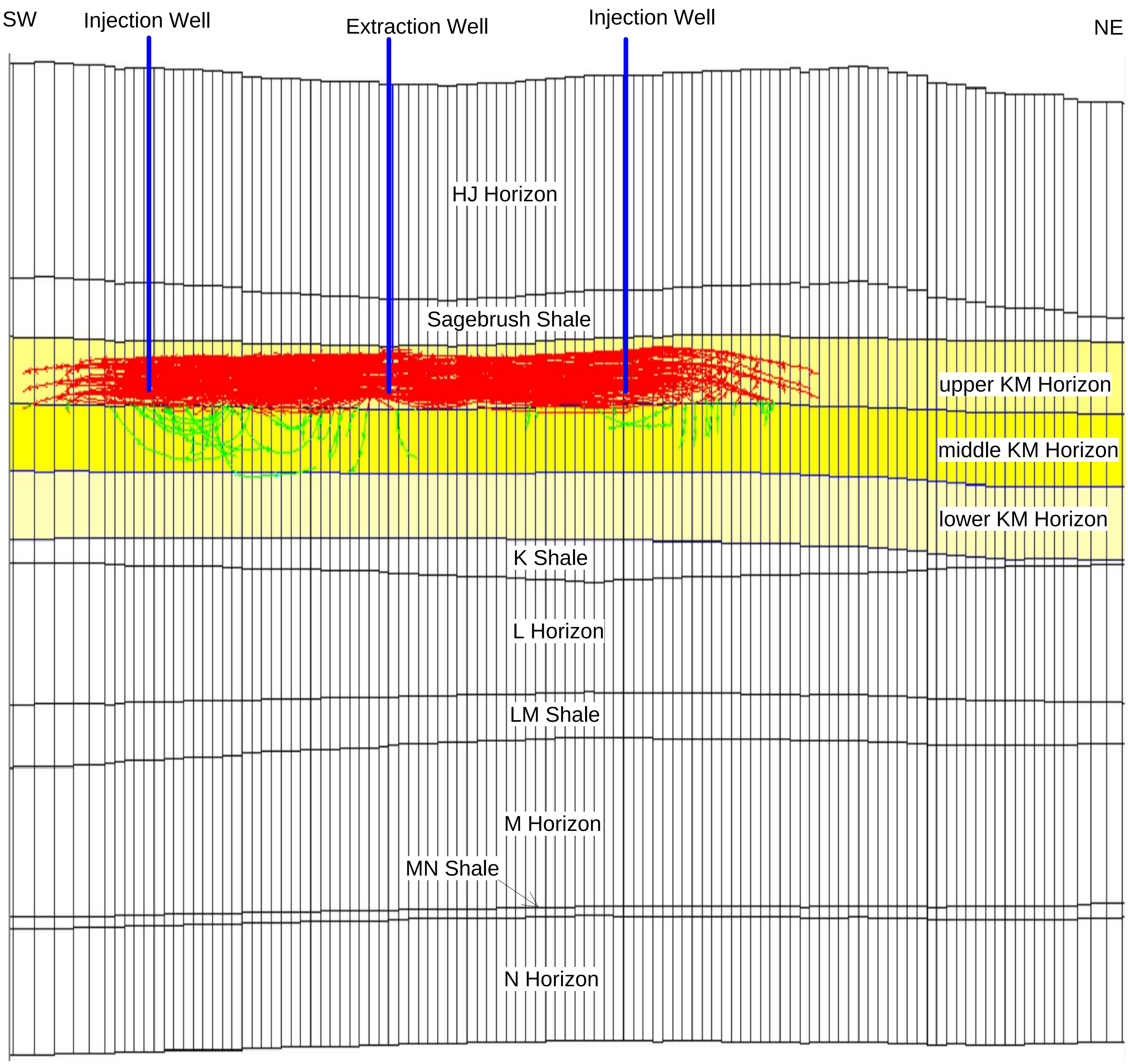
Issued /Revised: 12.15.15	
Drawing No.: Figure 23	



Flowpaths of particles originating from injection wells at start of production.

Flowpath-upper KM Horizon

Flowpath-middle KM Horizon

Arrows point in direction of flow
Arrows indicate 30 day travel time

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FIGURE 26

Injectate Flowpaths, During Production
Cross Section Along Model Row 115
Wellfield in upper KM Horizon (Layer 3)
KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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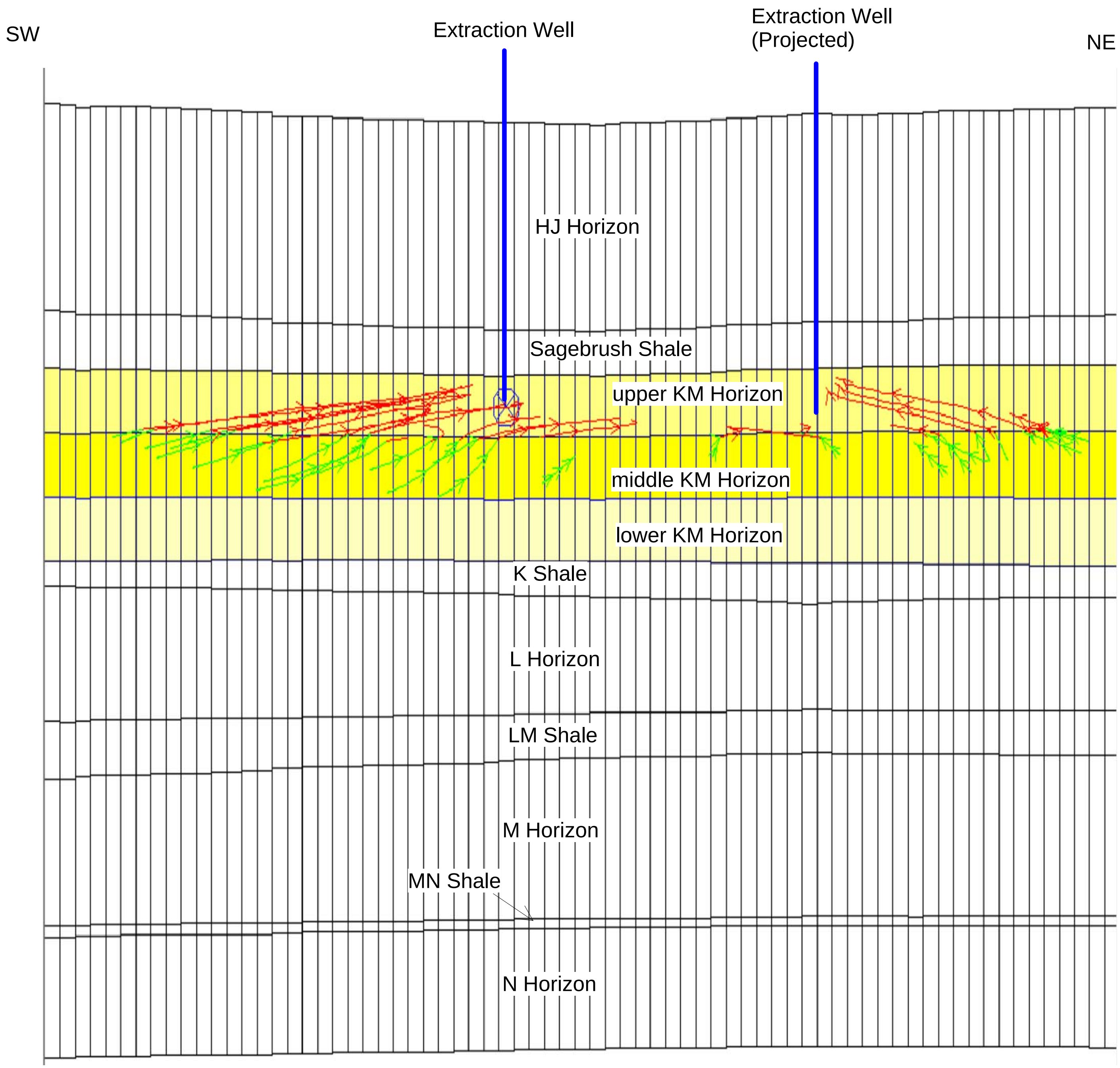
Issued /Revised: 12.15.15
Drawing No.: Figure 26



Flowpaths during GWS of all particles that were active in the end of production.

Flowpath-upper KM Horizon

Flowpath-middle KM Horizon

Arrows point in direction of flow
Arrows indicate 30 day travel time

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FIGURE 27
Injectate Flowpaths, Groundwater Sweep Cross Section Along Model Row 115 Wellfield in upper KM Horizon (Layer 3)
KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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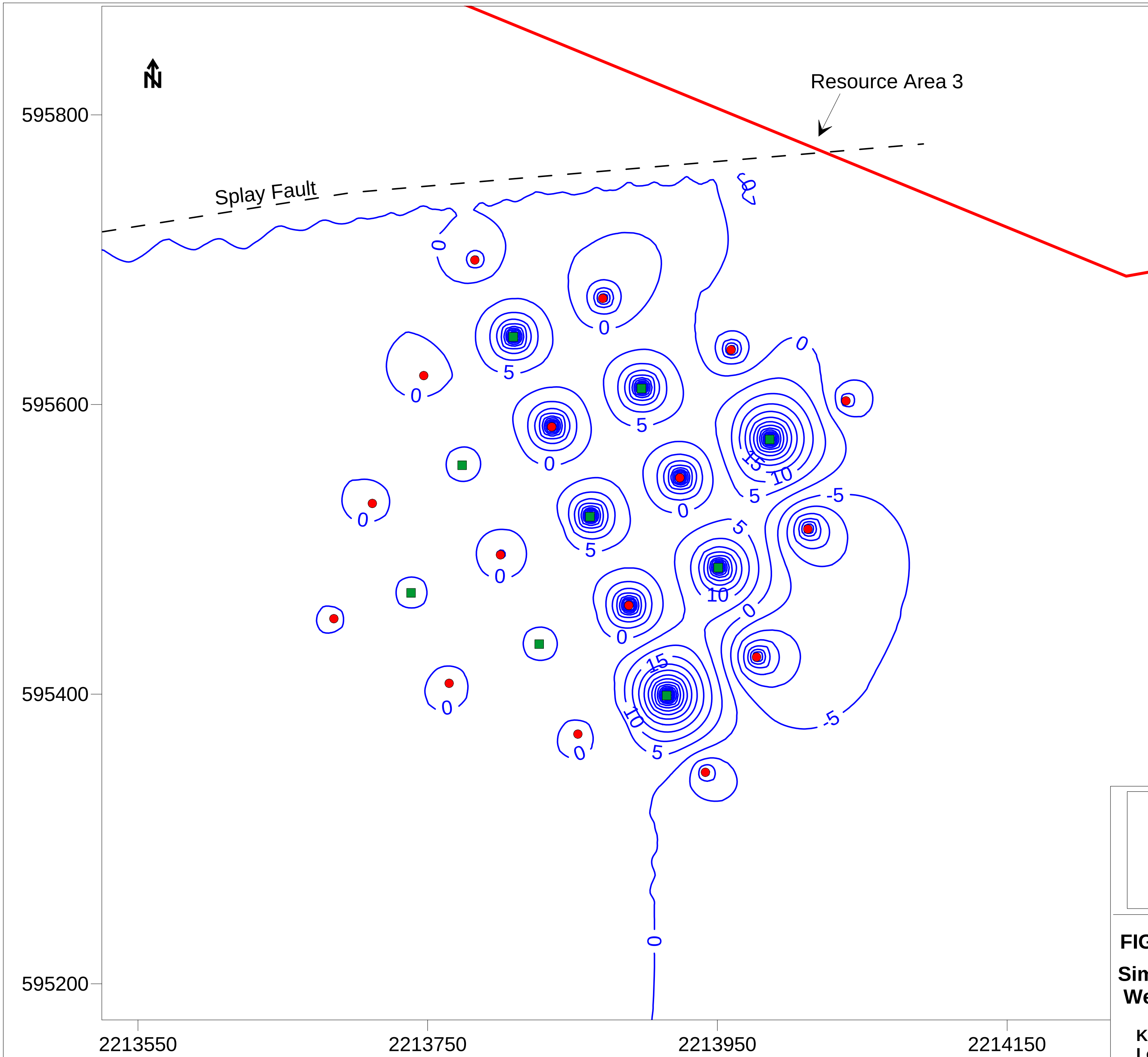
Issued /Revised: 12.15.15
Drawing No.: Figure 27



Drawdown
Contour interval = 5 ft

KM Horizon Wells

Injection Wells

Extraction Wells

Production Simulation
9 Extraction wells at 20 gpm each
1 % Bleed
Production Period of 585 days

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 28

Simulated Drawdown, End of Production Wellfield in middle KM Horizon (Layer 4)

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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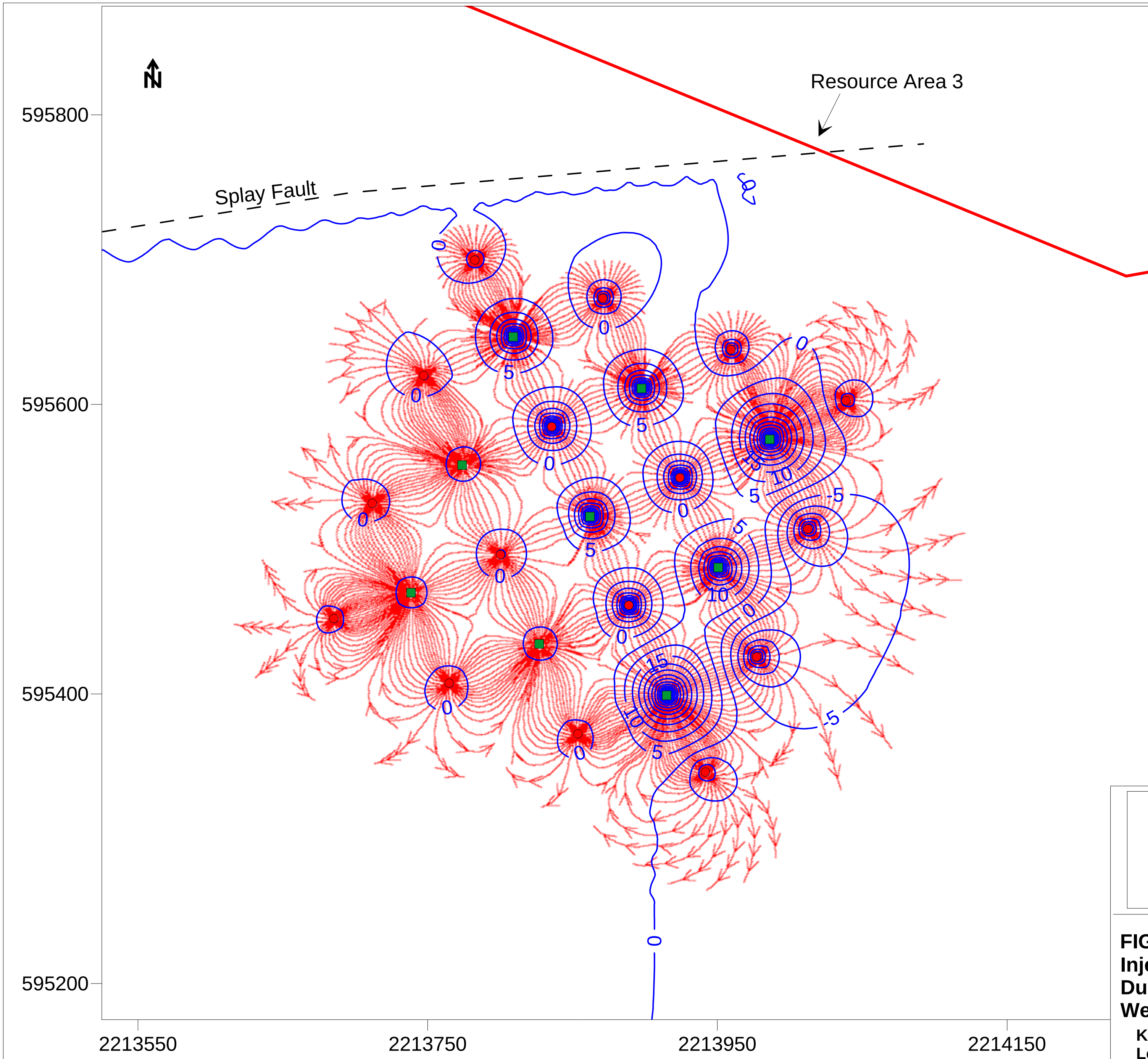
Issued /Revised: 12.15.15
Drawing No.: Figure 28



Drawdown
Contour interval = 5 ft

KM Horizon Wells

Injection Wells

Extraction Wells

Production Simulation
9 Extraction wells at 20 gpm each
1 % Bleed
Production Period of 585 days

Arrows point in direction of flow.
Arrows mark 120 day travel time

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 29
Injectate Flowpaths in middle KM Horizon During Production
Wellfield in middle KM Horizon (Layer 4)
KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC — Drawn By: EPL
Issued /Revised: 12.15.15
Drawing No.: Figure 29

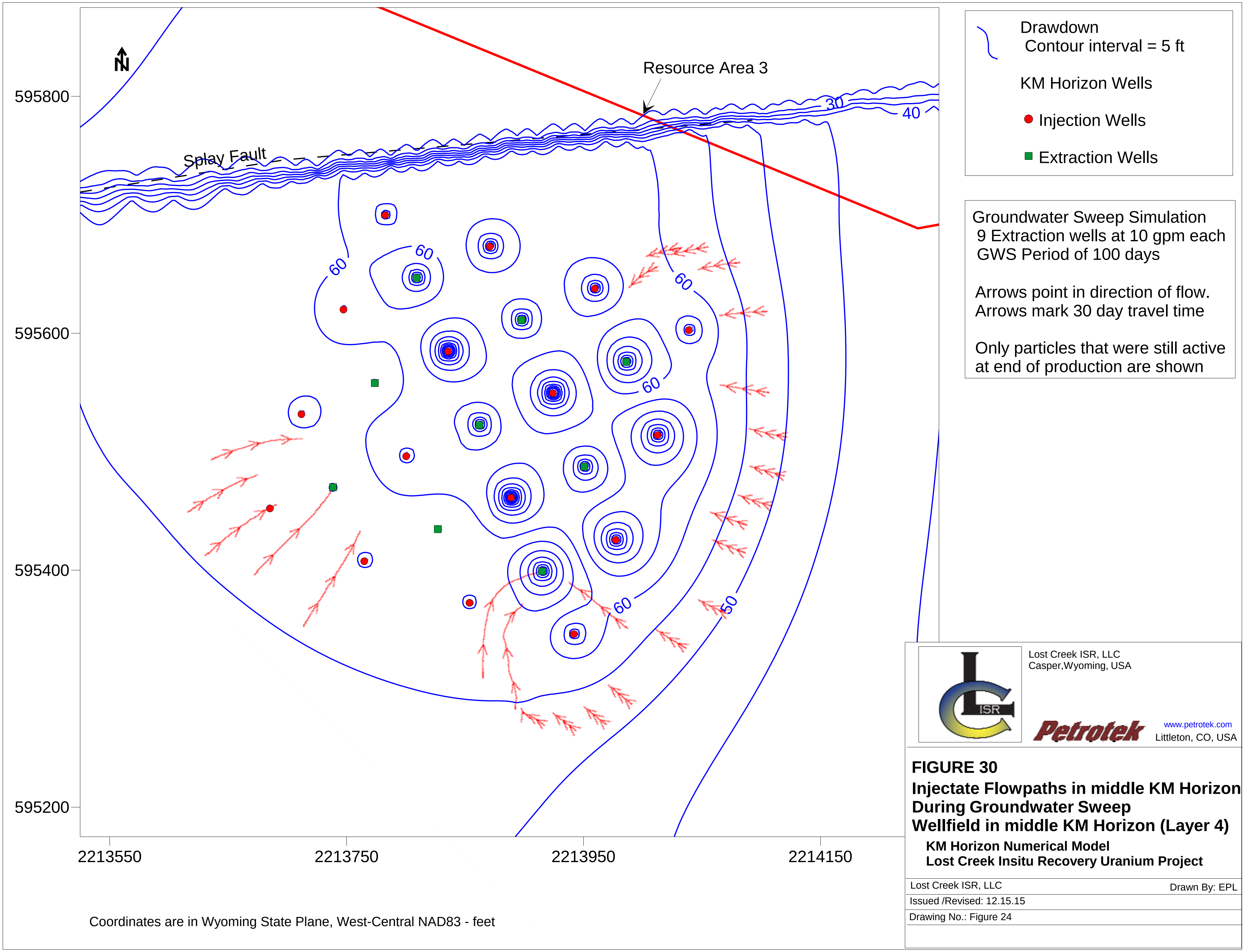

FIGURE 30
Injectate Flowpaths in middle KM Horizon During Groundwater Sweep
Wellfield in middle KM Horizon (Layer 4)
KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC — Drawn By: EPL
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Drawing No.: Figure 24

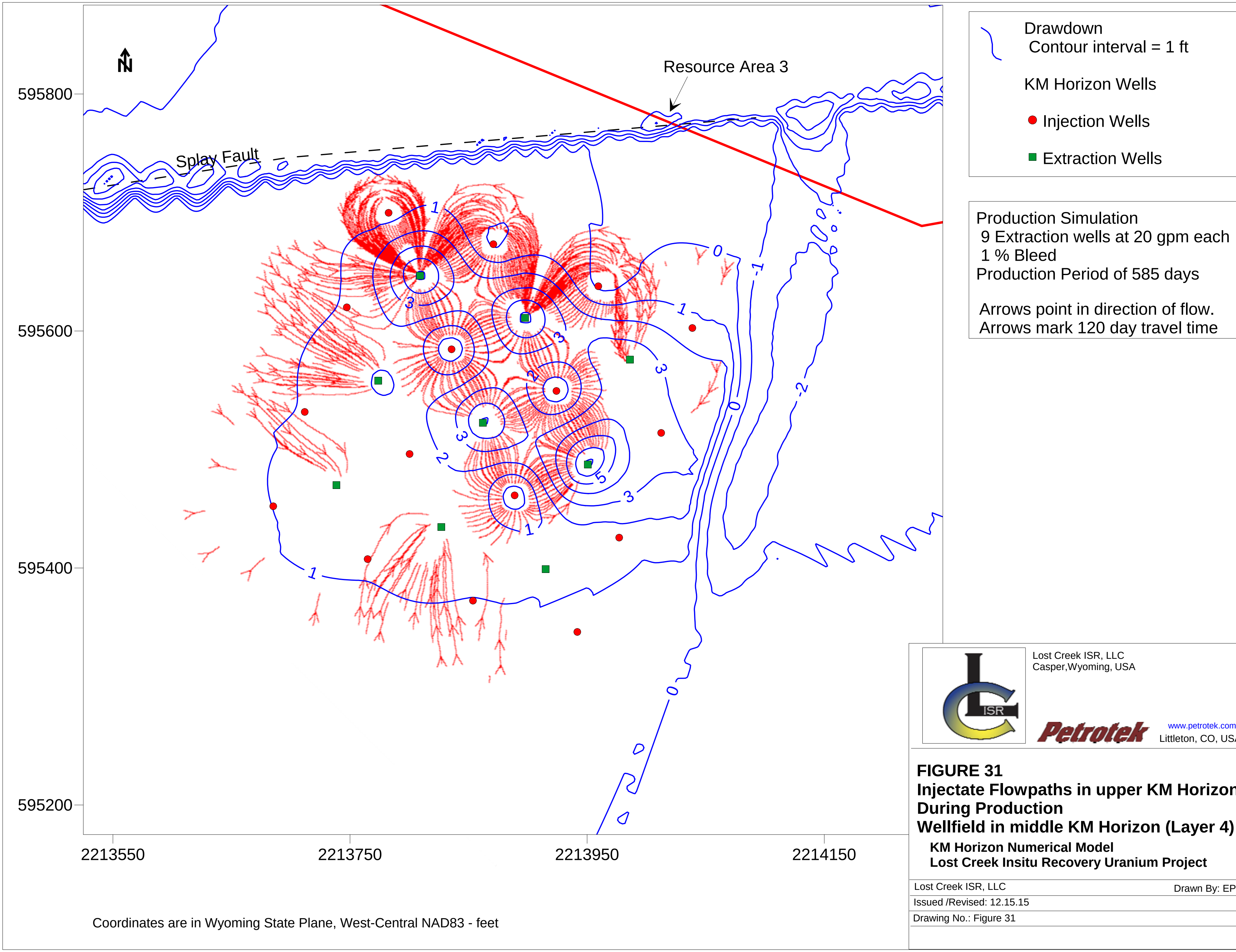

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FIGURE 31
Injectate Flowpaths in upper KM Horizon During Production
Wellfield in middle KM Horizon (Layer 4)
KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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Drawing No.: Figure 31	

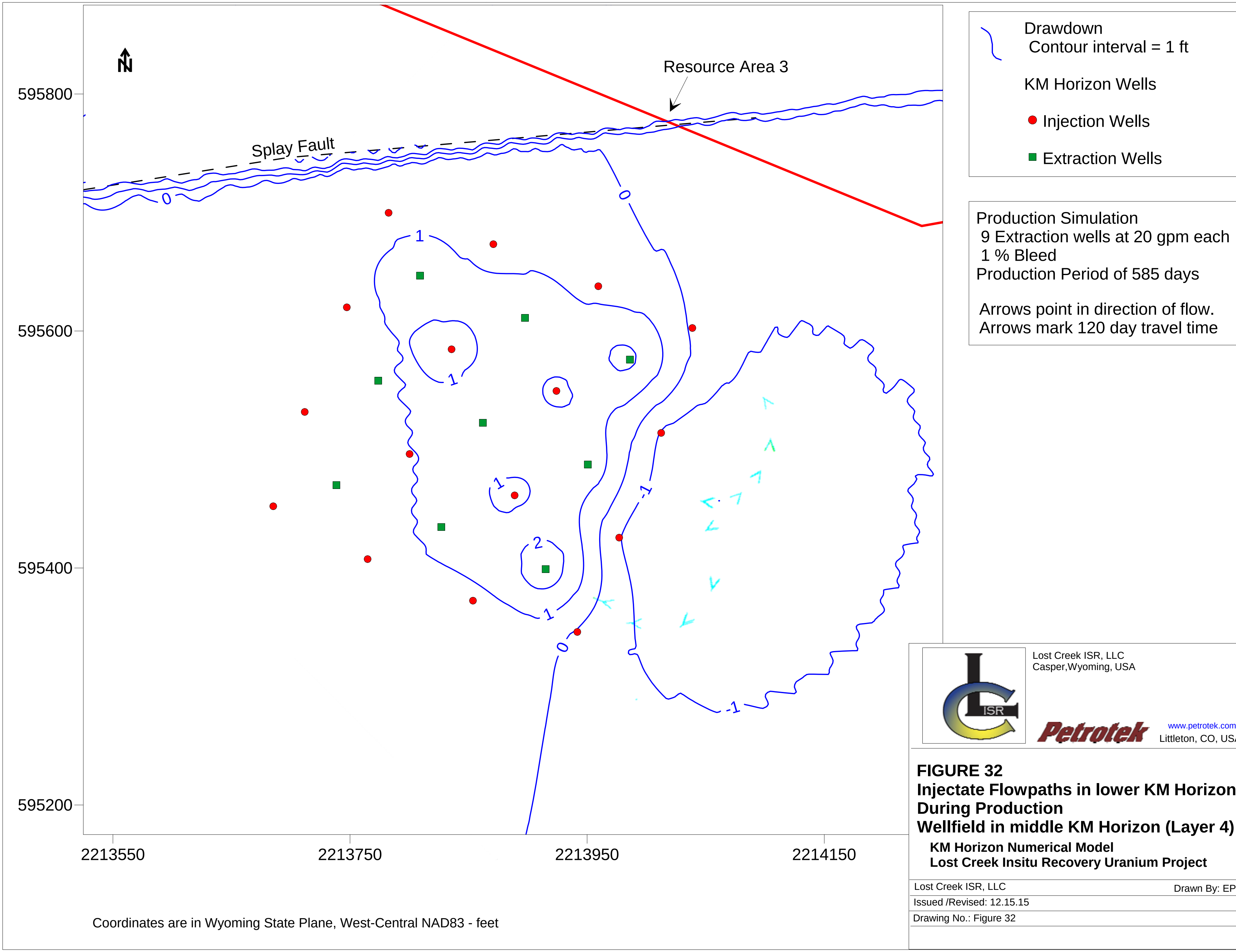

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FIGURE 32
Injectate Flowpaths in lower KM Horizon During Production
Wellfield in middle KM Horizon (Layer 4)
KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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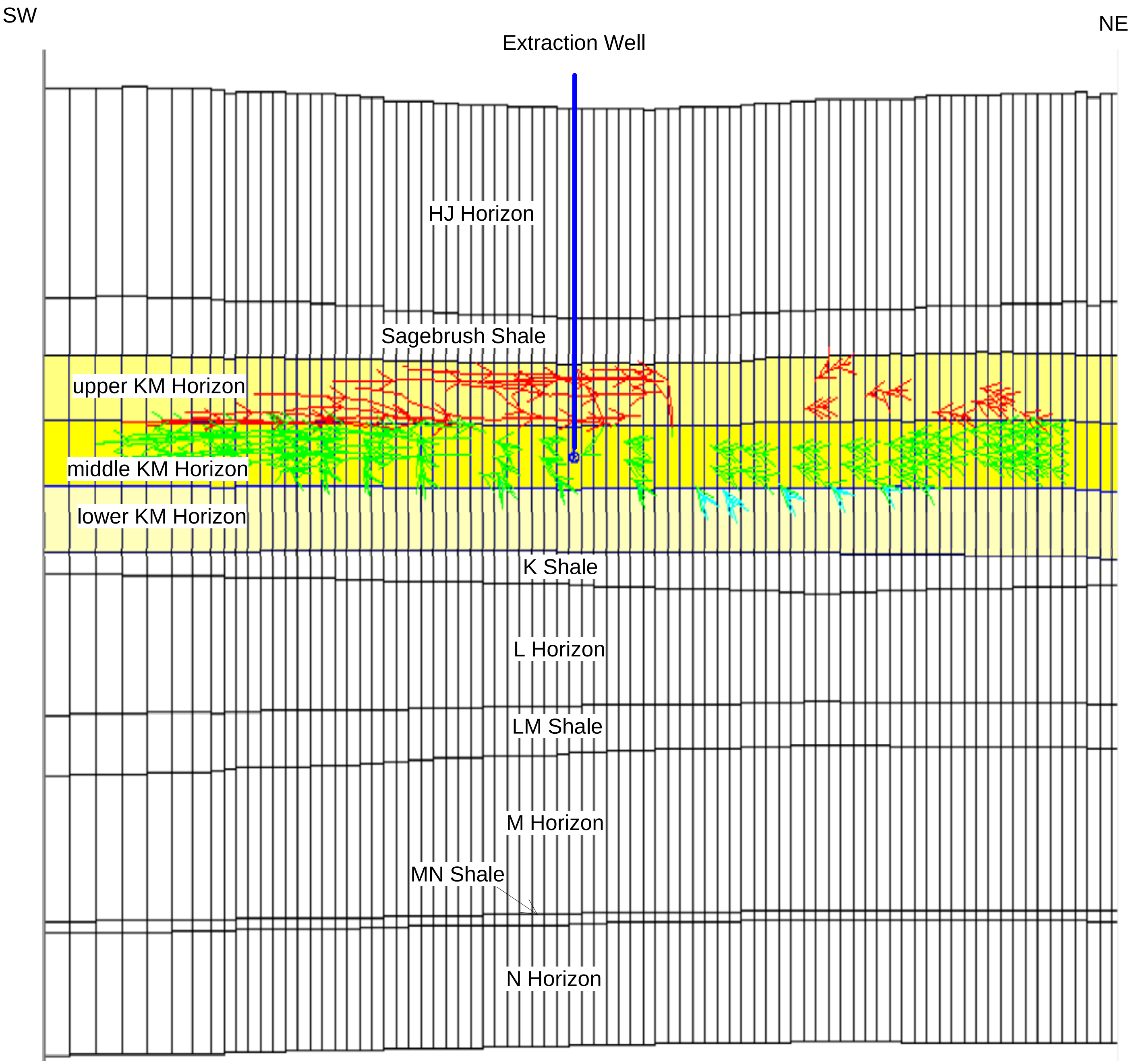
Drawing No.: Figure 32



Flowpaths during GWS of all particles that were active at the end of production.

- Flowpath-upper KM Horizon
- Flowpath-middle KM Horizon
- Flowpath-lower KM Horizon

Arrows point in direction of flow
Arrows indicate 30 day travel time

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FIGURE 33
Injectate Flowpaths, Groundwater Sweep
Cross Section Along Model Row 115
Wellfield in middle KM Horizon (Layer 4)

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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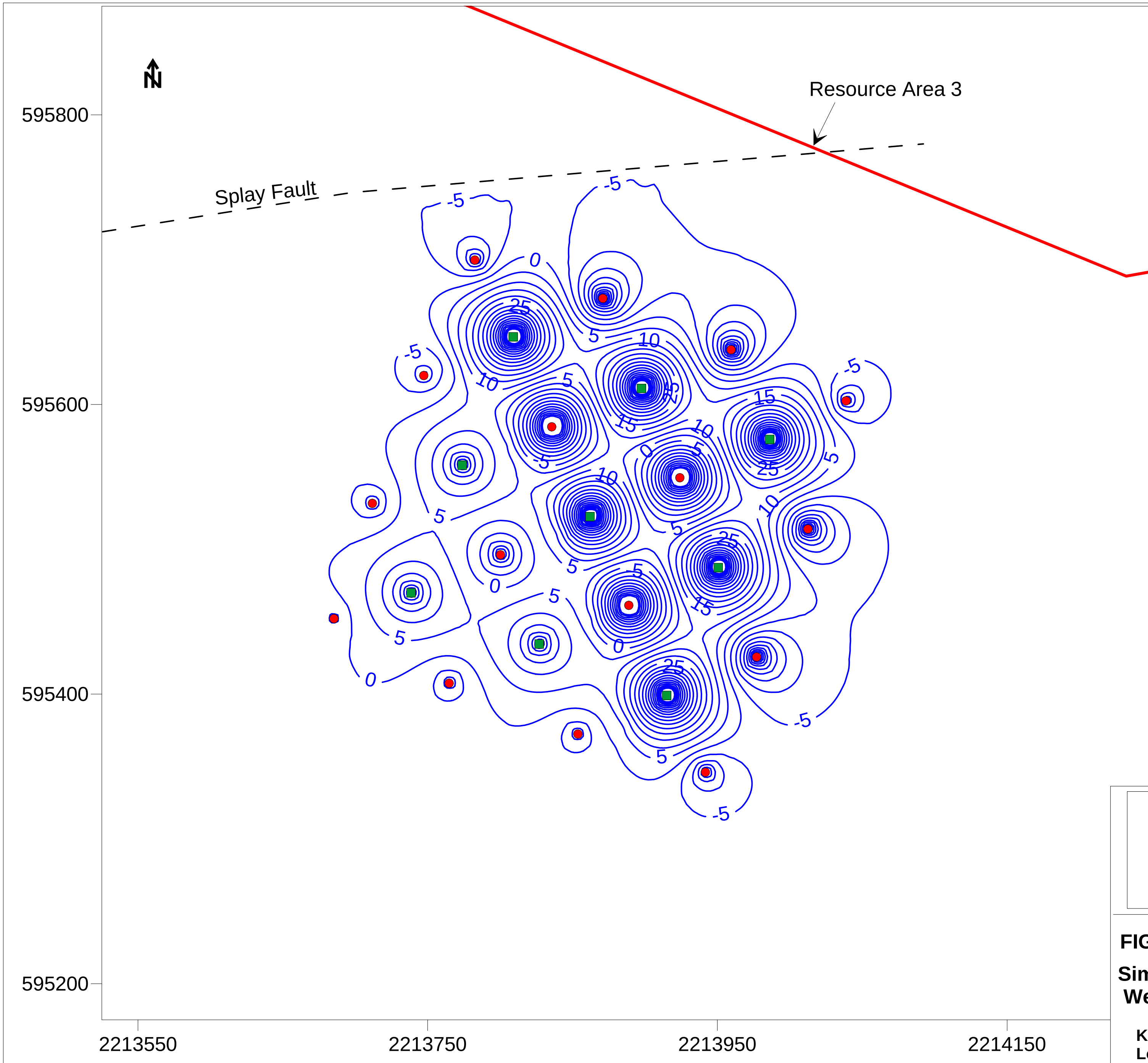
Issued /Revised: 12.15.15
Drawing No.: Figure 33



Drawdown
Contour interval = 5 ft

KM Horizon Wells

Injection Wells

Extraction Wells

Production Simulation
9 Extraction wells at 20 gpm each
1 % Bleed
Production Period of 585 days

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 34

Simulated Drawdown, End of Production Wellfield in lower KM Horizon (Layer 5)

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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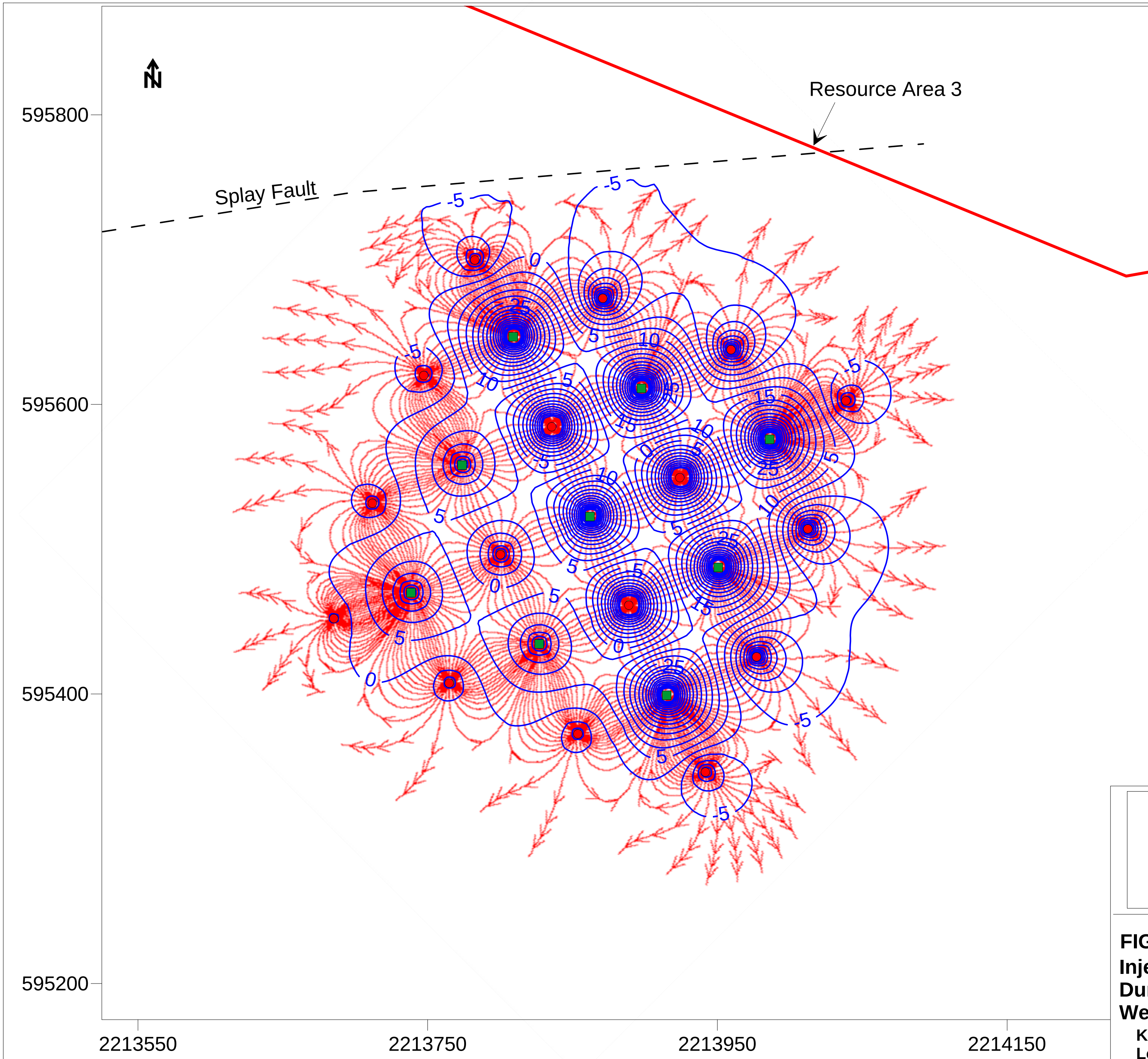
Issued /Revised: 12.15.15
Drawing No.: Figure 34



Drawdown
Contour interval = 5 ft

KM Horizon Wells

Injection Wells

Extraction Wells

Production Simulation
9 Extraction wells at 20 gpm each
1 % Bleed
Production Period of 585 days

Arrows point in direction of flow
Arrows mark 120 day travel time

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 35

Injectate Flowpaths in lower KM Horizon During Production

Wellfield in lower KM Horizon (Layer 5)

KM Horizon Numerical Model

Lost Creek Insitu Recovery Uranium Project

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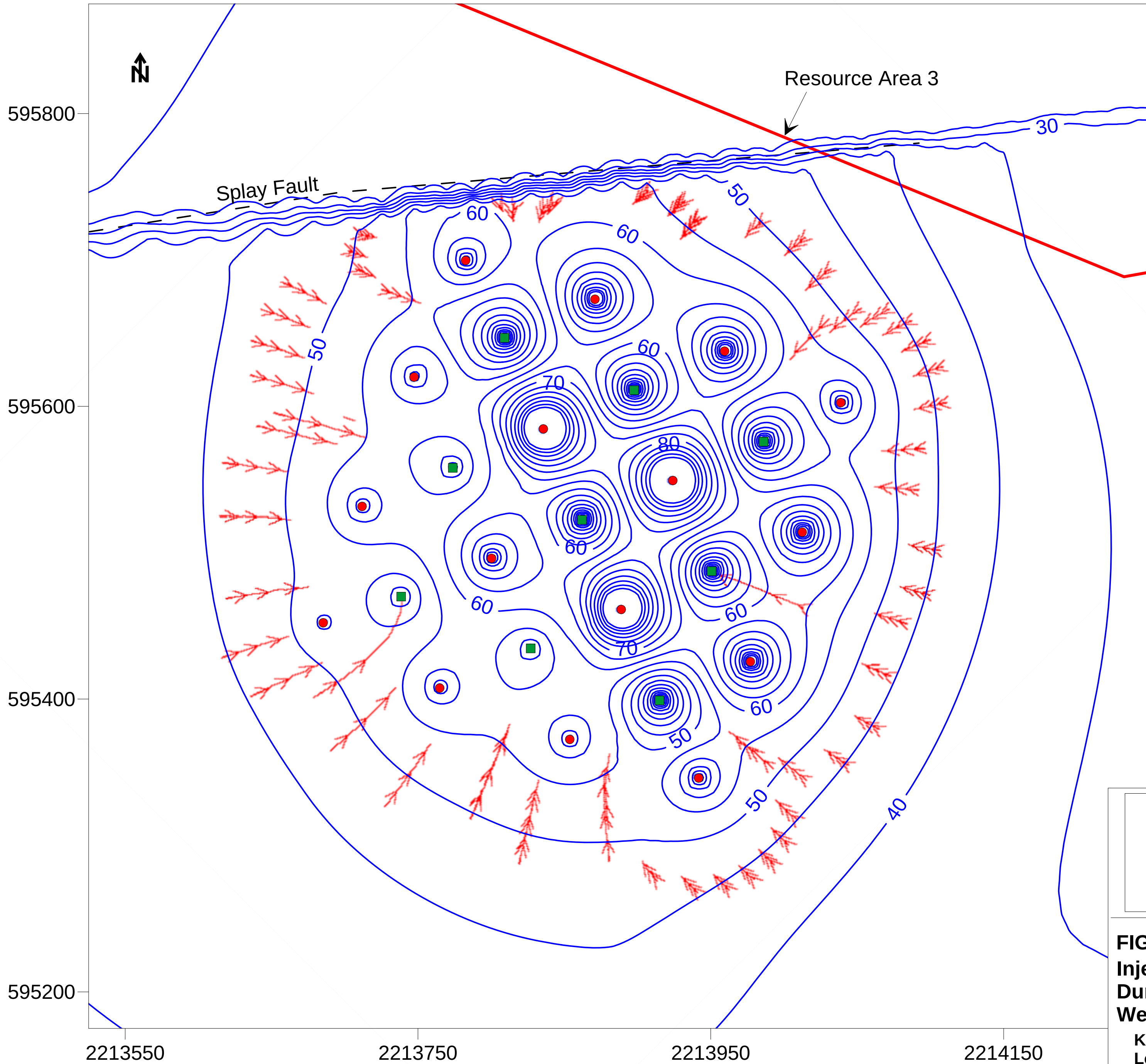
Drawing No.: Figure 35	



Drawdown
Contour interval = 5 ft

KM Horizon Wells

Injection Wells

Extraction Wells

Groundwater Sweep Simulation
9 Extraction wells at 10 gpm each
GWS Period of 100 days

Arrows point in direction of flow
Arrows mark 30 day travel time

Only particles that were still active at end of production are shown

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 36

Injectate Flowpaths in lower KM Horizon During Groundwater Sweep Wellfield in lower KM Horizon (Layer 4)

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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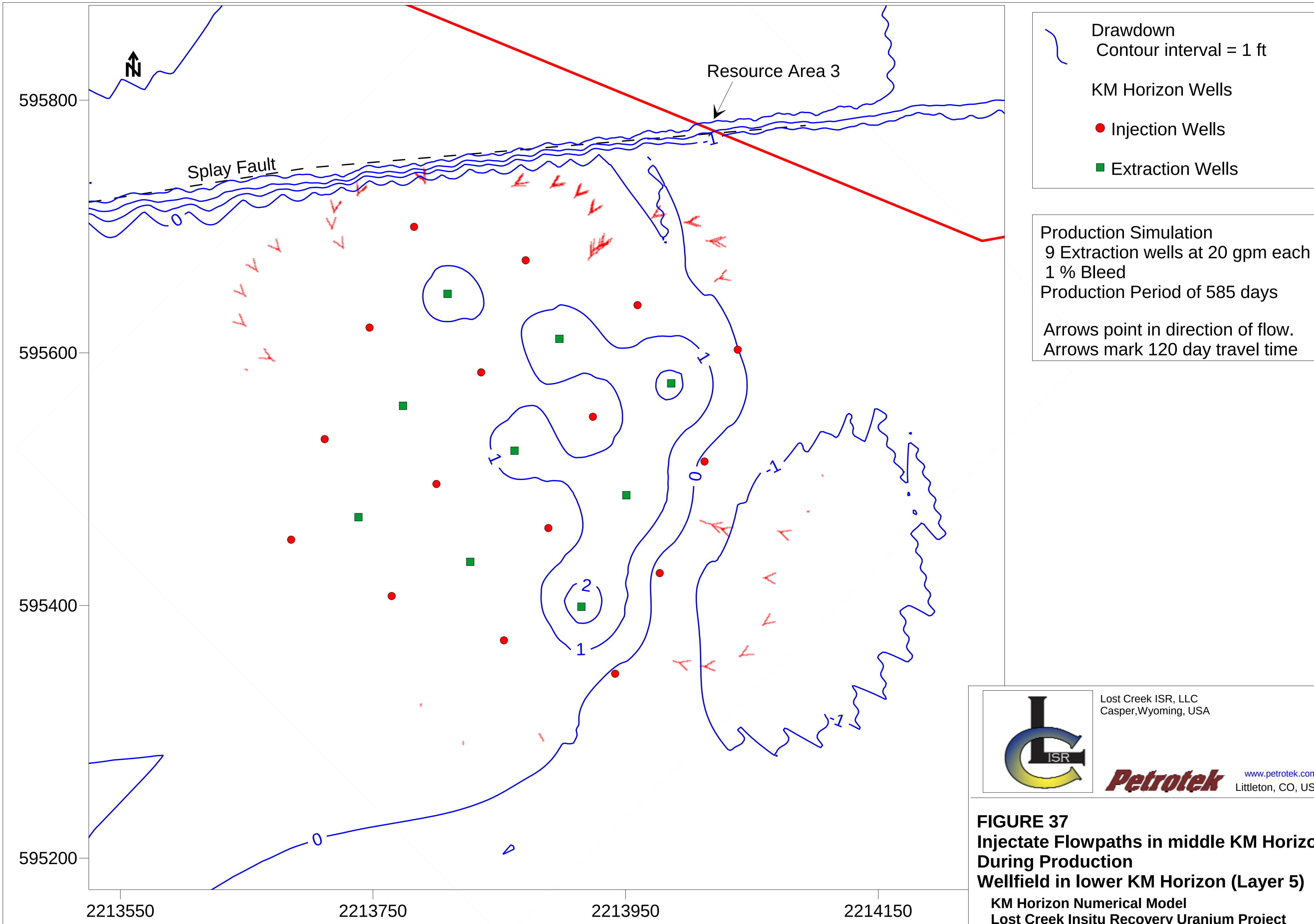
Issued /Revised: 12.15.15	
Drawing No.: Figure 36	



Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 37
Injectate Flowpaths in middle KM Horizon During Production
Wellfield in lower KM Horizon (Layer 5)
KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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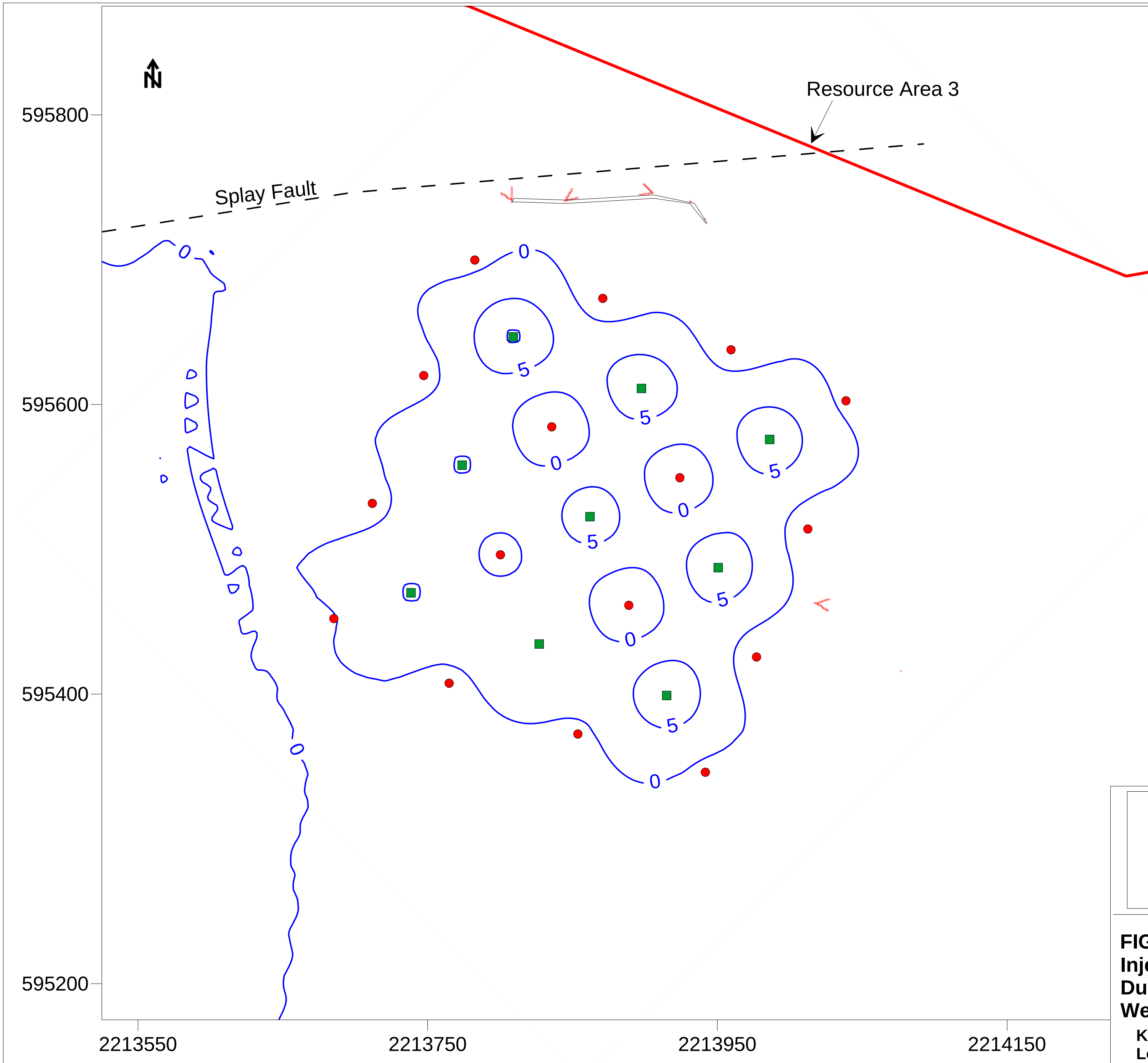
Drawing No.: Figure 37	



Drawdown
Contour interval = 5 ft

KM Horizon Wells

Injection Wells

Extraction Wells

Production Simulation
9 Extraction wells at 20 gpm each
1 % Bleed
Production Period of 585 days

Arrows point in direction of flow.
Arrows mark 120 day travel time

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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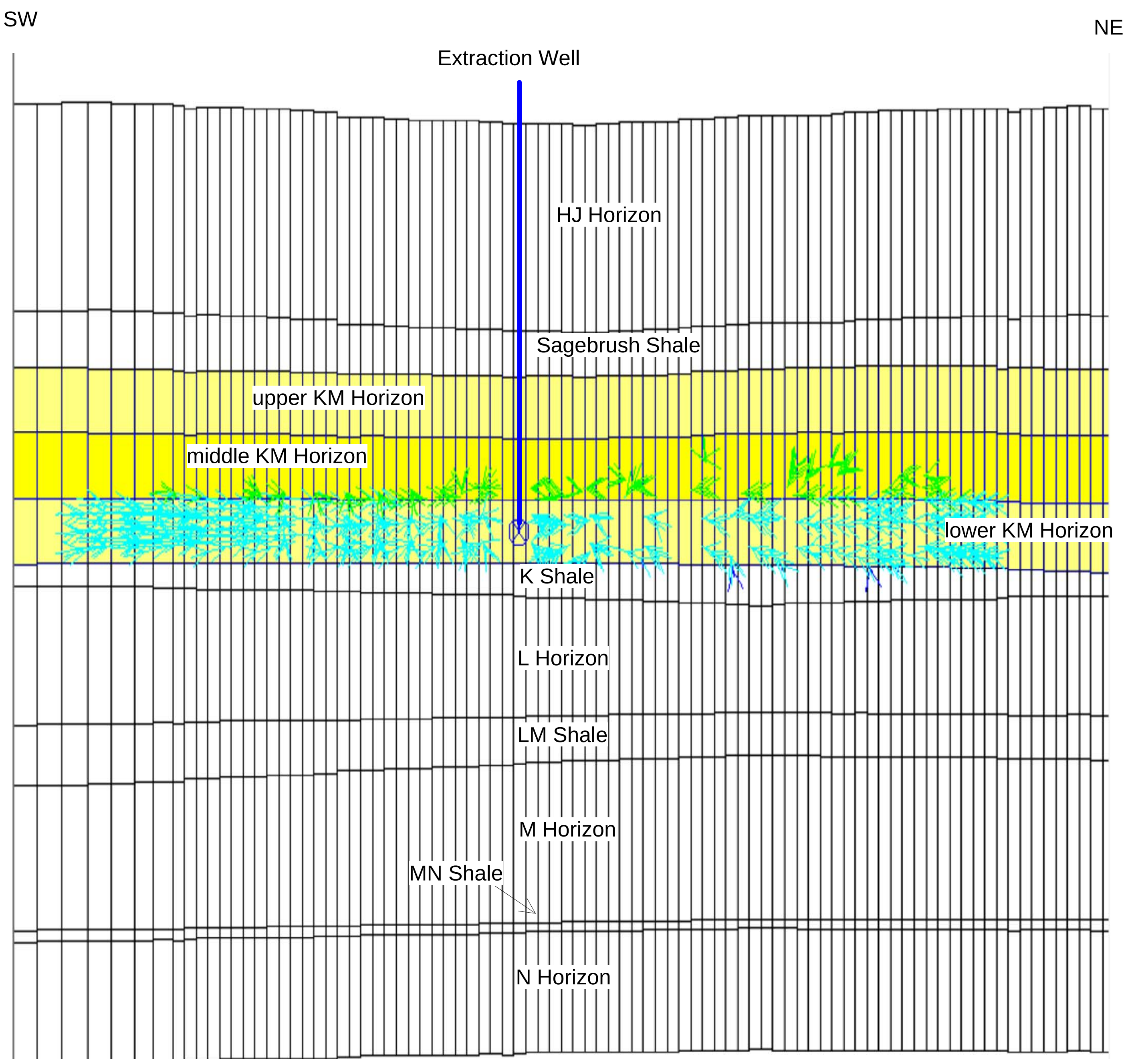
FIGURE 38
Injectate Flowpaths in K Shale During Production Wellfield in lower KM Horizon (Layer 5)
KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC | Drawn By: EPL
Issued /Revised: 12.15.15
Drawing No.: Figure 37



Flowpaths during GWS of all particles that were active at the end of production.

- Flowpath-middle KM Horizon
- Flowpath-lower KM Horizon
- Flowpath- K Shale

Arrows point in direction of flow
Arrows indicate 30 day travel time

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FIGURE 39
Injectate Flowpaths, Groundwater Sweep Cross Section - Along Model Row 115 Wellfield in lower KM Horizon (Layer 5)
KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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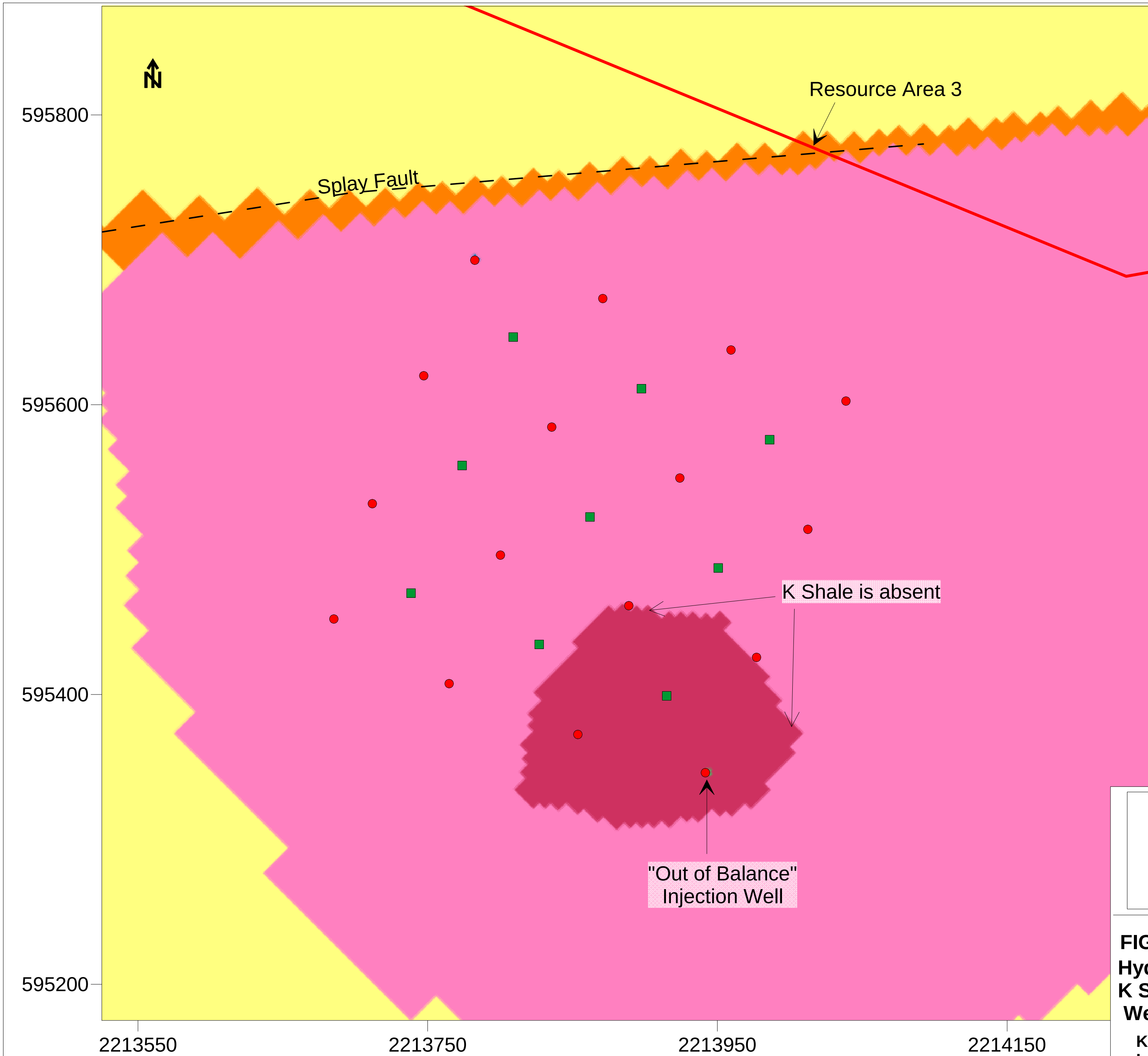
Issued /Revised: 12.15.15	
Drawing No.: Figure 39	



Zone	Kx	Kv
15	0.582	0.200
22	0.0023	0.0032
23	0.112	0.147
47	7.614	0.294

Coordinates are in Wyoming State Plane, West-Central NAD83 - feet

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FIGURE 40
Hydraulic Conductivity Distribution
K Shale (Layer 6), Excursion Simulation
Wellfield in lower KM Horizon (Layer 5)

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC — Drawn By: EPL
Issued /Revised: 12.15.15
Drawing No.: Figure 40

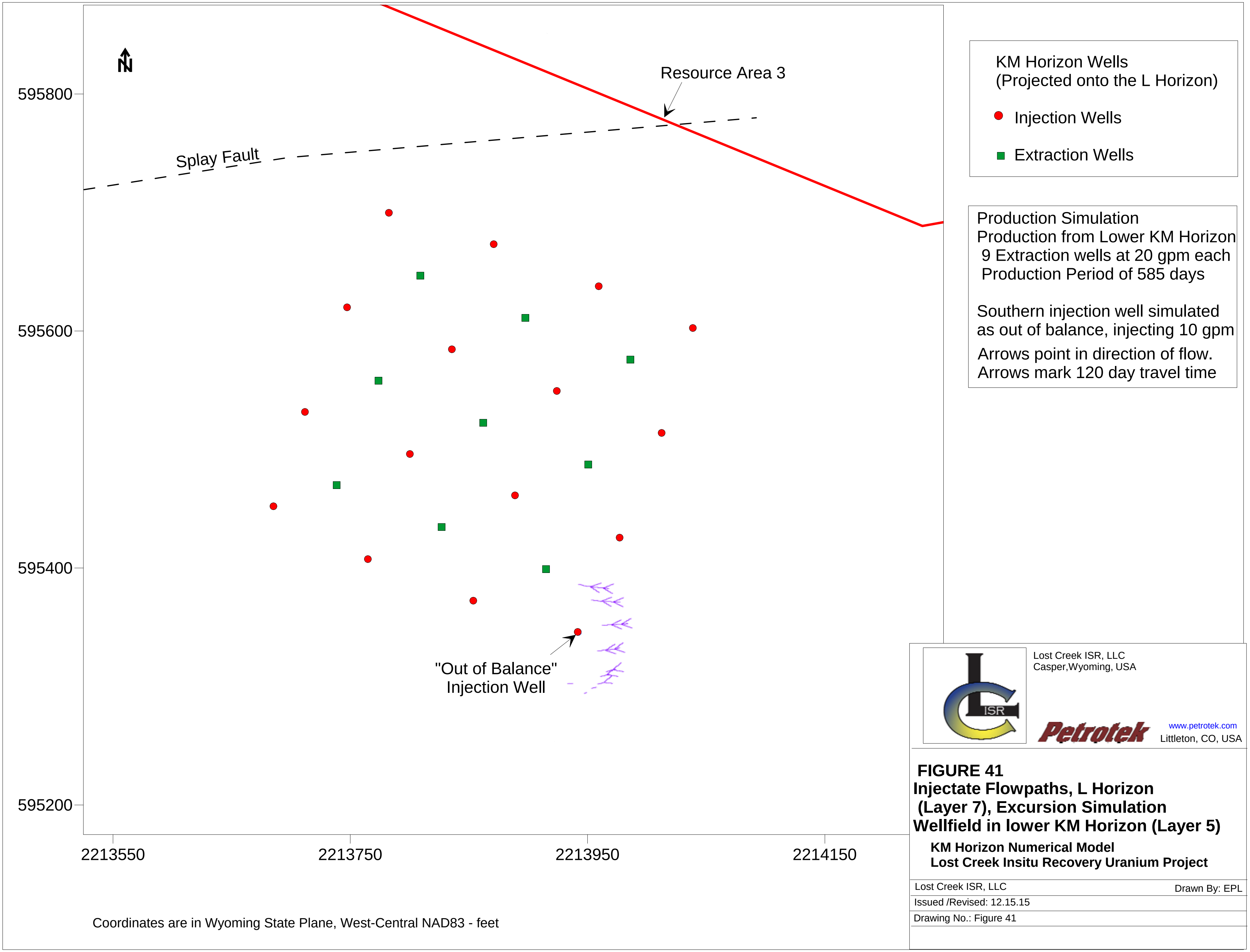

FIGURE 41
Injectate Flowpaths, L Horizon (Layer 7), Excursion Simulation Wellfield in lower KM Horizon (Layer 5)
KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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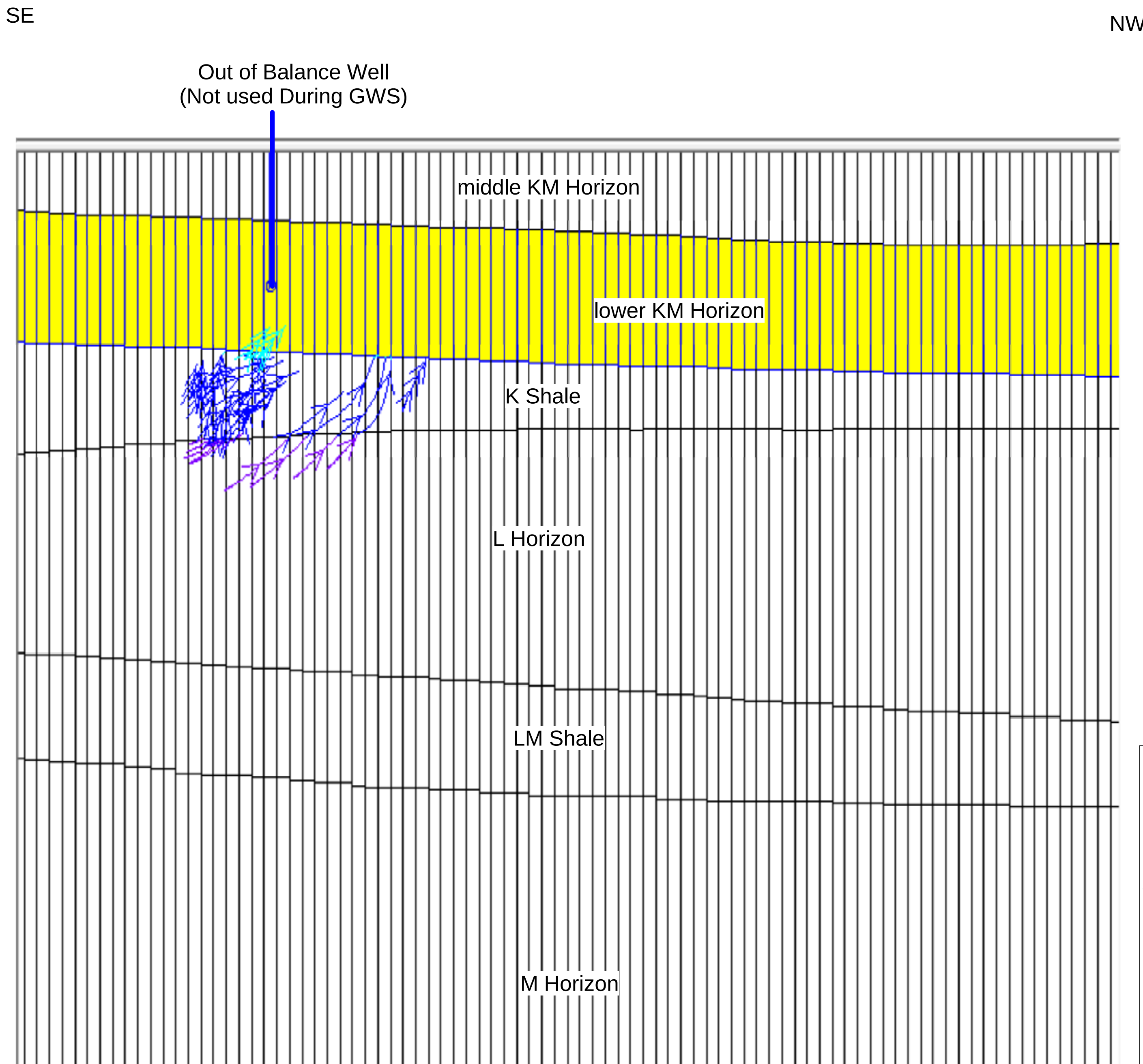
Issued /Revised: 12.15.15
Drawing No.: Figure 41



Flowpaths during GWS of all particles that were active at the end of production.

- Flowpath- lower KM Horizon
- Flowpath- K Shale
- Flowpath- L Horizon

Arrows point in direction of flow
Arrows indicate 30 day travel time

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FIGURE 42

Excursion Flowpaths, Groundwater Sweep Cross Section - Along Model Column 132 Wellfield in lower KM Horizon (Layer 5)

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

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Drawing No.: Figure 42

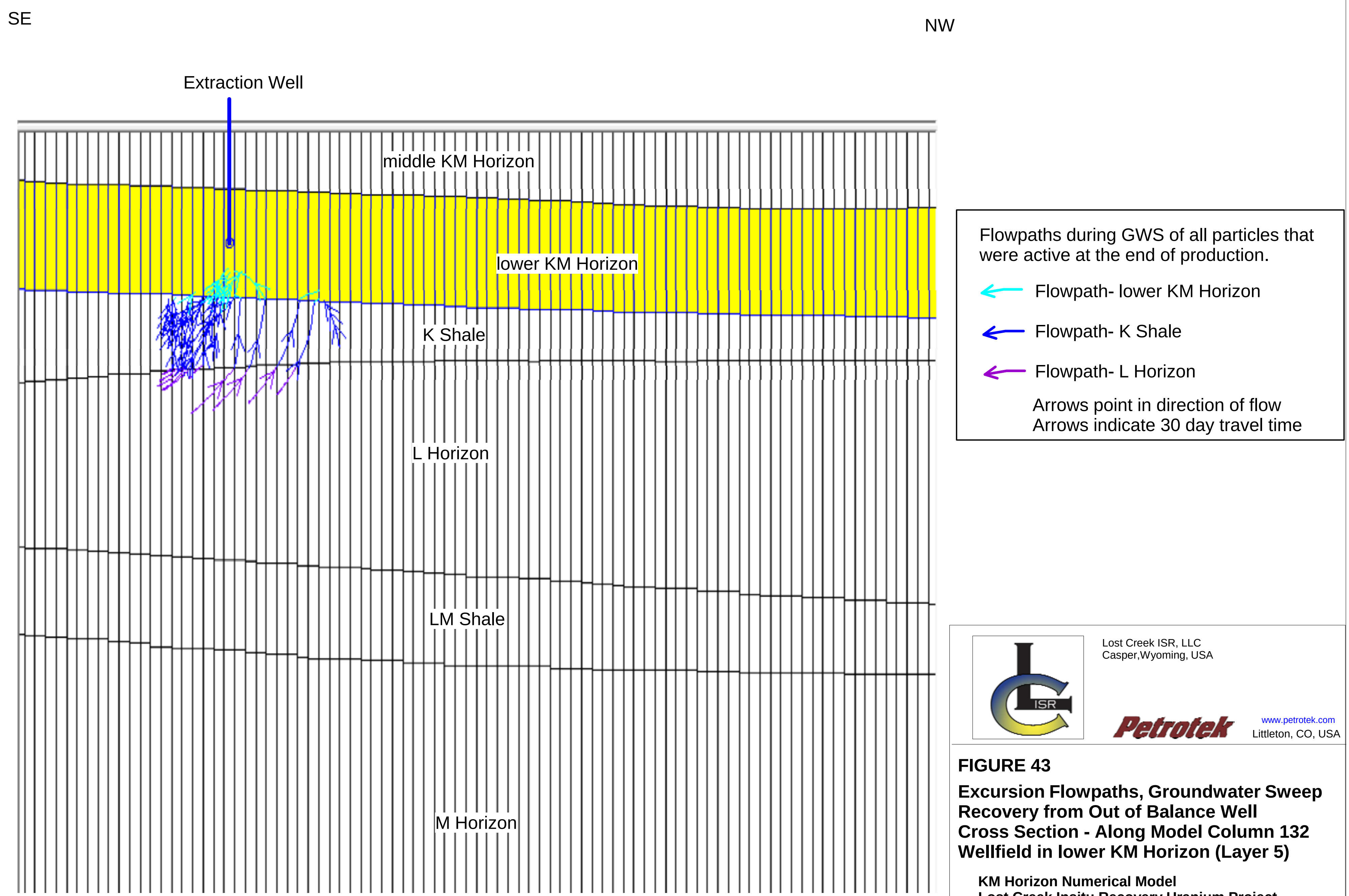

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FIGURE 43

Excursion Flowpaths, Groundwater Sweep Recovery from Out of Balance Well Cross Section - Along Model Column 132 Wellfield in lower KM Horizon (Layer 5)

KM Horizon Numerical Model
Lost Creek Insitu Recovery Uranium Project

Lost Creek ISR, LLC	Drawn By: EPL
Issued /Revised: 12.15.15	
Drawing No.: Figure 43	

Attachment A

Elevation and Thickness of Stratigraphic Units
Used to Develop the KM Horizon Numerical Model
Lost Creek Uranium ISR Project

January 2016

Boring ID	Easting - NAD 83	Northing - NAD 83	Ground Elevation	Depth to Sagebrush Shale	Elev. Top Sagebrush Shale	Sagebrush Shale Thickness	Depth To KM Horizon	Elev. Top KM Horizon	KM Horizon Thickness	Depth to K Shale	Elev. Top K Shale	K Shale Thickness	Depth to L Horizon
	(feet)	(feet)	(ft amsl)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)
1-13	2201396	595656	6970.0	659	6311.0	14	673	6297.0	100	773	6197.0	10	783
77-1	2209014	593497	6918.0	475	6443.0	42	517	6401.0	112	629	6289.0	27	656
83-1	2204502	594198	6932.0	587	6345.0	12	599	6333.0	129	728	6204.0	12	740
131-1	2205988	595892	6960.0	583	6377.0	16	599	6361.0	95	694	6266.0	6	700
139-3	2205777	593493	6916.0	545	6371.0	15	560	6356.0	113	673	6243.0	7	680
140-3	2207223	593485	6914.0	518	6396.0	6	524	6390.0	134	658	6256.0	10	668
HJMU-108	2211800	596011	6951.5	494	6457.5	15	509	6442.5	88	597	6354.5	11	608
HJMU-109	2212228	595549	6939.4	537	6402.4	3	540	6399.4	135	675	6264.4	10	685
HJMU-110	2212008	595909	6947.6	483	6464.6	8	491	6456.6	96	587	6360.6	22	609
HJMU-113	2212600	595521	6937.0	521	6416.0	3	524	6413.0	125	649	6288.0	13	662
HJT-105	2212760	595740	6938.9	530	6408.9	10	540	6398.9	133	673	6265.9	8	681
KMP-1	2216971	594512	6934.7	413	6521.7	10	423	6511.7	106	529	6405.7	25	554
KMU-2	2215182	595581	6952.3	490	6462.3	11	501	6451.3	103	604	6348.3	11	615
KMU-3	2214223	596514	6964.2	477	6487.2	8	485	6479.2	131	616	6348.2	9	625
KMU-4	2211054	595497	6942.9	483	6459.9	17	500	6442.9	93	593	6349.9	12	605
KPW-2	2210882	595485	6937.6	481	6456.6	17	498	6439.6	90	588	6349.6	7	595
LC3	2210396	595332	6923.0	481	6442.0	8	489	6434.0	100	589	6334.0	10	599
LC6C	2210926	595505	6930.0	489	6441.0	10	499	6431.0	101	600	6330.0	12	612
LC7C	2210254	595458	6932.0	487	6445.0	18	505	6427.0	92	597	6335.0	10	607
LC9C	2211321	595911	6934.0	492	6442.0	10	502	6432.0	90	592	6342.0	10	602
LC10C	2211706	596006	6950.0	482	6468.0	19	501	6449.0	98	599	6351.0	11	610
LC11C	2213320	595510	6933.0	503	6430.0	3	506	6427.0	119	625	6308.0	11	636
LC12C	2212907	595515	6935.0	500	6435.0	19	519	6416.0	119	638	6297.0	5	643
LC13C	2212030	596105	6948.0	490	6458.0	11	501	6447.0	99	600	6348.0	21	621
LC32W	2215209	597510	6984.3	489	6495.3	15	504	6480.3	115	619	6365.3	17	636
LC33W	2216311	595017	6941.5	456	6485.5	9	465	6476.5	114	579	6362.5	10	589
LC34	2212714	596412	6954.7	493	6461.7	9	502	6452.7	98	600	6354.7	22	622
LC36	2213185	596264	6956.3	470	6486.3	37	507	6449.3	95	602	6354.3	11	613
LC39	2212710	596209	6948.0	472	6476.0	18	490	6458.0	90	580	6368.0	13	593
LC40	2212610	596260	6951.4	492	6459.4	11	503	6448.4	108	611	6340.4	8	619
LC41	2212610	596109	6944.9	467	6477.9	8	475	6469.9	106	581	6363.9	7	588
LC42	2212406	596208	6950.4	481	6469.4	5	486	6464.4	129	615	6335.4	5	620
LC43	2212412	596113	6949.3	474	6475.3	24	498	6451.3	110	608	6341.3	12	620
LC45	2212209	596010	6945.6	469	6476.6	7	476	6469.6	123	599	6346.6	14	613
LC46	2212208	595907	6944.6	464	6480.6	10	474	6470.6	111	585	6359.6	19	604

ft amsl - feet above mean sea level   ft bgs - feet below ground surface   NR - not reached

Boring ID	Elev. Top L Horizon	L Horizon Thickness	Depth to LM Shale	Elev. Top LM Shale	LM Shale Thickness	Depth to M Horizon	Elev. Top M Horizon	M Horizon Thickness	Depth to MN Shale	Elev Top MN Shale	MN Shale Thickness	Depth to N Horizon	Elev. Top N Horizon
	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)
1-13	6187.0	90	873	6097.0	12	885	6085.0	-	NR	NR	-	NR	NR
77-1	6262.0	63	719	6199.0	20	739	6179.0	-	NR	NR	-	NR	NR
83-1	6192.0	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
131-1	6260.0	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
139-3	6236.0	67	747	6169.0	8	755	6161.0	-	NR	NR	-	NR	NR
140-3	6246.0	62	730	6184.0	21	751	6163.0	-	NR	NR	-	NR	NR
HJMU-108	6343.5	97	705	6246.5	9	714	6237.5	-	NR	NR	-	NR	NR
HJMU-109	6254.4	63	748	6191.4	20	768	6171.4	-	NR	NR	-	NR	NR
HJMU-110	6338.6	71	680	6267.6	4	684	6263.6	-	NR	NR	-	NR	NR
HJMU-113	6275.0	78	740	6197.0	5	745	6192.0	-	NR	NR	-	NR	NR
HJT-105	6257.9	75	756	6182.9	16	772	6166.9	-	NR	NR	-	NR	NR
KMP-1	6380.7	86	640	6294.7	32	672	6262.7	-	NR	NR	-	NR	NR
KMU-2	6337.3	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
KMU-3	6339.2	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
KMU-4	6337.9	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
KPW-2	6342.6	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC3	6324.0	85	684	6239.0	15	699	6224.0	-	NR	NR	-	NR	NR
LC6C	6318.0	85	697	6233.0	9	706	6224.0	-	NR	NR	-	NR	NR
LC7C	6325.0	87	694	6238.0	18	712	6220.0	-	NR	NR	-	NR	NR
LC9C	6332.0	96	698	6236.0	14	712	6222.0	-	NR	NR	-	NR	NR
LC10C	6340.0	100	710	6240.0	10	720	6230.0	-	NR	NR	-	NR	NR
LC11C	6297.0	98	734	6199.0	10	744	6189.0	-	NR	NR	-	NR	NR
LC12C	6292.0	85	728	6207.0	10	738	6197.0	-	NR	NR	-	NR	NR
LC13C	6327.0	87	708	6240.0	9	717	6231.0	-	NR	NR	-	NR	NR
LC32W	6348.3	65	701	6283.3	21	722	6262.3	-	NR	NR	-	NR	NR
LC33W	6352.5	85	674	6267.5	12	686	6255.5	-	NR	NR	-	NR	NR
LC34	6332.7	67	689	6265.7	8	697	6257.7	-	NR	NR	-	NR	NR
LC36	6343.3	77	690	6266.3	20	710	6246.3	-	NR	NR	-	NR	NR
LC39	6355.0	93	686	6262.0	16	702	6246.0	-	NR	NR	-	NR	NR
LC40	6332.4	64	683	6268.4	10	693	6258.4	-	NR	NR	-	NR	NR
LC41	6356.9	98	686	6258.9	21	707	6237.9	-	NR	NR	-	NR	NR
LC42	6330.4	77	697	6253.4	13	710	6240.4	-	NR	NR	-	NR	NR
LC43	6329.3	70	690	6259.3	14	704	6245.3	-	NR	NR	-	NR	NR
LC45	6332.6	69	682	6263.6	25	707	6238.6	-	NR	NR	-	NR	NR
LC46	6340.6	77	681	6263.6	20	701	6243.6	-	NR	NR	-	NR	NR

ft amsl - feet above mean sea level ft bgs - feet below ground surface NR - not reached

Boring ID	Easting	Northing	Ground Elevation	Depth to Sagebrush Shale	Elev. Top Sagebrush Shale	Sagebrush Shale thickness	Depth To KM Horizon	Elev. Top KM Horizon	KM Horizon Thickness	Depth to K Shale	Elev. Top K Shale	K Shale Thickness	Depth to L Horizon
	(feet)	(feet)	(ft amsl)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)
LC47	2212110	595808	6941.2	465	6476.2	5	470	6471.2	110	580	6361.2	3	583
LC48	2212037	595739	6943.6	465	6478.6	5	470	6473.6	110	580	6363.6	9	589
LC49	2212210	595715	6939.3	462	6477.3	6	468	6471.3	107	575	6364.3	25	600
LC50	2212315	595813	6939.4	456	6483.4	10	466	6473.4	110	576	6363.4	26	602
LC57	2212613	595812	6940.0	440	6500.0	21	461	6479.0	130	591	6349.0	7	598
LC67	2215237	596764	6964.7	465	6499.7	20	485	6479.7	100	585	6379.7	8	593
LC69	2215223	597124	6977.1	483	6494.1	2	485	6492.1	131	616	6361.1	14	630
LC70	2216291	595237	6945.7	447	6498.7	24	471	6474.7	107	578	6367.7	15	593
LC71	2216324	595124	6943.8	445	6498.8	8	453	6490.8	132	585	6358.8	9	594
LC72	2216324	594905	6940.6	439	6501.6	5	444	6496.6	123	567	6373.6	4	571
LC73	2216496	595227	6943.6	446	6497.6	21	467	6476.6	103	570	6373.6	9	579
LC85	2213301	595315	6939.6	504	6435.6	12	516	6423.6	110	626	6313.6	7	633
LC324	2210320	595205	6918.6	461	6457.6	5	466	6452.6	136	602	6316.6	4	606
LC367	2213457	596805	6957.1	492	6465.1	5	497	6460.1	114	611	6346.1	9	620
LC368	2213355	596977	6960.9	494	6466.9	6	500	6460.9	110	610	6350.9	10	620
LC369	2213254	597150	6963.9	505	6458.9	8	513	6450.9	97	610	6353.9	18	628
LC376	2211824	595712	6944.0	471	6473.0	8	479	6465.0	102	581	6363.0	9	590
LC386	2213052	597495	6969.3	503	6466.3	8	511	6458.3	110	621	6348.3	5	626
LC387	2212953	597664	6972.1	518	6454.1	4	522	6450.1	105	627	6345.1	10	637
LC388	2212850	597840	6973.2	525	6448.2	4	529	6444.2	107	636	6337.2	3	639
LC397	2209720	595805	6940.1	487	6453.1	29	516	6424.1	122	638	6302.1	10	648
LC420	2213402	596888	6958.7	495	6463.7	6	501	6457.7	104	605	6353.7	4	609
LC421	2212810	597930	6971.4	500	6471.4	21	521	6450.4	113	634	6337.4	14	648
LC424	2209721	594706	6915.3	521	6394.3	5	526	6389.3	129	655	6260.3	5	660
LC425	2209320	594705	6922.6	531	6391.6	5	536	6386.6	120	656	6266.6	11	667
LC426	2209320	594305	6925.4	544	6381.4	3	547	6378.4	128	675	6250.4	7	682
LC427	2209746	594268	6916.8	526	6390.8	6	532	6384.8	100	632	6284.8	15	647
LC428	2208920	594305	6929.7	542	6387.7	5	547	6382.7	128	675	6254.7	8	683
LC429	2209715	593460	6914.5	461	6453.5	24	485	6429.5	119	604	6310.5	18	622
LC439	2209820	595903	6941.6	510	6431.6	12	522	6419.6	114	636	6305.6	11	647
LC460	2209284	593436	6918.0	472	6446.0	32	504	6414.0	90	594	6324.0	17	611
LC461	2208884	593222	6916.2	472	6444.2	25	497	6419.2	141	638	6278.2	14	652
LC462	2208920	593507	6925.9	488	6437.9	14	502	6423.9	132	634	6291.9	16	650
LC464	2208120	593507	6921.5	509	6412.5	27	536	6385.5	80	616	6305.5	14	630
LC465	2207720	593105	6914.0	506	6408.0	7	513	6401.0	123	636	6278.0	21	657

ft amsl - feet above mean sea level ft bgs - feet below ground surface NR - not reached

Boring ID	Elev. Top L Horizon	L Horizon Thickness	Depth to LM Shale	Elev. Top LM Shale	LM Shale Thickness	Depth to M Horizon	Elev. Top M Horizon	M Horizon Thickness	Depth to MN Shale	Elev Top MN Shale	MN Shale Thickness	Depth to N Horizon	Elev. Top N Horizon
	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)
LC47	6358.2	94	677	6264.2	3	680	6261.2	-	NR	NR	-	NR	NR
LC48	6354.6	92	681	6262.6	19	700	6243.6	-	NR	NR	-	NR	NR
LC49	6339.3	80	680	6259.3	10	690	6249.3	-	NR	NR	-	NR	NR
LC50	6337.4	65	667	6272.4	9	676	6263.4	-	NR	NR	-	NR	NR
LC57	6342.0	73	671	6269.0	26	697	6243.0	-	NR	NR	-	NR	NR
LC67	6371.7	83	676	6288.7	13	689	6275.7	-	NR	NR	-	NR	NR
LC69	6347.1	72	702	6275.1	11	713	6264.1	-	NR	NR	-	NR	NR
LC70	6352.7	86	679	6266.7	14	693	6252.7	-	NR	NR	-	NR	NR
LC71	6349.8	82	676	6267.8	13	689	6254.8	-	NR	NR	-	NR	NR
LC72	6369.6	89	660	6280.6	7	667	6273.6	-	NR	NR	-	NR	NR
LC73	6364.6	97	676	6267.6	19	695	6248.6	-	NR	NR	-	NR	NR
LC85	6306.6	91	724	6215.6	15	739	6200.6	-	NR	NR	-	NR	NR
LC324	6312.6	67	673	6245.6	6	679	6239.6	-	NR	NR	-	NR	NR
LC367	6337.1	81	701	6256.1	8	709	6248.1	-	NR	NR	-	NR	NR
LC368	6340.9	97	717	6243.9	9	726	6234.9	-	NR	NR	-	NR	NR
LC369	6335.9	94	722	6241.9	8	730	6233.9	-	NR	NR	-	NR	NR
LC376	6354.0	100	690	6254.0	14	704	6240.0	-	NR	NR	-	NR	NR
LC386	6343.3	94	720	6249.3	15	735	6234.3	-	NR	NR	-	NR	NR
LC387	6335.1	89	726	6246.1	6	732	6240.1	-	NR	NR	-	NR	NR
LC388	6334.2	88	727	6246.2	7	734	6239.2	-	NR	NR	-	NR	NR
LC397	6292.1	66	714	6226.1	4	718	6222.1	-	NR	NR	-	NR	NR
LC420	6349.7	93	702	6256.7	8	710	6248.7	-	NR	NR	-	NR	NR
LC421	6323.4	86	734	6237.4	8	742	6229.4	-	NR	NR	-	NR	NR
LC424	6255.3	65	725	6190.3	10	735	6180.3	-	NR	NR	-	NR	NR
LC425	6255.6	63	730	6192.6	3	733	6189.6	-	NR	NR	-	NR	NR
LC426	6243.4	68	750	6175.4	15	765	6160.4	-	NR	NR	-	NR	NR
LC427	6269.8	98	745	6171.8	8	753	6163.8	-	NR	NR	-	NR	NR
LC428	6246.7	62	745	6184.7	5	750	6179.7	-	NR	NR	-	NR	NR
LC429	6292.5	87	709	6205.5	5	714	6200.5	-	NR	NR	-	NR	NR
LC439	6294.6	65	712	6229.6	8	720	6221.6	-	NR	NR	-	NR	NR
LC460	6307.0	99	710	6208.0	10	720	6198.0	-	NR	NR	-	NR	NR
LC461	6264.2	52	704	6212.2	27	731	6185.2	-	NR	NR	-	NR	NR
LC462	6275.9	75	725	6200.9	11	736	6189.9	-	NR	NR	-	NR	NR
LC464	6291.5	99	729	6192.5	5	734	6187.5	-	NR	NR	-	NR	NR
LC465	6257.0	72	729	6185.0	10	739	6175.0	-	NR	NR	-	NR	NR

ft amsl - feet above mean sea level   ft bgs - feet below ground surface   NR - not reached

Boring ID	Easting	Northing	Ground Elevation	Depth to Sagebrush Shale	Elev. Top Sagebrush Shale	Sagebrush Shale thickness	Depth To KM Horizon	Elev. Top KM Horizon	KM Horizon Thickness	Depth to K Shale	Elev. Top K Shale	K Shale Thickness	Depth to L Horizon
	(feet)	(feet)	(ft amsl)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)
LC466	2209719	593105	6903.2	464	6439.2	11	475	6428.2	135	610	6293.2	17	627
LC467	2209324	593908	6927.0	531	6396.0	21	552	6375.0	136	688	6239.0	5	693
LC468	2208120	593105	6916.4	493	6423.4	32	525	6391.4	101	626	6290.4	25	651
LC469	2208521	593104	6916.4	479	6437.4	18	497	6419.4	121	618	6298.4	5	623
LC500	2208920	593105	6912.6	482	6430.6	27	509	6403.6	91	600	6312.6	10	610
LC501	2209321	593102	6905.5	467	6438.5	16	483	6422.5	112	595	6310.5	12	607
LC502	2208120	592706	6905.6	482	6423.6	21	503	6402.6	112	615	6290.6	10	625
LC503	2208520	592705	6907.1	478	6429.1	17	495	6412.1	121	616	6291.1	7	623
LC504	2208921	592691	6903.3	468	6435.3	17	485	6418.3	133	618	6285.3	14	632
LC515	2209349	592709	6894.4	455	6439.4	16	471	6423.4	133	604	6290.4	13	617
LC516	2208921	593906	6928.3	549	6379.3	9	558	6370.3	120	678	6250.3	18	696
LC517	2208889	593626	6927.6	481	6446.6	25	506	6421.6	113	619	6308.6	32	651
LC518	2208968	593225	6915.4	484	6431.4	28	512	6403.4	90	602	6313.4	16	618
LC519	2209722	593907	6920.1	514	6406.1	22	536	6384.1	95	631	6289.1	7	638
LC540	2208405	593520	6923.8	499	6424.8	33	532	6391.8	93	625	6298.8	34	659
LC541	2208925	592877	6907.6	464	6443.6	11	475	6432.6	130	605	6302.6	4	609
LC542	2208921	592501	6896.2	469	6427.2	12	481	6415.2	135	616	6280.2	10	626
LC543	2208330	592703	6907.7	492	6415.7	8	500	6407.7	111	611	6296.7	14	625
LC544	2207705	592907	6912.6	490	6422.6	8	498	6414.6	152	650	6262.6	9	659
LC545	2209514	593908	6925.4	523	6402.4	23	546	6379.4	97	643	6282.4	8	651
LC546	2209116	593102	6909.8	472	6437.8	16	488	6421.8	136	624	6285.8	16	640
LC547	2208730	593102	6913.9	479	6434.9	28	507	6406.9	126	633	6280.9	9	642
LC548	2208524	593315	6921.2	485	6436.2	57	542	6379.2	74	616	6305.2	11	627
LC549	2208963	593806	6928.6	480	6448.6	32	512	6416.6	109	621	6307.6	7	628
LC550	2208830	592899	6909.8	472	6437.8	21	493	6416.8	123	616	6293.8	6	622
LC551	2209219	593086	6907.1	464	6443.1	20	484	6423.1	119	603	6304.1	7	610
LC552	2208980	593756	6927.9	490	6437.9	14	504	6423.9	108	612	6315.9	13	625
LC554	2208366	593742	6925.4	497	6428.4	28	525	6400.4	105	630	6295.4	14	644
LC556	2213337	596199	6954.6	479	6475.6	13	492	6462.6	98	590	6364.6	11	601
LC557	2213722	596203	6951.3	451	6500.3	14	465	6486.3	126	591	6360.3	18	609
LC558	2214122	596227	6954.2	520	6434.2	3	523	6431.2	110	633	6321.2	6	639
LC559	2214522	596438	6959.3	451	6508.3	8	459	6500.3	143	602	6357.3	8	610
LC560	2214919	596600	6960.2	456	6504.2	8	464	6496.2	137	601	6359.2	16	617
LC561	2215322	596600	6961.7	465	6496.7	12	477	6484.7	131	608	6353.7	10	618
LC562	2215720	596702	6967.1	470	6497.1	10	480	6487.1	111	591	6376.1	9	600

ft amsl - feet above mean sea level ft bgs - feet below ground surface NR - not reached

Boring ID	Elev. Top L Horizon	L Horizon Thickness	Depth to LM Shale	Elev. Top LM Shale	LM Shale Thickness	Depth to M Horizon	Elev. Top M Horizon	M Horizon Thickness	Depth to MN Shale	Elev Top MN Shale	MN Shale Thickness	Depth to N Horizon	Elev. Top N Horizon
	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)
LC466	6276.2	63	690	6213.2	34	724	6179.2	-	NR	NR	-	NR	NR
LC467	6234.0	79	772	6155.0	16	788	6139.0	-	NR	NR	-	NR	NR
LC468	6265.4	70	721	6195.4	20	741	6175.4	-	NR	NR	-	NR	NR
LC469	6293.4	103	726	6190.4	6	732	6184.4	-	NR	NR	-	NR	NR
LC500	6302.6	96	706	6206.6	25	731	6181.6	-	NR	NR	-	NR	NR
LC501	6298.5	98	705	6200.5	10	715	6190.5	-	NR	NR	-	NR	NR
LC502	6280.6	91	716	6189.6	13	729	6176.6	-	NR	NR	-	NR	NR
LC503	6284.1	91	714	6193.1	12	726	6181.1	-	NR	NR	-	NR	NR
LC504	6271.3	74	706	6197.3	11	717	6186.3	-	NR	NR	-	NR	NR
LC515	6277.4	72	689	6205.4	14	703	6191.4	-	NR	NR	-	NR	NR
LC516	6232.3	88	784	6144.3	11	795	6133.3	-	NR	NR	-	NR	NR
LC517	6276.6	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC518	6297.4	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC519	6282.1	130	768	6152.1	16	784	6136.1	-	NR	NR	-	NR	NR
LC540	6264.8	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC541	6298.6	90	699	6208.6	9	708	6199.6	-	NR	NR	-	NR	NR
LC542	6270.2	71	697	6199.2	3	700	6196.2	-	NR	NR	-	NR	NR
LC543	6282.7	93	718	6189.7	9	727	6180.7	-	NR	NR	-	NR	NR
LC544	6253.6	71	730	6182.6	11	741	6171.6	-	NR	NR	-	NR	NR
LC545	6274.4	124	775	6150.4	15	790	6135.4	-	NR	NR	-	NR	NR
LC546	6269.8	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC547	6271.9	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC548	6294.2	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC549	6300.6	97	725	6203.6	22	747	6181.6	-	NR	NR	-	NR	NR
LC550	6287.8	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC551	6297.1	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC552	6302.9	88	713	6214.9	6	719	6208.9	-	NR	NR	-	NR	NR
LC554	6281.4	90	734	6191.4	16	750	6175.4	-	NR	NR	-	NR	NR
LC556	6353.6	73	674	6280.6	7	681	6273.6	-	NR	NR	-	NR	NR
LC557	6342.3	59	668	6283.3	29	697	6254.3	-	NR	NR	-	NR	NR
LC558	6315.2	93	732	6222.2	15	747	6207.2	-	NR	NR	-	NR	NR
LC559	6349.3	70	680	6279.3	25	705	6254.3	-	NR	NR	-	NR	NR
LC560	6343.2	53	670	6290.2	16	686	6274.2	-	NR	NR	-	NR	NR
LC561	6343.7	75	693	6268.7	5	698	6263.7	-	NR	NR	-	NR	NR
LC562	6367.1	80	680	6287.1	5	685	6282.1	-	NR	NR	-	NR	NR

ft amsl - feet above mean sea level   ft bgs - feet below ground surface   NR - not reached

Boring ID	Easting	Northing	Ground Elevation	Depth to Sagebrush Shale	Elev. Top Sagebrush Shale	Sagebrush Shale thickness	Depth To KM Horizon	Elev. Top KM Horizon	KM Horizon Thickness	Depth to K Shale	Elev. Top K Shale	K Shale Thickness	Depth to L Horizon
	(feet)	(feet)	(ft amsl)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)
LC563	2215315	596403	6958.0	513	6445.0	6	519	6439.0	119	638	6320.0	5	643
LC564	2213330	596143	6952.4	443	6509.4	25	468	6484.4	136	604	6348.4	10	614
LC577	2204366	592832	6916.3	564	6352.3	14	578	6338.3	108	686	6230.3	7	693
LC591	2214905	595980	6951.3	509	6442.3	9	518	6433.3	99	617	6334.3	3	620
LC598	2213717	596248	6953.3	464	6489.3	7	471	6482.3	124	595	6358.3	15	610
LC599	2213726	596151	6949.9	450	6499.9	11	461	6488.9	129	590	6359.9	10	600
LC615	2214321	595938	6947.7	515	6432.7	3	518	6429.7	125	643	6304.7	5	648
LC616	2214517	595886	6948.0	499	6449.0	5	504	6444.0	143	647	6301.0	5	652
LC619	2214812	595924	6950.5	507	6443.5	5	512	6438.5	111	623	6327.5	4	627
LC620	2214902	596026	6951.1	507	6444.1	10	517	6434.1	106	623	6328.1	10	633
LC621	2215104	596123	6953.3	511	6442.3	5	516	6437.3	104	620	6333.3	2	622
LC622	2215327	595826	6951.2	496	6455.2	12	508	6443.2	127	635	6316.2	13	648
MB-11	2221630	599748	7011.1	424	6587.1	7	431	6580.1	122	553	6458.1	7	560
MB-12A	2204650	596550	6987.2	598	6389.2	11	609	6378.2	103	712	6275.2	17	729
MB-13	2201673	585198	6805.7	457	6348.7	18	475	6330.7	141	616	6189.7	16	632
MU-104	2212009	595501	6937.9	506	6431.9	11	517	6420.9	117	634	6303.9	3	637
MU-107	2210980	595811	6936.1	495	6441.1	7	502	6434.1	97	599	6337.1	9	608
RD436	2211158	595141	6925.0	517	6408.0	7	524	6401.0	109	633	6292.0	10	643
TE17	2204405	595168	6961.0	606	6355.0	8	614	6347.0	92	706	6255.0	14	720
TE18	2204245	593478	6923.0	575	6348.0	9	584	6339.0	128	712	6211.0	18	730
TE22	2203457	594260	6949.0	620	6329.0	15	635	6314.0	110	745	6204.0	15	760
TE69	2204515	593486	6922.0	573	6349.0	9	582	6340.0	128	710	6212.0	13	723
TT7	2205245	594288	6928.0	577	6351.0	13	590	6338.0	100	690	6238.0	20	710
TT28	2204869	593844	6926.0	561	6365.0	9	570	6356.0	105	675	6251.0	7	682
TT37	2209670	595908	6936.0	510	6426.0	10	520	6416.0	106	626	6310.0	17	643
TT43	2209901	594180	6913.0	503	6410.0	26	529	6384.0	123	652	6261.0	4	656
TT45	2208653	593611	6918.0	486	6432.0	21	507	6411.0	133	640	6278.0	11	651
TT46	2208317	593714	6920.0	506	6414.0	5	511	6409.0	117	628	6292.0	8	636
TT51	2206819	593748	6913.0	530	6383.0	20	550	6363.0	83	633	6280.0	24	657
TT52	2206062	593825	6919.0	540	6379.0	5	545	6374.0	138	683	6236.0	9	692
TT57	2204994	593065	6916.0	544	6372.0	7	551	6365.0	123	674	6242.0	15	689
TT82	2207810	594140	6923.0	563	6360.0	6	569	6354.0	101	670	6253.0	20	690
TT101	2207420	594405	6912.0	560	6352.0	10	570	6342.0	114	684	6228.0	5	689
TT106	2206536	594090	6924.0	560	6364.0	7	567	6357.0	100	667	6257.0	17	684
TT132	2205320	593705	6920.0	550	6370.0	10	560	6360.0	110	670	6250.0	8	678

ft amsl - feet above mean sea level   ft bgs - feet below ground surface   NR - not reached

Boring ID	Elev. Top L Horizon	L Horizon Thickness	Depth to LM Shale	Elev. Top LM Shale	LM Shale Thickness	Depth to M Horizon	Elev. Top M Horizon	M Horizon Thickness	Depth to MN Shale	Elev Top MN Shale	MN Shale Thickness	Depth to N Horizon	Elev. Top N Horizon
	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)
LC563	6315.0	80	723	6235.0	6	729	6229.0	-	NR	NR	-	NR	NR
LC564	6338.4	65	679	6273.4	3	682	6270.4	-	NR	NR	-	NR	NR
LC577	6223.3	99	792	6124.3	6	798	6118.3	-	NR	NR	-	NR	NR
LC591	6331.3	110	730	6221.3	12	742	6209.3	-	NR	NR	-	NR	NR
LC598	6343.3	75	685	6268.3	15	700	6253.3	-	NR	NR	-	NR	NR
LC599	6349.9	69	669	6280.9	11	680	6269.9	-	NR	NR	-	NR	NR
LC615	6299.7	77	725	6222.7	10	735	6212.7	-	NR	NR	-	NR	NR
LC616	6296.0	85	737	6211.0	15	752	6196.0	-	NR	NR	-	NR	NR
LC619	6323.5	105	732	6218.5	10	742	6208.5	-	NR	NR	-	NR	NR
LC620	6318.1	103	736	6215.1	10	746	6205.1	-	NR	NR	-	NR	NR
LC621	6331.3	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC622	6303.2	63	711	6240.2	6	717	6234.2	-	NR	NR	-	NR	NR
MB-11	6451.1	82	642	6369.1	32	674	6337.1	-	NR	NR	-	NR	NR
MB-12A	6258.2	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
MB-13	6173.7	82	714	6091.7	32	746	6059.7	-	NR	NR	-	NR	NR
MU-104	6300.9	100	737	6200.9	10	747	6190.9	-	NR	NR	-	NR	NR
MU-107	6328.1	92	700	6236.1	5	705	6231.1	-	NR	NR	-	NR	NR
RD436	6282.0	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TE17	6241.0	105	825	6136.0	12	837	6124.0	-	NR	NR	-	NR	NR
TE18	6193.0	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TE22	6189.0	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TE69	6199.0	65	788	6134.0	4	792	6130.0	-	NR	NR	-	NR	NR
TT7	6218.0	82	792	6136.0	16	808	6120.0	-	NR	NR	-	NR	NR
TT28	6244.0	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TT37	6293.0	77	720	6216.0	17	737	6199.0	-	NR	NR	-	NR	NR
TT43	6257.0	68	724	6189.0	6	730	6183.0	-	NR	NR	-	NR	NR
TT45	6267.0	86	737	6181.0	7	744	6174.0	-	NR	NR	-	NR	NR
TT46	6284.0	104	740	6180.0	7	747	6173.0	-	NR	NR	-	NR	NR
TT51	6256.0	88	745	6168.0	9	754	6159.0	-	NR	NR	-	NR	NR
TT52	6227.0	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TT57	6227.0	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TT82	6233.0	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TT101	6223.0	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TT106	6240.0	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TT132	6242.0	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR

ft amsl - feet above mean sea level   ft bgs - feet below ground surface   NR - not reached

Boring ID	Easting	Northing	Ground Elevation	Depth to Sagebrush Shale	Elev. Top Sagebrush Shale	Sagebrush Shale thickness	Depth To KM Horizon	Elev. Top KM Horizon	KM Horizon Thickness	Depth to K Shale	Elev. Top K Shale	K Shale Thickness	Depth to L Horizon
	(feet)	(feet)	(ft amsl)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)
UKMU-102A	2212430	595846	6940.8	459	6481.8	8	467	6473.8	127	594	6346.8	13	607
UKMU-103	2212811	596259	6950.9	485	6465.9	9	494	6456.9	96	590	6360.9	8	598
5S-KM1	2213950	595640	6945.7	490	6455.7	30	520	6425.7	-	NR	NR	-	NR
5S-KM2	2214046	595610	6945.7	490	6455.7	18	508	6437.7	-	NR	NR	-	NR
5S-KM3	2213986	595579	6945.3	485	6460.3	27	512	6433.3	-	NR	NR	-	NR
5S-KM4	2213955	595563	6944.9	488	6456.9	27	515	6429.9	-	NR	NR	-	NR
5S-N1	2213940	595615	6945.5	490	6455.5	25	515	6430.5	115	630	6315.5	25	655
KMU-1	2214011	595543	6944.6	485	6459.6	27	512	6432.6	116	628	6316.6	17	645
LC103	2213619	595403	6942.1	485	6457.1	33	518	6424.1	-	NR	NR	-	NR
LC309	2214217	595397	6940.8	478	6462.8	28	506	6434.8	-	NR	NR	-	NR
LC322	2214115	595396	6939.6	479	6460.6	36	515	6424.6	-	NR	NR	-	NR
LC323	2214014	595494	6940.7	481	6459.7	30	511	6429.7	-	NR	NR	-	NR
LC479	2213768	595344	6941.4	481	6460.4	32	513	6428.4	-	NR	NR	-	NR
LC495	2213767	595246	6940.2	479	6461.2	26	505	6435.2	-	NR	NR	-	NR
LC553	2213922	595824	6946.9	500	6446.9	25	525	6421.9	111	636	6310.9	9	645
LC575	2214320	595833	6946.7	505	6441.7	15	520	6426.7	120	640	6306.7	5	645
LC583	2214513	595768	6946.1	482	6464.1	28	510	6436.1	128	638	6308.1	22	660
LC584	2214516	595661	6944.4	480	6464.4	25	505	6439.4	120	625	6319.4	38	663
LC613	2213924	595875	6946.7	500	6446.7	15	515	6431.7	115	630	6316.7	15	645
LC614	2214128	595822	6948.8	505	6443.8	17	522	6426.8	123	645	6303.8	3	648
LC88	2214009	595391	6940.8	478	6462.8	29	507	6433.8	-	NR	NR	-	NR
LC89	2214009	595308	6939.8	473	6466.8	39	512	6427.8	-	NR	NR	-	NR
LC90	2214045	595211	6939.2	475	6464.2	31	506	6433.2	-	NR	NR	-	NR
LC91	2213916	595402	6942.0	482	6460.0	34	516	6426.0	-	NR	NR	-	NR
LC92	2213915	595210	6940.8	478	6462.8	35	513	6427.8	-	NR	NR	-	NR
LC937	2213699	595800	6944.5	500	6444.5	30	530	6414.5	110	640	6304.5	9	649
LC938	2213800	595799	6946.8	498	6448.8	27	525	6421.8	105	630	6316.8	6	636
LC94	2213823	595405	6941.8	484	6457.8	28	512	6429.8	-	NR	NR	-	NR
LC95	2213817	595303	6940.2	490	6450.2	20	510	6430.2	-	NR	NR	-	NR
LC972C	2214040	595187	6939.5	486	6453.5	22	508	6431.5	107	615	6324.5	32	647
LC99	2213723	595402	6940.7	480	6460.7	35	515	6425.7	-	NR	NR	-	NR
M-L1	2213855	595210	6938.9	477	6461.9	31	508	6430.9	109	617	6321.9	18	635
M-M1	2213989	595526	6943.9	485	6458.9	30	515	6428.9	115	630	6313.9	15	645
M-M2	2213830	595194	6939.5	475	6464.5	35	510	6429.5	105	615	6324.5	13	628
M-M3	2214552	595550	6944.9	475	6469.9	30	505	6439.9	115	620	6324.9	30	650
M-N1	2213777	595217	6940.2	472	6468.2	31	503	6437.2	118	621	6319.2	13	634
M-UKM1	2214017	595516	6944.0	475	6469.0	40	515	6429.0	-	NR	NR	-	NR

Boring ID	Elev. Top L Horizon	L Horizon Thickness	Depth to LM Shale	Elev. Top LM Shale	LM Shale Thickness	Depth to M Horizon	Elev. Top M Horizon	M Horizon Thickness	Depth to MN Shale	Elev Top MN Shale	MN Shale Thickness	Depth to N Horizon	Elev. Top N Horizon
	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)
UKMU-102A	6333.8	68	675	6265.8	17	692	6248.8	-	NR	NR	-	NR	NR
UKMU-103	6352.9	95	693	6257.9	29	722	6228.9	-	NR	NR	-	NR	NR
5S-KM1	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
5S-KM2	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
5S-KM3	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
5S-KM4	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
5S-N1	6290.5	60	715	6230.5	25	740	6205.5	95	835	6110.5	5	840	#REF!
KMU-1	6299.6	-	715	6229.6	-	NR	NR	-	NR	NR	-	NR	NR
LC103	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC309	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC322	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC323	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC479	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC495	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC553	6301.9	75	720	6226.9	30	750	6196.9	97	847	6099.9	3	850	#REF!
LC575	6301.7	80	725	6221.7	25	750	6196.7	85	835	6111.7	10	845	#REF!
LC583	6286.1	50	710	6236.1	30	740	6206.1		NR	NR	-	NR	NR
LC584	6281.4	44	707	6237.4	33	740	6204.4		NR	NR	-	NR	NR
LC613	6301.7	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC614	6300.8	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC88	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC89	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC90	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC91	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC92	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC937	6295.5	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC938	6310.8	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC94	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC95	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
LC972C	6292.5	54	701	6238.5	29	730	6209.5	28	758	6181.5	-	NR	NR
LC99	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
M-L1	6303.9	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
M-M1	6298.9	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
M-M2	6311.5	81	709	6230.5	38	747	6192.5	23	770	6169.5	-	NR	NR
M-M3	6294.9	50	700	6244.9	45	745	6199.9	20	765	6179.9	-	NR	NR
M-N1	6306.2	76	710	6230.2	43	753	6187.2	97	850	6090.2	-	NR	NR
M-UKM1	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR

Attachment A. Elevation and Thickness of Stratigraphic Units, Lost Creek Uranium ISR Project

Boring ID	Easting	Northing	Ground Elevation	Depth to Sagebrush Shale	Elev. Top Sagebrush Shale	Sagebrush Shale thickness	Depth To KM Horizon	Elev. Top KM Horizon	KM Horizon Thickness	Depth to K Shale	Elev. Top K Shale	K Shale Thickness	Depth to L Horizon
	(feet)	(feet)	(ft amsl)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)
M-M2	2213830	595194	6939.5	475	6464.5	35	510	6429.5	105	615	6324.5	13	628
M-M3	2214552	595550	6944.9	475	6469.9	30	505	6439.9	115	620	6324.9	30	650
M-N1	2213777	595217	6940.2	472	6468.2	31	503	6437.2	118	621	6319.2	13	634
M-UKM1	2214017	595516	6944.0	475	6469.0	40	515	6429.0	-	NR	NR	-	NR
TG13-20	2213713	595719	6945.4	495	6450.4	20	515	6430.4	-	NR	NR	-	NR
TG14-20	2213709	595523	6945.2	498	6447.2	29	527	6418.2	-	NR	NR	-	NR
TG16-20	2214123	595317	6941.2	475	6466.2	27	502	6439.2	-	NR	NR	-	NR
TG17-20	2214115	595518	6943.0	480	6463.0	30	510	6433.0	-	NR	NR	-	NR
TG18-20	2214115	595721	6946.3	482	6464.3	38	520	6426.3	-	NR	NR	-	NR
TG66-20	2213914	595321	6940.4	485	6455.4	28	513	6427.4	-	NR	NR	-	NR
TG67-20	2213920	595505	6939.0	488	6451.0	27	515	6424.0	-	NR	NR	-	NR
TG68-20	2213909	595722	6946.2	492	6454.2	38	530	6416.2	-	NR	NR	-	NR
TG70-20	2214320	595505	6941.0	480	6461.0	30	510	6431.0	-	NR	NR	-	NR

ft amsl - feet above mean sea level   ft bgs - feet below ground surface   NR - not reached

Boring ID	Elev. Top L Horizon	L Horizon Thickness	Depth to LM Shale	Elev. Top LM Shale	LM Shale Thickness	Depth to M Horizon	Elev. Top M Horizon	M Horizon Thickness	Depth to MN Shale	Elev Top MN Shale	MN Shale Thickness	Depth to N Horizon	Elev. Top N Horizon
	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)	(feet)	(ft bgs)	(ft amsl)
M-M2	6311.5	81	709	6230.5	38	747	6192.5	23	770	6169.5	-	NR	NR
M-M3	6294.9	50	700	6244.9	45	745	6199.9	20	765	6179.9	-	NR	NR
M-N1	6306.2	76	710	6230.2	43	753	6187.2	97	850	6090.2	-	NR	NR
M-UKM1	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TG13-20	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TG14-20	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TG16-20	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TG17-20	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TG18-20	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TG66-20	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TG67-20	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TG68-20	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR
TG70-20	NR	-	NR	NR	-	NR	NR	-	NR	NR	-	NR	NR

ft amsl - feet above mean sea level ft bgs - feet below ground surface NR - not reached

Attachment B

Input and Output Files
KM Horizon Numerical Model
Lost Creek Uranium Project

January 2016

The following folders are included on the disc (shown in italics). The root file name for each model simulation that is included in the folder is shown beneath the folder name (and underlined). All of the associated MODFLOW input and output file as well as the Groundwater Vistas file (rootfilename.gwv) are included in the indicated folder. Groundwater Vistas Version 6.80 Build 12, (64 bit version) was used to generate the input files and run the simulations using MODFLOW2000. The basemaps showing fault locations, permit boundaries, mine unit and wellfield outlines are provided for ease of orientation and viewing of the model setup in Groundwater Vistas and are already in the native format for that application (*.map).

Calibration Simulations

KM_Model_FinalCalib_121015.*

Production Simulations

KM_Model_Lower_Prod_20gpm_1%Bleed.*
KM_Model_Lower_GWS_10gpm.*
KM_Model_Middle_Prod_20gpm_1%Bleed.*
KM_Model_Middle_GWS_10gpm.*
KM_Model_Upper_Prod_20gpm_1%Bleed.*
KM_Model_Upper_GWS_10gpm.*

Excursion Simulations

KM_Model_Excurson.*
KM_Model_Excurson_GWSRecovery1.*
KM_Model_Excurson_GWSRecovery2.*

Basemaps