DRAFT REPORT

Sentinel Well Installation Work Plan

Landsburg Mine Site

Submitted to:

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Submitted by:

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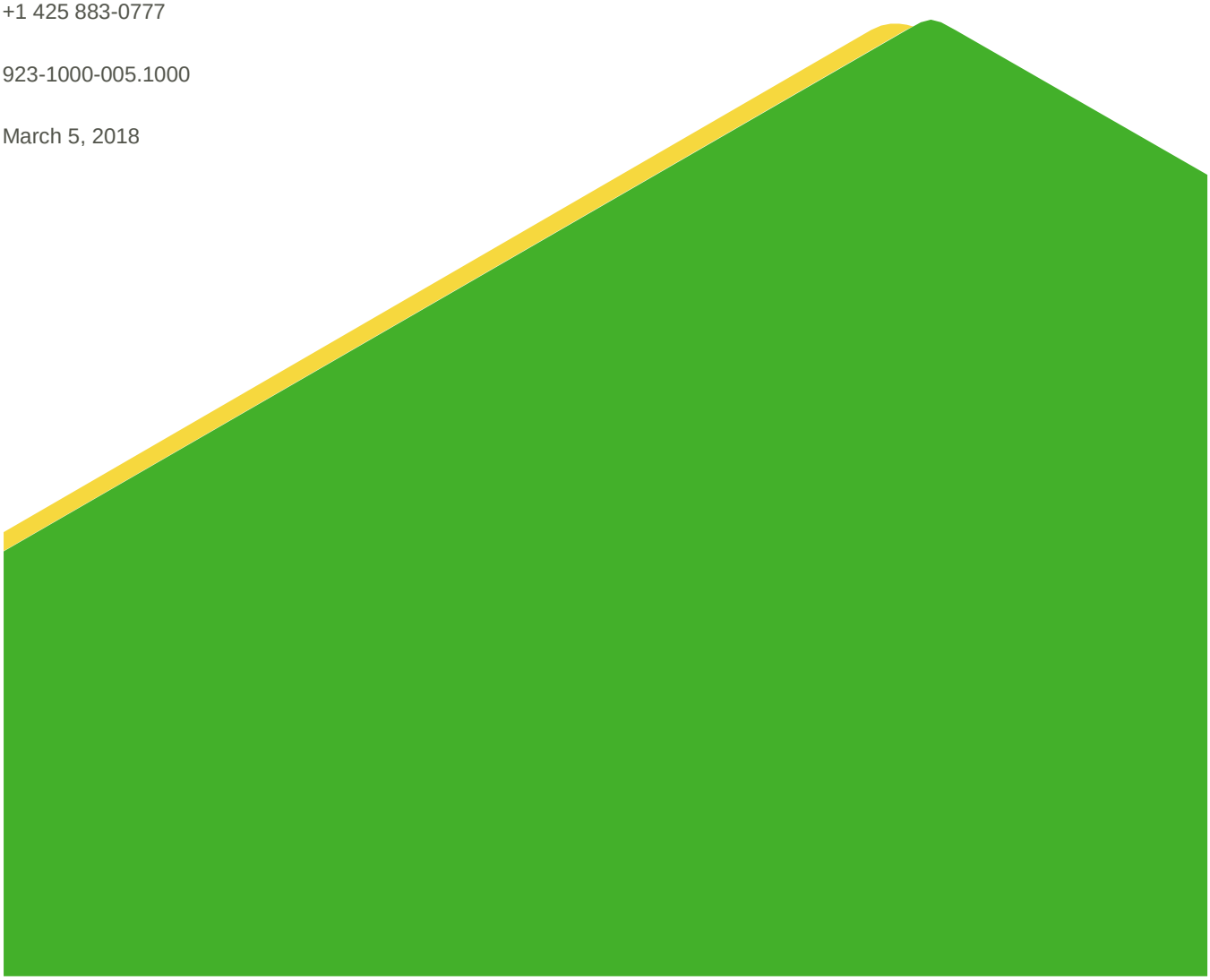

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1.0 INTRODUCTION

1.1 General

This work plan describes the procedures that will be used to drill and install four additional groundwater monitoring wells at the Landsburg Mine Site (the Site). The Site is a Washington State Model Toxics Control Act (MCTA) listed site, administered by the Washington State Department of Ecology (Ecology). Installation of the wells is being conducted in accordance with the requirements of the Final Cleanup Action Plan (CAP) (Ecology 2017). The four additional groundwater monitoring wells are referred to as "sentinel wells" within the CAP, because they will be used as an early warning for impacted groundwater migration.

The purpose, rationale, and justification for the sentinel well locations and proposed monitored depth intervals are detailed in the CAP (Ecology 2017). The Compliance Monitoring Plan (CMP), which is Part A of the CAP, specifies the groundwater monitoring requirements for all Site wells, including the four new sentinel wells discussed in this work plan. As such, this information is provided by reference only within this work plan.

In general, the primary items addressed in this Work Plan include the following:

- Summary of the Site location and background
- Description of the proposed sentinel well locations, drilling methods, well installation and construction details, well surveying, and water level monitoring program following installation

1.2 Location and Background of the Project

The Site consists of a former underground coal mine located approximately 1.5 miles northwest of Ravensdale in a rural area of southeast King County, Washington. The Site is situated directly south and east of the S.E. Summit-Landsburg Road, and north of the S.E. Kent-Kangley Road. The Cedar River passes within approximately 700 feet of the Site to the north. The location of the Site is shown in Figure 1. The topography of the Site and general Site features are depicted in Figure 2.

The coal seam under study at the Site is named the Rogers Seam, which had active mining operations from 1959 to 1975. The mined section of the Rogers Seam has a near vertical dip and consists of coal and interbedded shale approximately 16 feet wide. The mined section is about a mile in length. Mining occurred at depths up to 750 feet below the ground surface. Figure 3 shows a cross-section along the strike of the Rogers coal seam. Mining was accomplished by causing the coal seam to cave into mine workings (locally called "booming"), from which the coal was hauled to the surface. As a result of this caving, subsidence trenches developed on the land surface above the mine workings. Based on available information, the northern portions of these trenches from the Summit-Landsburg Road (depicted in Figure 4) were used in the late 1960s to the late 1970s for disposal of various industrial waste materials, construction materials, and land-clearing debris.

Various investigations, including completion of a MTCA remedial investigation and feasibility study (RI/FS) were completed at the site from 1991 to 1996 (Golder 1996). Subsequent to completion of the RI/FS, additional groundwater monitoring wells and hydrogeologic studies were completed in support of the final selected remedial action, which is detailed within the CAP (Ecology 2017). The selected remedial action includes the installation of four groundwater sentinel wells for inclusion in the Site's protection and confirmational monitoring programs. Details of the Site's groundwater monitoring program are provided in the CMP (Part A of the CAP [Ecology 2017]).

1.3 Geology and Hydrogeology

The surface soils at the top of the site are typically a glacial till consisting of dense sand and gravel with silt. The till is usually relatively thin near the top of the hill. Underlying the till is the bedrock. The bedrock lithology consists of interbedded shales, siltstones, and sandstones with coal seams. The lithologic bedrock units are dipping to the west at approximately 65 to 70 degrees from horizontal on the south end of the Site and approximately 85 to 95 from horizontal (near vertical) on the northern end of the Site. The potential exists for large voids to be present within the mine workings. The mine workings have relatively high hydraulic conductivity, and the fine-grained Puget Group sediments located to either side of the seam are at least several orders of magnitude less permeable than the mined out seam. The coal mine workings are filled with collapsed rubble (and potential voids), are very permeable. Previous drilling at the site in the bedrock has produced little groundwater until the mine workings or coal seam is encountered.

Within the former mine workings, the depth to groundwater varies from about 160 feet below the ground surface in the central portion of the Site to near zero at either end. The variability in depth to water is primarily a function of changes in topography and hydraulic gradient. The groundwater within the Rogers Seam occurs under water table or unconfined conditions as any potential confining layers are now absent due to mining. Bedrock groundwater elsewhere in the Study Area may occur locally under confined to semi-confined conditions due to the presence of till which mantles much of the area or from lower permeability lithologies lying over more permeable lithologies. Groundwater is present at land surface at both Portal #2, located at the north end of the mine, and Portal #3, located at the south end of the mine. Groundwater flow in the north portion of the Rogers Seam is towards the north as observed by groundwater elevations in monitoring wells LMW-1, LMW-2, LMW-4 and LMW-10 that are located to the south and north of Portal #2 in the Rogers Seam. The groundwater flow direction along the southern portion of the Rogers Coal Mine is toward the south from the mine. The flow of groundwater from the Rogers Mine toward the south reveals that a groundwater divide exists within the mine. Groundwater potentiometric head measurements indicate that the groundwater divide exists near the south end of the mine.

There are currently ten groundwater monitoring wells routinely monitored at the Site (LMW-2 through LMW-11). Figure 2 shows the location of the existing Site monitoring wells, and Figure 3 is a cross-section that shows the monitored depth intervals of the existing wells. In addition to these ten monitoring wells, LMW-1 and LMW-1A and P-2 are used to measure water levels. The construction details for all current Site groundwater monitoring wells are summarized in Table 1. The proposed locations and monitored depth intervals of the four additional sentinel wells were selected in the CAP to augment the existing Site monitoring wells. The final monitoring well network will further refine groundwater gradients within the Rogers mine seam, and provide for early detection should mine waste contaminants be released from the mine.

2.0 MONITORING WELL DRILLING AND INSTALLATION

The sentinel wells will be drilled and installed in accordance with Golder Technical Guidelines TG-1.2-12 *Monitoring Well Drilling and Installation* and TG-1.2 6 *Soil Description System*. Upon well completion, sampling and water level measurements will be conducted in accordance with the approved procedures detailed in the CMP (Part A of the CAP [Ecology 2017]) and associated Quality Assurance Project Plan (QAPP). The Health and Safety Plan contained within the CMP will be augmented to address potential health and safety risks specific to drilling activities. Table 2 presents the proposed drilling depths and well construction details for the four sentinel wells. Figure 4 shows the well locations, and Figure 3 shows the well locations and depths along the cross-section of the Rogers mine seam.

In order to intercept the targeted depths within the Rogers Coal Mine, the two sentinel wells located south of the waste disposal area (LMW-14 and LMW-15) will require drilling at an angle. It is anticipated that a drill angle of 20 degrees from vertical (inclination of 70 degrees from horizontal) will be necessary to position the boreholes a safe distance from the western edge of the surface subsidence trench. This is a similar angled drilling method that used was during the RI for monitoring wells LMW-4 and LMW-7.

The boreholes will be drilled, by a Washington State licensed driller, using a roto-sonic drilling method. The borehole will be drilled at either a 10 or 8 inch diameter. The roto-sonic drilling method collects continuous cores. A Golder geologist will inspect the cores to evaluate the soil/bedrock lithology, create the borehole log, and evaluate the depth when the mine workings are encountered. Drilling will extend in each hole until the targeted depth is reached and the borehole is cleared to permit monitoring well construction.

The northern sentinel wells will be constructed of 4-inch diameter polyvinyl chloride (PVC) screens and flush-threaded PVC riser casing. The southern sentinel wells will be constructed of 2-inch diameter PVC screens and flush-threaded PVC riser casing. The larger diameter of the northern sentinel wells would allow groundwater extraction from these wells for hydraulic containment, if necessary. The anticipated screen length will be 10 feet (0.02 inch slot size). The screened intervals will be gravel packed with coarse silica sand properly sized for the screen slot size. The borehole annulus above each screen section will be sealed with bentonitic cement grout or a bentonite clay seal to land surface. A protective lockable steel monument will be installed for secured access at the well port. The well will have a dedicated sampling pump installed for subsequent sampling efforts. Figure 5 illustrates a typical monitoring well construction.

Investigative derived waste (IDW) will include drill cuttings and groundwater removed during drilling and development of the sentinel wells. Soil and rock contamination is not expected to be encountered, but all cores will be placed on plastic and field inspected for odors, staining or unusual discoloration, and screened for volatile organic compounds (VOCs) using a photo-ionization detector (PID). Groundwater produced during drilling will be captured and contained on-site. The results of the groundwater sampling and analyses will be used to determine proper disposal requirements for the captured groundwater IDW and whether the captured soil IDW needs further characterization for disposal.

A Washington State licensed land surveyor will conduct the geodetic survey. After installation, the sentinel wells will be surveyed for horizontal position (x- and y- coordinates) and elevation (z- coordinate) to the same benchmark established for the other Landsburg Mine Site monitoring wells. The horizontal survey will be in conformance with “Third-Order” accuracy and precision using differential Global Positioning System (GPS). Elevation survey will be to within 0.01 foot accuracy and precision using land surveying transects from existing Site groundwater monitoring wells.

Groundwater levels will be allowed to stabilize for at least one week before a measurement is obtained in the new sentinel wells and existing monitoring wells and piezometers in the vicinity of the Landsburg Mine. Groundwater levels will be measured using an electric water level tape. Groundwater levels will be obtained in triplicate for precision evaluations and will be converted to groundwater elevation based on the surveyed wellhead elevations. Water level measurements will be obtained in accordance with the procedures detailed in the approved CMP (Part A of the CAP [Ecology 2017]).

The completed sentinel wells will be incorporated into the groundwater monitoring programs as specified in the CAP. In addition to the monitoring specified in the CAP and CMP, the Landsburg PLP Group will work with Ecology on the scope for any targeted groundwater monitoring specific to assessing the initial groundwater quality in the new sentinel wells.

3.0 REPORTING

A technical report will be prepared following completion of the monitoring well installation, water level measurements, data collection, and sample analysis. The report will contain the following:

- Summary of field investigations and data generated.
- Analysis and interpretation of the new data including but not limited to:

1) Geologic log and well installation diagram
2) Survey result
3) Groundwater elevation
4) Groundwater elevation maps and flow directions
5) Groundwater quality results

Golder Associates Inc.

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Principal

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Douglas Dunster
Principal

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TABLES

Table 1: Landsburg Mine Site Existing Monitoring Well Details

Well ID	Coordinates		Installation Date	Measuring Point Elevation (ft)	Borehole Depth (ft)	Borehole Diameter (inches)	Well Casing Diameter (inches)	Well Materials	Depth to Top of Screen (ft)	Depth to Bottom of Screen (ft)	Screen Slot Size (inches)	Depth to Top of Filter Pack (ft)	Comments
	Northing	Easting											
LMW-1	138279.4	1354991.4	34357	765.16	180	8	4	Stainless/PVC	162	177	0.02	158	In area of gangway that connects mine fault off-set
LMW-1A	138322.87	1354997.2	34372	763.18	220	8	2	PVC	129	149	0.02	n/a	Only for water levels
LMW-2	139076.87	1355972.6	34376	617.73	46	8	4	Stainless/PVC	28	38	0.02	25	Shallow north compliance
LMW-3	135192.23	1353220.4	38313	656.75	76	8	4	Stainless/PVC	50	65	0.02	47	Shallow south compliance
LMW-4	139122.48	1355864.9	34384	619.26	233	8	4	Stainless/PVC	195	210	0.02	210	Deep north compliance
LMW-5	135206.05	1353141.3	38329	658.27	247	8	4	Stainless/PVC	232	242	0.02	232	Deep south compliance
LMW-6	138772.683	1714004.8	34347	632.33	106	8	4	Stainless/PVC	91	106	0.02	83	Frasier Coal Seam
LMW-7	138055.1	1355483.6	34344	771.51	254	8	4	Stainless/PVC	240	254	0.02	n/a	Landsburg Coal Seam
LMW-8	135074.898	1353229.4	38084	646.97	15	9	2	PVC	7.5	13	0.02	6	Representative of Portal #3 discharge, before daylighting
LMW-9	135727.33	1353324	38091	743.99	160	9	2	PVC	149	159	0.02	144	Southern Sentinel Well mid-depth
LMW-10	139054.3	1355787.9	38118	618.87	450	9	4	PVC	267	287	0.02	258	Deep, near bottom of mine, northern end
LMW-11			38588	801.87	707	9	4	Stainless/PVC	697	707	0.02	688	Deep, near bottom of mine, south end
P-2	135117.598	1353212.7	38093	651.37	70	9	2	PVC	39	44	0.02	*n/a	Representative of Portal #3 discharge, before daylighting

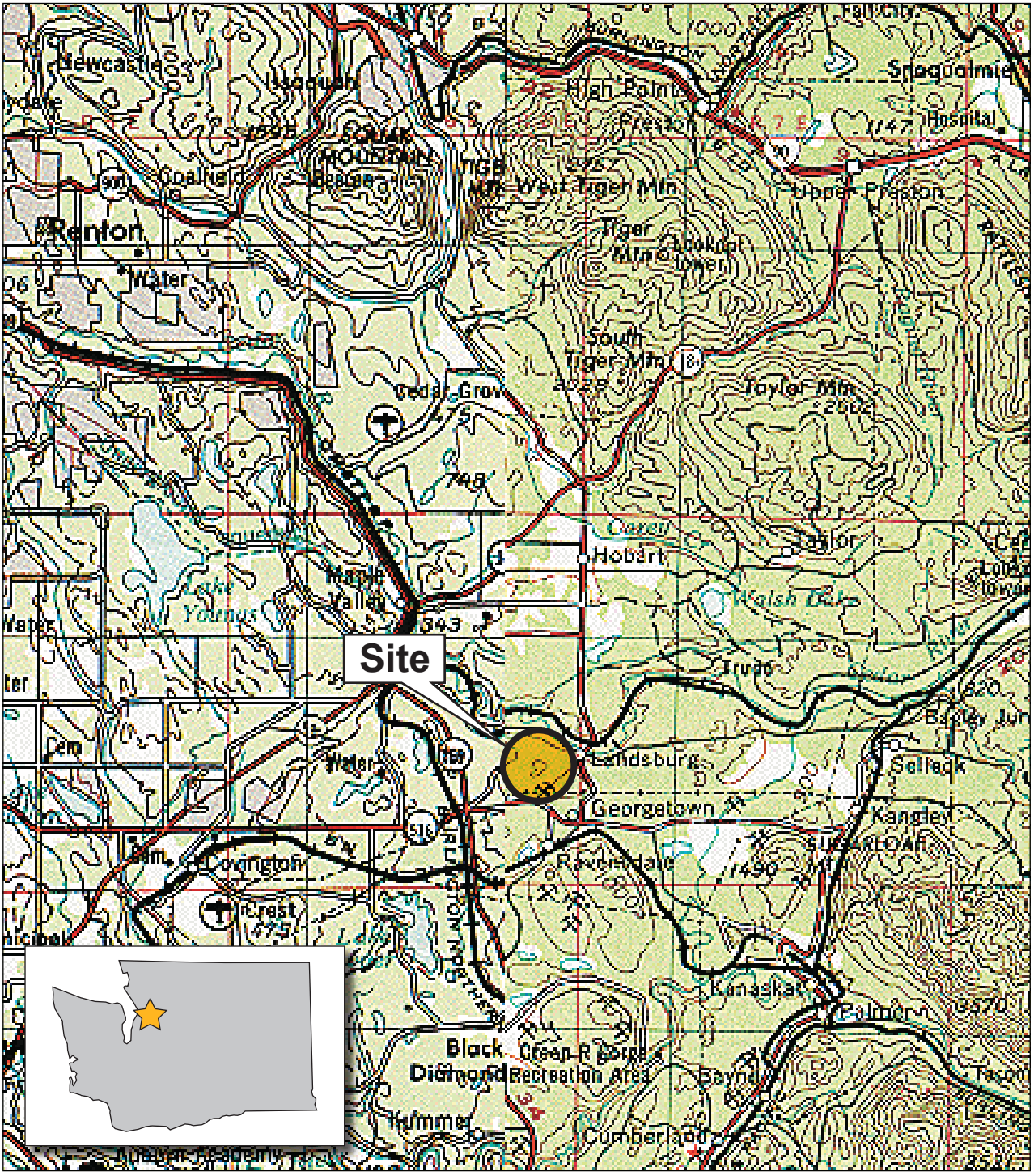
Note:
* No filter pack was installed in P-2 due to the open mine shaft at 39 feet to 44 feet. The casing was removed, and the native material collapsed around the well to 15 feet below ground surface.

Table 2: Sentinel Wells Proposed Construction Details

Sentinel Well	Well ID	Approx. Ground Surface Elevation	Approx. Depth to Water (feet bgs)	Approx. Well Depth Vertical (feet bgs)	Screen Interval (ft bgs)	Proposed Drilling Angle	Total Drilling Footage[(1)]	Screen Length (feet)	Well Diameter	Well Location Northing/Easting[(2)]
Shallow North	LMW-12	620	6 to 8	<30	20 to 30	90	30	10	4	
Deep North	LMW-13	620	SWL 6 to 8	150	140 to 150	90	150	10	4	
South/Cap Effectiveness	LMW-14	800	167	175	165 to 175	70	186	10	2	
South Shallow (near LMW-11)	LMW-15	800	157	165	155 to 165	70	176	10	2	

Notes:
(1) - For angle holes, calculating the hypotenuse
(2) - Proposed location, actual location may be adjusted in the field as necessary to position drill rig
See Figure X for typical well construction details.

FIGURES



Source: USGS 1:250,000 Sheets,Seattle and Wenatchee

0 8000

SCALE IN FEET

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CLIENT

PALMER COKING COAL COMPANY, LLP

CONSULTANT

GOLDER

YYYY-MM-DD	2018-02-27
PREPARED	REDMOND
DESIGN	
REVIEW	
APPROVED	

PROJECT

LANDSBURG MINE SITE

TITLE

SITE LOCATION

PROJECT No.	PHASE	FIGURE
923-1000	002	1

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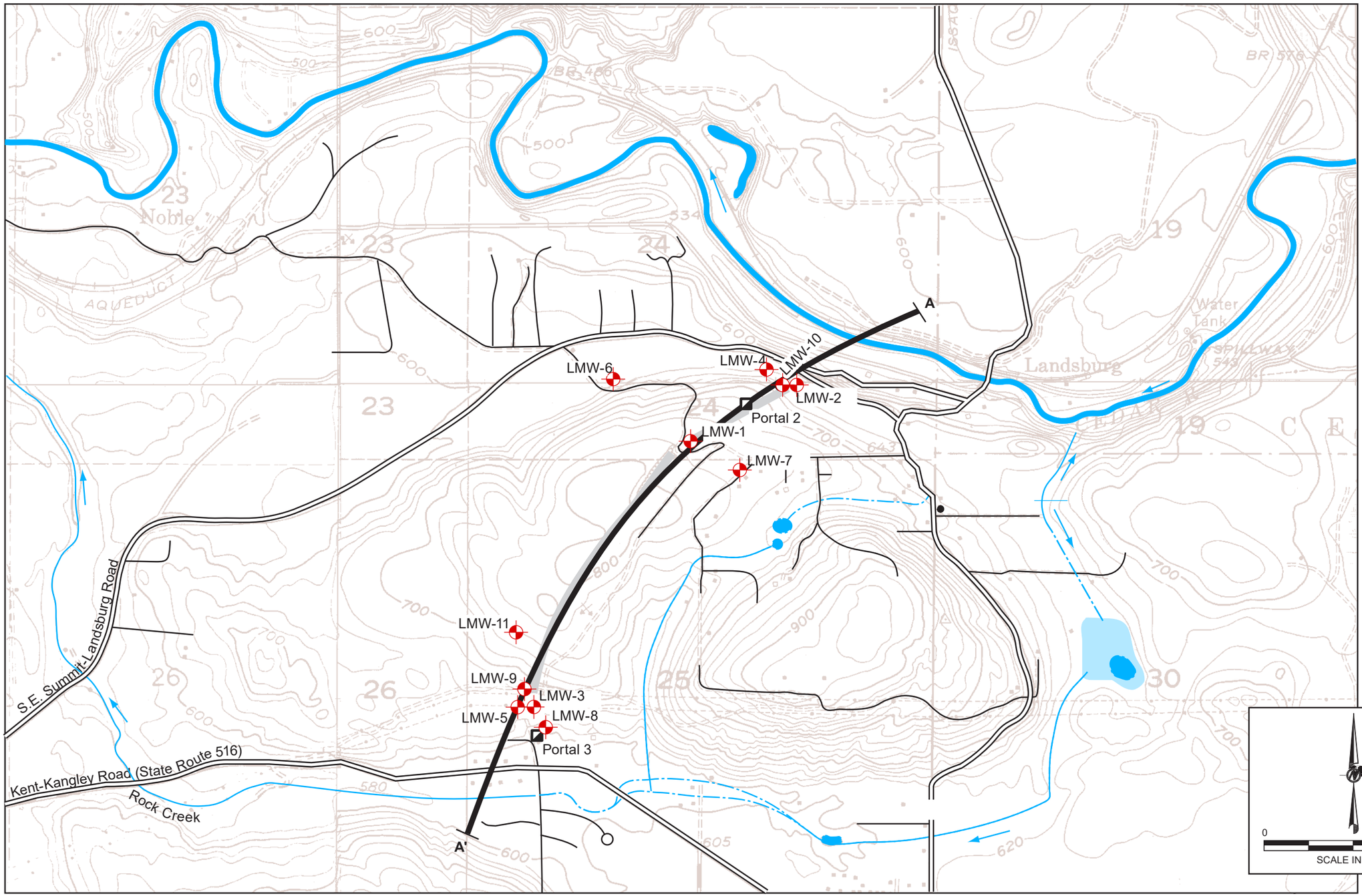

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Base map from USGS 7.5' topographic quadrangles "Cumberland" and "Hobart".

CLIENT	PALMER COKING COAL COMPANY, LLP
CONSULTANT	GOLDER
YYYY-MM-DD	2018-02-27
PREPARED	REDMOND
DESIGN	
REVIEW	
APPROVED	
PROJECT	LANDSBURG MINE SITE
TITLE	**SITE FEATURES AND MAP VIEW FOR LANDSBURG CROSS-SECTION**
PROJECT No.	923-1000
PHASE	002
FIGURE	2

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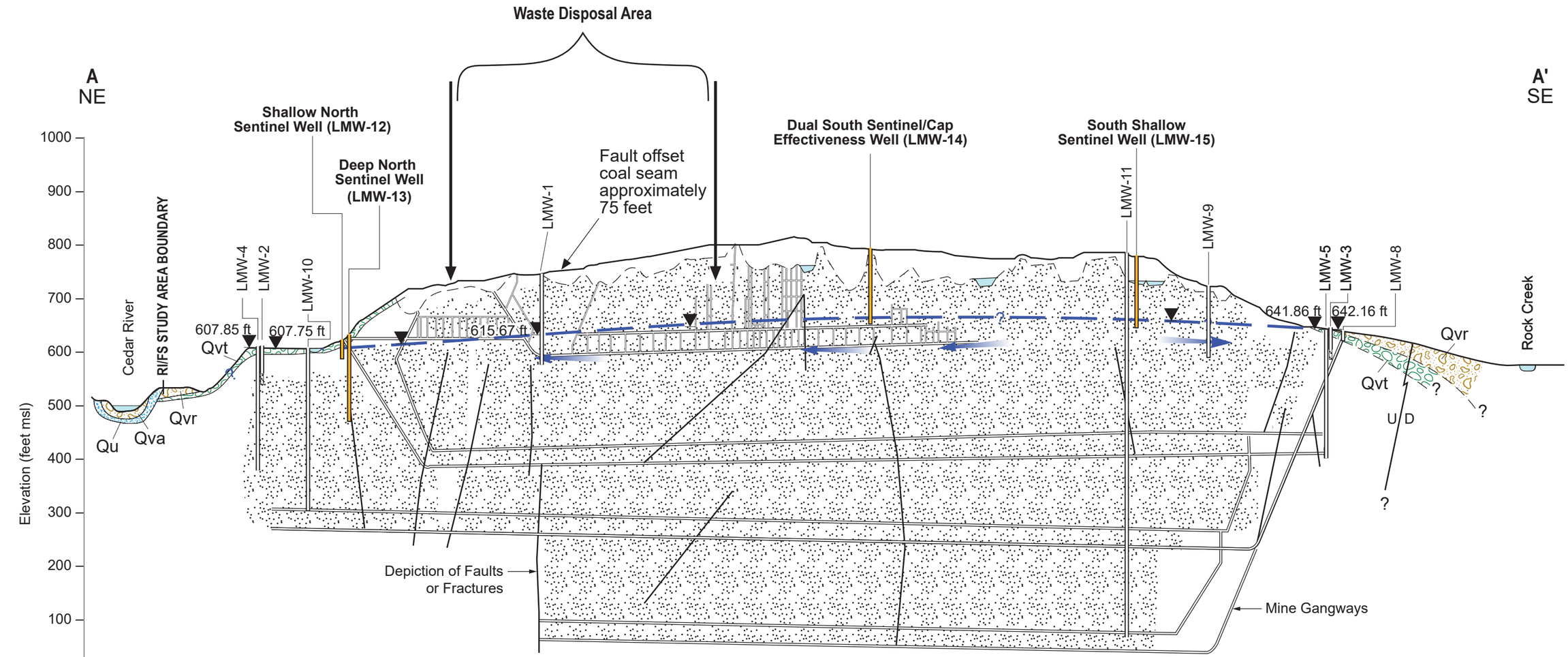

EXPLANATION

- Potentiometric surface
- Outline of trench bottom
- Water Level (ft. amsl) 2/23/94
- Qvt Till, compact mixture of gravel occasional boulders in clayey silty sand matrix
- Sandstone
- Surface water feature
- Anticipated collapsed zone within mine
- Qu Drift, till, fluvial sand and gravel, lacustrine sand, silt, clay and peat
- Qvr Recessional outwash, well sorted sand and pebble-cobble
- Qva Advanced outwash pebble-cobble gravel may include very fine sand
- Monitoring Interval
- Groundwater Flow Direction

0 500
FEET

Sources for the Geology and Mine Information:
J.E. Luzier 1969; surficial geology
State of Washington, Water Well reports
Mine Superintendant's Records
Landsburg Well Logs

NOTE: Vertical to horizontal scale ratio is 2.5:1
Wells are project normal into the strike of the Cross-Section A-A'

Assuming groundwater discharge at the north and south end of mine.

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CLIENT	PALMER COKING COAL COMPANY, LLP
CONSULTANT	GOLDER
YYYY-MM-DD	2018-02-27
PREPARED	REDMOND
DESIGN	
REVIEW	
APPROVED	
PROJECT	LANDSBURG MINE SITE
TITLE	**CROSS-SECTION ALONG STRIKE AT COAL SEAM CROSS-SECTION A-A'**
PROJECT No.	923-1000
PHASE	002
FIGURE	3

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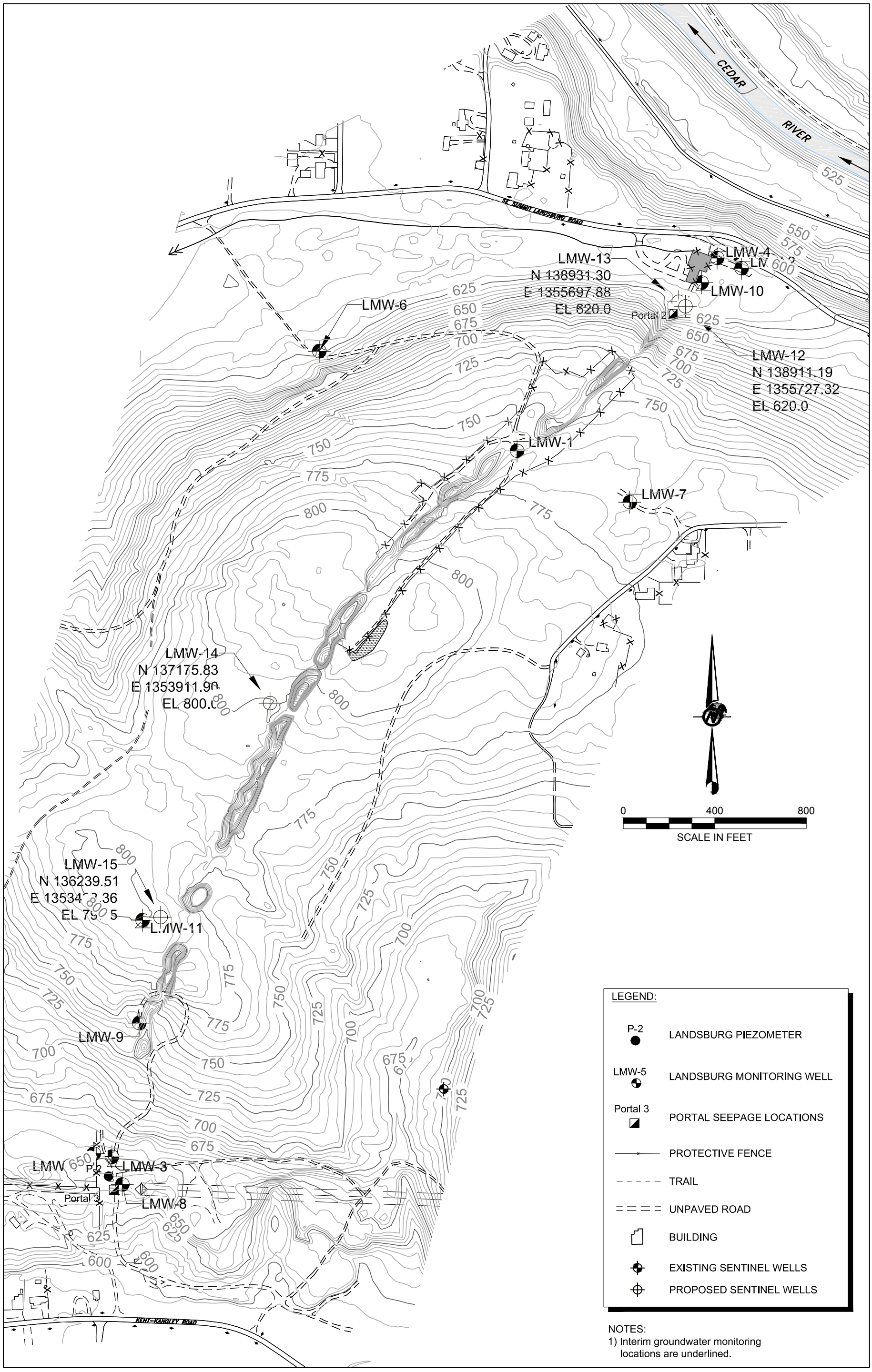

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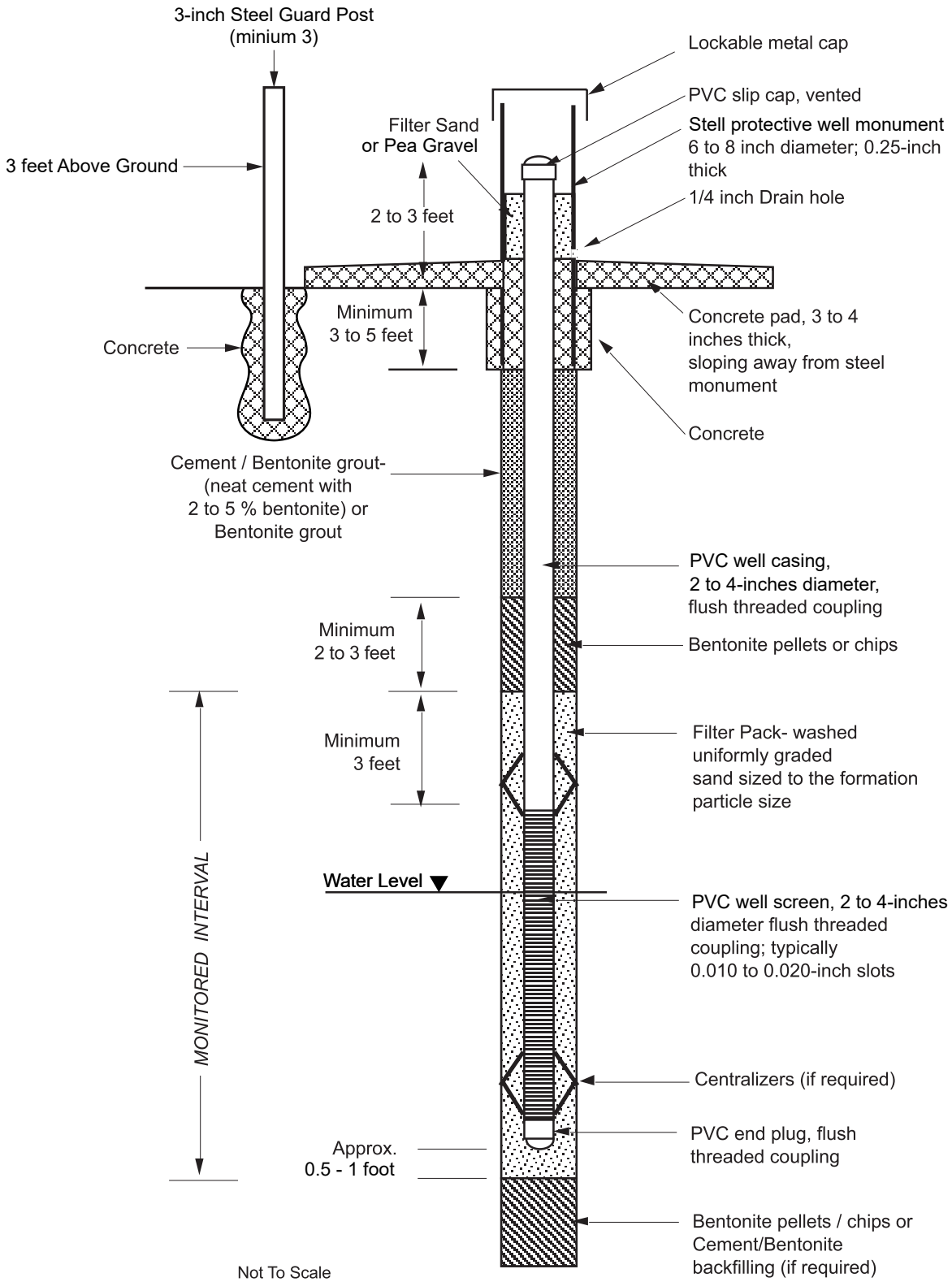
FIGURE **4**

PROPOSED SENTINEL WELL LOCATIONS

PALMER/LANDSBURG MINE/WA

Above Ground Monument Installation



Not To Scale

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CLIENT

PALMER COKING COAL COMPANY, LLP

PROJECT

LANDSBURG MINE SITE

CONSULTANT

GOLDER

YYYY-MM-DD	2018-02-27
PREPARED	REDMOND
DESIGN	
REVIEW	
APPROVED	

TITLE

TYPICAL MONITORING WELL INSTALLATION

PROJECT No.	PHASE	FIGURE
923-1000	002	5

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