ICICLECREEK ENGINEERS

Revised Report
Geotechnical Engineering Services
Ravensdale Reclamation Trench Filling and Restoration Project
Ravensdale LLC Property
Section 1, T21N, R6E and Section 36, T22N, R6E
Ravensdale Area, King County, Washington

June 29, 2020
ICE File No. 1352-001

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Prepared For:
Ravensdale LLC

Prepared By:
Icicle Creek Engineers, Inc.

June 29, 2020

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1.0 INTRODUCTION

This revised report presents the results of Icicle Creek Engineers' (ICE's) geotechnical engineering services related to the Ravensdale Reclamation Trench Filling and Restoration (Ravensdale Trench Reclamation Project) of unreclaimed "strip pits" located at the Ravensdale LLC Property. The Ravensdale LLC Property is located in Section 1, Township 21 North, Range 6 East and Section 36, Township 22 North, Range 6 East, Willamette Meridian, south of the community of Ravensdale in King County, Washington. The strip pits, referred to as "Trenches" in this report, are abandoned surface coal mines that were operated in the 1940s to 1950s.

Seven Trenches subject to this report are referred to as follows:

- Trench A (West) and Trench A (East)
- Trench B
- Trench C (West) and Trench C (East)
- Trench E (future permit)
- Trench F (future permit)
- Trench G
- Trench H (North) and Trench H (South)
- Trench I
- Trench J

The location of the Ravensdale LLC Property relative to nearby physical features is shown on the Vicinity Map, Figure 1. The locations of the Trenches subject to this report, along with Trenches A (North) and D that have already been filled, are shown on the Site Plan, Figure 2. Trenches F, I and J are included in this report, but do not contain geotechnical issues.

2.0 BACKGROUND INFORMATION

We understand that Ravensdale LLC has reclaimed (filled) and restored the ground surface in Trenches A (North) and D, and partially filled Trenches C (East), E and F with soil imported from various nearby sites. The goal of reclaiming the abandoned Trenches is to 1) restore the ground to its original surface which eliminates the current serious to extreme public safety hazard, 2) reestablish the natural flow of surface and groundwater systems, and 3) reestablish forest land by replanting with tree seedlings or other vegetation as appropriate for each site.

ICE previously prepared a geotechnical report for this project dated March 26, 2020. Since that time, a virtual meeting with King County Department of Local Services – Permitting Division (DLS – PD) and the Ravensdale LLC project team was held on May 5, 2020. Joe Barto of King County DLS – PD provided comments dated May 11, 2020 related to the geotechnical report and the virtual meeting discussion. This revised report incorporates our response to those comments by Mr. Barto and is intended to replace our report dated March 26, 2020.

The current plans for reclamation Trench filling and restoration are referenced as follows:

- Contour Engineering LLC, June 17, 2020, *Ravensdale Reclamation Trench Filling and Restoration Project*, sheets 1 and C2 through C24.

3.0 SCOPE OF SERVICES

The purpose of our services was to review available information, including the project plans and observe site conditions at the Ravensdale LLC Property as a basis for providing geotechnical support for the Ravensdale Trench Reclamation Project. Specifically, our scope of services included the following:

- Review available geologic, geotechnical and hydrogeologic information including regional geologic mapping and geotechnical reports that have been completed within the Ravensdale LLC Property.
- Complete a site visit to observe site conditions in the area of Trenches A (West and East), B, C (West and East), E, F, G, H (North and South), I and J, with a focus on fill placement and slope stability.
- Complete static and pseudostatic slope stability analysis for potentially affected fill slopes greater than 33 percent grade and/or greater than 10 feet in height.
- Provide recommendations for the Trenches, as appropriate, for site preparation to be completed prior to imported fill placement.
- Provide recommendations for fill placement including material specifications, compaction criteria, final slope inclination and “keying” of fill placed in slope areas.
- Provide recommendations for geotechnical observation during construction including the frequency of monitoring.
- Describe the constructability of Trenches A (West and East), B, C (West and East), E, F, G, H (North and South), I and J.

4.0 ORIGIN OF TRENCHES AND COAL MINE HAZARDS

4.1 TRENCHES

The following is a list of references that document coal mining within the Ravensdale LLC Property.

- King County iMap (https://gismaps.kingcounty.gov/iMap/), Environmentally Sensitive Areas, Coal Mine Hazards layer.

- US Geological Survey, Warren, W.C., Norbisrath, H., Grivetti, R.M. and Brown, S.P., 1945, Preliminary Geologic Map and Brief Description of the Coal Fields of King County, Washington, scale 1 inch = 8,000 feet.
- Washington State Department of Natural Resources (DNR), Schasse, H.W., Koler, L.M., Eberle, N.A. and Christie, R.A., May 1994, *The Washington State Coal Mine Collection Guide: A Catalog, Index and User's Guide*, Maps K56, K57, K58, K59, K60, K61, K62, and K63 (microfilm).
- Washington State DNR, Geologic Information Portal (https://geologyportal.dnr.wa.gov/#coal), Coal Mine Maps layer.
- Washington State DNR - Division of Geology & Earth Resources, undated, *Table 11 – Summary of Coal Production in King County, Washington, by Mine and Year from 1888 through 1967*.
- Washington State Division of Mines and Mining, Green, Stephen H., 1943, *Coal and Coal Mining in Washington*, Report of Investigations No. 4, 41 pages.

At least seven coal seams were mined in at least four separate coal mines under portions of the Ravensdale LLC Property. These coal seams are referred to as the No. 1, No. 3, No. 4, No. 5, No. 7, No. 9 and the McKay Coal Seams. Collectively, the mines in this area were referred to as the Ravensdale Mines. King County has regionally mapped the areas underlain abandoned underground coal mines as shown on the Coal Mine Hazards Map, Figure 3 (from King County iMap).

The Ravensdale Mines (all underground) were active from the late 1800s to about 1930 when most of these underground mines were abandoned. However, during the late 1940s and 1950s, shallow coal was mined in the area of the Ravensdale LLC Property using surface methods (referred to as "strip pits" or as "Trenches" in this report).

The underground mines followed the coal seams, typically at a "dip" ranging from 15 to 60 degrees below horizontal. For this reason, the depth to the underground mine workings varies considerably and may be as much as 600 feet below the ground surface and in other areas a few feet below the ground surface. The underground mines were developed using "room-and-pillar" (also referred to as "breast-and-pillar") mining methods. Initial development of the mine from the surface began with a main slope (a wide, main entry tunnel) driven down the maximum dip of the coal seam. The main slope served as the primary entry for the mine. Normally, the main slope was heavily shored with wood timbers to assure long-term access to the mine. In some mines, the main haulageways were developed along the "strike" of the coal near valley floors. This type of mining allowed ground water to drain by gravity out the mine entrance; thus were called "water level mines."

Most or all of the pillars were removed before abandonment of a level; pillar removal is referred to as "full pillar extraction." Full pillar extraction is a normal underground mining process designed to maximize coal extraction (estimated at about 90 percent coal extraction) and to promote collapse of the finished mined-out areas.

Strip pits are a surface means to extract near surface coal and resulted in the current Trenches. After World War II, there was a surplus of heavy equipment which was relatively inexpensive to purchase. Given the low cost of equipment at that time, there was a period during the late 1940s and 1950s when strip mining was feasible. Strip mining involves removing the overburden soils and bedrock, then mining the coal seam directly using heavy equipment. The strip mining method typically results in a deep excavation with steep near-vertical sideslopes referred to as "highwalls."

Strip mining required the removal of overburden soils and other bedrock. The coal seams beneath the Ravensdale LLC Property are tilted (inclined) so that during excavation one side of the Trench was near vertical (the "hanging wall") and the opposite wall (the "footwall") was less steep. The resulting offset "V" shaped slope is entirely excavated into bedrock.

No reclamation to restore the natural environment or eliminate safety hazards by flattening of the trench walls or filling was completed when surface mining ceased in the area of the Ravensdale LLC Property. The resulting Trenches are void of regrowth (no topsoil), and intercept rainfall that reduces or eliminates groundwater recharge (storage as stagnant water only in Trench E). The rims (top edges) of the Trenches pose a serious to extreme safety hazard (cliffs). Reclamation by filling the Trenches would effectively restore the original environment and eliminate the safety hazard, provided recommendations in this report are implemented.

4.2 COAL MINE HAZARD REGULATORY CONSIDERATIONS

Based on the regional mapping of coal mine hazards, all of the Ravensdale LLC Property Trenches are within a coal mine hazard area. King County Code 21A.24.205 and King County Ordinance 13319 provides definitions for Severe, Moderate and Declassified Coal Mine Hazard Areas.

Based on our knowledge of the Ravensdale LLC Property area and the abandoned surface mines, Trenches A, C, E, F and G are within a Severe Coal Mine Hazard Area. Trenches B, H, I and J are located within the regional Coal Mine Hazard Area; based on available information, it is not known if abandoned underground coal mines underlie these areas. A Severe Coal Mine Hazard is defined by Ordinance 13319 *as unmitigated openings such as entries, portals, adits, mine shafts, air shafts, timber shafts, sinkholes, improperly filled sink holes, and other areas of past or significant probability for catastrophic ground surface collapse. Severe coal mine hazard areas typically include, but are not limited to, over land surfaces underlain or directly affected by abandoned coal mine workings from a depth of zero (i.e. surface of the land) to one hundred fifty feet.*

King County 21A.24.210 D.1 encourages *"eliminating or mitigating threats to human health, public safety, environmental restoration or protection of property"* within Severe Coal Mine Hazard Areas.

5.0 TRENCH RECLAMATION/RESTORATION METHODOLOGY

Based on our review of the current plans (Contour Engineering LLC, June 17, 2020) Trenches A (West and East), B, C (West and East), E, F, G, H (North and South), I and J are proposed to be filled. We understand that Trenches A (West and East) have been permitted. Trench A (North), Trench D and an unnamed trench west of Trench F have already been filled under a previous Clearing and Grading Permit. At this time, Trenches C (East) and E and F have been partially filled; we understand that trench reclamation/ restoration has ceased pending permit approval.

Based on information provided by Kurt Erickson with Ravensdale LLC, the fill imported to the Ravensdale LLC Property is from local earthwork projects, which typically results from other projects where 1) the earthwork balance requires export, or 2) unsuitable fill (too wet/dry or does not meet specifications) is encountered and requires export. Contour Engineering LLC (June 17, 2020, sheet C3) Geotechnical Notes indicate that the imported fill material is to be "clean" and "below MTCA" criteria for contamination with hazardous substances. At this time there are no specific standards in the plans for earthwork methods; such standards are subject to this report and are intended to be implemented for the project.

Brian Beaman of ICE completed an initial site visit on October 2, 2019 and met with Mr. Erickson at Trench C (East) to discuss the general methods of Trench filling and compaction of this fill. Mr. Erickson indicated that no wood, metal, glass, asphalt or concrete is accepted as fill, and that all imported fill must be inorganic. However, much of the fill that has been imported to the site is "wet," therefore "structural fill" standards of compaction are not possible.

Compaction of fill is essential in limiting the infiltration of precipitation and to build strength into the soil. Based on our observations of Trench C (East), compaction of new fill was completed by spreading the fill with a bulldozer followed by track-rolling with the bulldozer to achieve compaction. We were not on site long enough to observe whether this method was being completed in a consistent manner.

Based on our experience, track-rolling is nominally effective in achieving compaction (typically may achieve 85 to 90 percent of the maximum dry density (MDD) measured in accordance with ASTM Test Method D 1557. The effectiveness of this method of compaction is directly related to the size of equipment used to track-roll, the lift thickness and the quality of the fill.

6.0 TRENCH DESCRIPTION

Mr. Beaman completed a detailed field review of Trenches A (West and East), B, C (West and East), E, G, and H (North and South) on February 19, 2020. The LiDAR Digital Terrain Model (DTM) raw data (King County 2016 acquisition) of the Ravensdale LLC Property was obtained from the DNR Washington LiDAR Portal (http://lidarportal.dnr.wa.gov) and processed by ICE for 2- and 5-foot contours using Esri ArcGIS Desktop version 10.6. The Trench details, including the 5-foot topographic contours, are shown on Figures 4 through 12. The following is a summary description of each Trench based on our plan review and field observations.

Trench	Length (feet)	Width (feet)	Area (acres)	Axis Slope(1) (%)	Native Slope(2) (%)	Vegetation	Fill?(3)(5)	Water(4)(5)
A (West)	800	200	2.9	30 -35 3.3H/2.8H:1V	25 4H:1V	Scattered brush/bare	Partially filled (north end)	None
A(East)	600	90	1.3	20-35 5H/2.8H:1V	25 4H:1V	Scattered brush/bare	Partially filled (north end)	None
B	125	50	0.2	85-100 1.2H/1H:1V	80-100 1.2H/1H:1V	Brush/small trees	None	None
C (West)	260	120	0.7	14-20 7H/5H:1V	40-50 2.5H/2H:1V	Scattered brush/bare	None	None
C (East)	830	250-300	4.6	12-18 8H/5H:1V	45-50 2.2H/2H:1V	Bare	Partially filled	Seepage at the toe
E	910	100-300	4.0	Flat-sloped at each end	<10 <9.5H:1V	Water/bare; scattered trees	Partially filled (south end)	Stagnant ponded water
F	1,200	175	4.0	Nearly level	Nearly level	Brush and trees	Unknown	Unknown
G	860	120-160	3.6	7-18 14H/3H:1V	35-40 1.4H/1.2H:1V	Brush and trees	None	Seepage full length

H (North)	310	80	0.7	12-14 8H/7H:1V	<33 <3H:1V	Scattered brush/bare	None	None
H (South)	550	50-100	1.2	14-50 4H/2H:1V	35 -40 1.4H/1.2H:1V	Scattered brush/bare	None	None
I	200	100	0.5	Nearly level	Nearly level	Brush and trees	Unknown	Unknown
J	350	130	1.0	20 5H:1V	Nearly level	Brush and trees	Unknown	Unknown

Notes: H:V = horizontal to vertical
(1) Measured along the longitudinal axis of the Trench
(2) Inclination of the native slope adjacent to the Trench
(3) Pre-existing fill. Trench C (East) has been 75 percent filled
(4) Groundwater seepage or surface water at the time of our site visit
(5) No field review was completed for Trenches F, I and J

Trench A (West) – Trench A (West) as shown on Figure 4 is an open-ended, relatively steep/deep slot in the hillside that extends to the south property line. The sidewalls are near vertical on the west side, and near 100 percent grade on the east side. The base of the slot has scattered blackberry and other invasive plants and bare bedrock; no surface water was observed.

Trench A (East) – Trench A (East) as shown on Figure 4 is similar to Trench A (West) as an open-ended, relatively steep/deep slot in the hillside that extends to the south property line. The sidewalls are near vertical on the west side, and near 100 percent grade on the east side. The base of the slot has scattered blackberry and other invasive plants and bare bedrock; no surface water was observed.

Trench B – Trench B (formerly referred to as Trench K) as shown on Figure 5 is very shallow (less than 5-feet deep) and occurs on a very steep hillside covered with dense brush. We expect that because of the very steep site conditions and small area that Trench B will be filled.

Trench C (West) – Trench C (West) as shown on Figure 6 "daylights" to a steep, recently clear-cut slope (more than 40 percent grade) overlooking the Ravensdale valley. It appears that this hillside has been partially graded in the past (bench topography).

Trench C (East) – Trench C (East) as shown on Figure 6 has been substantially filled. During our October 2, 2019 site visit, we observed wet soil conditions at the toe of the new fill that has caused localized slumps and failures extending out from the toe of the new fill. It appeared that a crude fill embankment had been constructed at the distal toe area (yet to be filled) to contain turbid water and shallow landslides. The crude fill embankment appeared to be effective in containing the turbid water runoff and shallow landslides. No further filling should occur at Trench C (East) until a plan is developed to stabilize the area of wet, soft soil accumulation.

Trench E – Based on our field observations and topographic mapping (Washington LiDAR Portal, Esri ArcGIS) using 2-foot topographic contour interval, Trench E exists in a closed depression (watershed) with no stream inflow or outflow as shown on Figure 7. The underlying bedrock is generally considered to be impermeable.

Based on our site observations on October 2, 2019, the water surface appears to fluctuate by at least 4 feet. Any inflow or outflow of water from the wet area is by direct precipitation or evaporation.

Trench F – We did not field review Trench F (shown on Figure 8). Based on aerial photographs and LiDAR-based topography, Trench F occupies and narrow and relatively-deep slot (closed depression) that is obscured in aerial photographs by mature trees and brush. We do not expect that geotechnical issues are of concern for Trench F.

Trench G – Trench G as shown on Figure 9 is densely vegetated with brush and trees with a defined stream channel with surface water.

Trench H (North) – Trench H (North) as shown on Figure 10 is a shallow excavation and is open to densely vegetated. It does not appear that a formal deep excavation ever occurred.

Trench H (South) – Trench H (South) as shown on Figure 10 is a long and relatively narrow partially vegetated excavation that is cut into a moderately sloping hillside.

Trench I – We did not field review Trench I (shown on Figure 11). Based on aerial photographs and LiDAR-based topography, Trench I occupies a nearly-level shallow (less than 5-feet deep) area covered with mature trees and brush. We do not expect that geotechnical issues are of concern for Trench I.

Trench J – We did not field review Trench J (shown on Figure 12). Based on aerial photographs and LiDAR-based topography, Trench J occupies a relatively shallow (up to 10-feet deep) and wide slot covered with mature trees and brush. We do not expect that geotechnical issues are of concern for Trench J.

7.0 SLOPE STABILITY ANALYSIS

The project involves filling in large trenches that are typically inclined because of topography. For this reason, the downhill end of the trenches are open, especially for Trenches C (West and East), G and H (South). Trenches E and F are closed-depressions therefore slope stability is not an issue. Trench B is a shallow, nearly non-existent excavation on a very steep hillside that will remain as-is (recommend no reclamation).

All of the Trenches, with the exception of Trenches C (West) and G, are situated within the Ravensdale LLC Property such that should a slope failure occur, the result would be contained within the property, and is therefore a property ownership problem. The reclamation of Trenches C (West) and G should be carefully planned and implemented because of the possible impacts to off-property public resources and private properties.

An open-ended trench will require a fill slope to finish the grading as shown on the current plans (Contour Engineering LLC, June 17, 2020). Based on the plans the approximate dimensions of these proposed trenches will be as follows:

Trench(1)(2)	Area (acres)	Base Slope (H:V)(3)	Slope Height (feet)(4)	Fill Thickness (feet)(5)
A (West)	2.9	3.3H/2.8H:1V	220	45
A (East)	1.3	5H/2.8H:1V	150	40
C (West)	0.7	7H/5H:1V	85	40
C (East)	4.6	8H/5H:1V	80	90
G	3.6	14H/3H:1V	135	60
H (North)	0.7	8H:7H:1V	50	10
H (South)	1.2	4H/2H:1V	145	25

(1) Trench E was not analyzed (no slope stability issues); Trench B was not analyzed (recommend leaving as-is, too steep for filling)
(2) Trenches F, I and J are situated in areas where there are no geotechnical issues.
(3) H:V = horizontal to vertical measured along the longitudinal section of the trench
(4) The slope height measured from the toe elevation to the top elevation of the trench
(5) Fill at the thickest section (+/-)

Our slope stability evaluation targeted the open-ended configuration of the trench (referred to as the “end-slope”) when filled. As previously described, King County (July 12, 2019) requested *“Slope stability analysis for all slopes greater that 33% and/or greater than 10 feet in height. The analysis should incorporate both static and pseudostatic conditions.”* Based on the current plans (Contour Engineering LLC, June 17, 2020), the end slopes for filling of Trenches C (West and East), G, and H (North and South) are proposed at well over 10-feet high and up to 50-percent grade (2H:1V).

Slope stability analysis was completed by ICE using the computer application Slide 6.039 (RocScience, 2016). This computer application has the capability for limit equilibrium slope stability analysis using a variety of methods. For comparison purposes we reviewed results using GLE/Morganstein Method, Janbu Simplified Method and the Bishop Simplified Method.

Our slope stability analysis assumes that the Fill will be inorganic and will be placed and compacted as described in section **8.2.2** of this report. This will result in what is considered “nominal” compaction. Compaction is the way in which strength is added to the soil mass. With track-walking fill of varying quality, only nominal compaction can be attained. For this reason, lower soil strength values must be used to represent the fill mass for the Trench filling application. A measure of soil strength is quantified by the angle of internal friction, referred to as “phi” and the shear strength, referred to as C (cohesion). For this purpose, the phi and C have standard “values” which can be considered standard practice in this area without laboratory testing. For a comparison of soil strengths, we completed a sensitivity analysis to better understand the effects of changing the soil strength parameters. The sensitivity analysis was completed by varying phi from 26, 28 and 30 degrees with a cohesion (C) of zero. Any higher values of phi or adding C would be unreasonable, in our opinion. We expect the moist unit weight of the nominally compacted fill to be about 120 pounds per cubic foot (pcf).

The following is a summary of the soil strength parameters used in our analysis.

Soil Type	Moist Unit Weight (pcf)	Φ (degrees)	C (psf)
Fill	120	26/28/30	0

For the fill section geometry we analyzed 33-percent grade (3H:1V), 40-percent grade (2.5H:1V) and 50-percent grade (2H:1V) final end-slopes. We further analyzed these end-slopes for varying fill slope heights of up to 80 feet.

For pseudostatic seismic evaluation we used a Peak Ground Acceleration (PGA) of 0.51g (from ASCE 7-10 Design Response Spectrum).

In stability analyses, the relative stability of a slope or structural system can be expressed in terms of a factor of safety (FOS) against failure for the most likely potential failure mode. A FOS of 1.0 corresponds to the conditions in which the resisting and the driving forces are equal (equilibrium conditions), and failure would theoretically be imminent as the result of a decrease in the resisting force or an increase in the driving force. A FOS greater than 1.0 indicates that the forces tending to resist failure are greater than the forces tending to cause failure. The general minimum FOS (static) for fill embankments for this geographic application is 1.3. The minimum seismic FOS is typically acceptable at 1.0 considering the remote location of this activity. The results of our slope stability analysis are presented in the following tables for the final end-slope configurations.

End-Slope 33-Percent Grade (3H:1V) – Slope Height Varies from 20 to 80 Feet			
Soil Type(1)	**Phi(2)**	**Static FOS**	**Seismic FOS**
Fill	26	1.4 – 1.8	0.9 – 1.1
Fill	28	1.6 – 2.0	1.0 – 1.3
Fill	30	1.7 – 2.2	1.1 – 1.4

End-Slope 40-Percent Grade (2.5H:1V) – Slope Height Varies from 20 to 80 Feet			
Soil Type(1)	**Phi(2)**	**Static FOS**	**Seismic FOS**
Fill	26	1.2 – 1.6	0.8 – 1.1
Fill	28	1.3 – 1.8	0.8 – 1.2
Fill	30	1.4 – 1.9	0.9 – 1.3

End-Slope 50-Percent Grade (2H:1V) – Slope Height Varies from 20 to 80 Feet			
Soil Type(1)	**Phi(2)**	**Static FOS(3)**	**Seismic FOS(3)**
Fill	26	0.9 – 1.4	0.6 – 1.0
Fill	28	1.0 – 1.5	0.7 – 1.1
Fill	30	1.1 – 1.6	0.7 – 1.2

(1) Nominally-compacted fill (80 to 95 percent of the MDD measured in accordance with ASTM Test Method D 1557.
(2) Phi in degrees.
(3) Green shading = OK; FOS ≥ 1.3 (static) and ≥ 1.0 (seismic); Red shading = Fails; FOS <1.3 (static) or <1.0 (seismic).

To summarize, the slope stability analysis suggests that final end-slopes should be no steeper than 33-percent grade (3H:1V).

As a performance example, the current end-slope at the Trench E site that was previously partially filled is sloped at about a 33-percent grade (3H:1V slope). We observed local gullying and slumping of the surface of this fill which suggests that a maximum slope of 33-percent grade (3H:1V) is appropriate with emphasis on erosion control and surface water drainage improvements to improve outcomes for the permanent condition.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 GENERAL

The Trenches are the result of surface mining of coal that was completed in this area in the 1940s and 1950s. The Trenches have not been reclaimed/restored, and most present a serious to extreme safety hazard. The Trenches, especially Trench E have disrupted and/or intercepted natural surface water flow and recharge conditions to the area groundwater systems and streams (public resources).

In our opinion reclamation by filling the Trenches to restore the area to a more natural condition and to eliminate safety concerns can be successfully completed provided that recommendations presented in this report are implemented. The primary challenges to fill these Trenches are related to the probable low quality fill that is imported to the site combined with nominal compaction and sloping terrain.

For all Trenches, except Trenches E and F, the downhill end of the excavation slot is open, creating a condition of potential instability of the final slope face. It is important to use site preparation and fill placement methods that provide the best result to maintain slope stability and minimize erosion. In our opinion, this can be accomplished, but requires consistent care in preparation of the area to receive fill, providing uniform effort in placement and compaction of the new fill, and final surface treatment on end-slopes that are inclined no more than 33 percent grade (3H:1V slope) to manage surface water runoff and stabilize the surface from erosion. The following sections of this report are intended to provide guidance for a successful project in filling the Trenches.

Steeper end-slopes (40-percent grade/2.5H:1V or 50-percent grade/2H:1V) can be considered on a case-by-case basis and will require higher quality fill as well as placement and compaction using structural fill construction standards that are described in section **8.2.2.2** of this report.

Trenches E and F are likely the easiest to fill. The stagnant water in Trench E should be pumped out before filling. Trenches E and F are basically closed depressions, therefore filling the excavation with loose, poor quality fill has little or no adverse impacts. Trenches E and F should be designated the sites where the most unsuitable fill (very wet soil, clays and silts) should be placed. Trench E has been partially filled. Trenches E and F should be filled to restore groundwater and surface water flow conditions in addition to eliminating the high-risk safety hazard for Trench E of the near vertical hanging wall that is adjacent to the access road.

For Trench C (West), the toe of the new fill should be set back at least 50 feet from the natural steep break in slope to the north.

The low point of Trench G is in close proximity to a perennial stream and a wetland with Fish-Habitat according to the Washington State Department of Natural Resources Forest Practices Mapping Tool (FPARS - https://fpamt.dnr.wa.gov/default.aspx). Careful planning is required to limit sediment delivery to this public resource.

Trench B should be removed from consideration for receiving fill because of slope limitations (up to 100 percent grade).

All the Trenches, with the exception of Trenches C (West) and G, are situated within the Ravensdale LLC Property such that should a slope failure occur, the result is contained within the property, and is therefore a property ownership problem. The reclamation of Trenches C (West) and G should be carefully planned and implemented because of the possible impacts to off-property public and private properties.

The "constructability" of reclaiming/restoring the Trenches is feasible provided that civil and geotechnical engineering oversight is completed on a regular basis to document progress and effectiveness of the work-in-progress. Some of the Trenches are "easy" (such as filling closed depressions at Trenches E and F), while some have more challenging conditions such as Trench C (West) that is perched at the top of steep hillside.

Based on our preliminary review of the Contour Engineering LLC project plans dated June 17, 2020, additional details are needed to be consistent with the recommendations presented in this geotechnical report. We recommend that these revisions be made along with a final review by ICE to evaluate if our recommendations have been interpreted as intended. This geotechnical report should be referred to in the plans and attached to the plan set used by the contractor.

8.2 EARTHWORK

8.2.1 Site Preparation

We recommend that all trees, logs, brush, and low-growing vegetation be removed from the base of the Trenches prior to starting grading operations. This material should be stockpiled at a location where it may be used to cover the filled area depending on the character of this material.

Areas along the longitudinal axis of the Trenches that exceed 4H:1V (25-percent grade) should be benched to key in new fill. The benches should be 4- to 8-feet wide and cross the longitudinal axis of the base of the Trench. The bench does not need to extend to the top edges of the Trench.

If groundwater seepage is encountered during site preparation, additional drainage, such as finger drains, may be required to provide a path for this groundwater. Drainage measures should be added as a field recommendation by the geotechnical engineer on a case-by-case basis.

We recommend that site preparation be observed by a representative from our firm to assess the adequacy of the earthwork and provide alternative recommendations as appropriate.

8.2.2 Fill Placement

8.2.2.1 General Fill

For Trenches that have an open-ended downslope condition (all Trenches except Trench E), we recommend that a berm be created at the open end using better fill (inorganic fill that is at or near optimum moisture content for compaction) being imported to the site. The berm will eventually be the toe of the Trench backfill area and will serve to buttress the fill mass that may be of weaker soil types where only nominal compaction is obtained. The berm will also serve to intercept turbid water runoff during the backfilling process.

The crude fill embankment that has been constructed at the Trench C (East) site is an "approximate" example of toe berm construction though needs improvement. For any new Trench fill, regardless of location, existing surficial soft and/or wet soil and organic material should be removed prior to fill placement. The berm crest should be at least 10-feet wide with 3H:1V sideslopes.

For Trench C (West), the toe of the new fill should be set back at least 50 feet from the natural steep break in slope to the north.

Based our limited site observations during fill placement at Trench C (East) in October 2019, it appears that some of the imported fill is either end dumped or pushed out onto an open slope creating a "sidecast fill" condition. This method of fill placement is not favorable for achieving compaction and establishes downsloping planes of weakness where slope failure may occur. However, sidecast fill may be completed in closed Trenches such as Trench E or at least 300 feet from the toe (berm/buttress) area of the other downslope open-ended Trenches.

All fill should be placed in horizontal lifts which are 12 to 24 inches in loose thickness. The fill should be track-rolled with heavy equipment (such as a Cat D-8). The fill should be compacted to at least 90 percent of the MDD determined in accordance with ASTM Test Method D 1557. Based on our experience, a heavy (40-ton) "sheepsfoot" roller is often used to compact marginally suitable fill.

We recommend that backfill and compaction operations be monitored on a frequent basis to evaluate whether or not the specified compaction is being obtained and to provide alternative recommendations of compaction methods, if necessary.

The fill, if wet, will likely not be able to support loaded dump trucks, so this will need to be considered in filling operations. Where truck access is critical, a haul road alignment can be planned where a layer of woven geotextile fabric is placed on the soft subgrade followed by the placement of 18 to 24 inches of compactible (not wet) fill.

We expect that the nominally compacted new fill could experience 5 to 10 percent of its total thickness as settlement. This settlement will likely occur over a period of several years.

8.2.2.2 Structural Fill Standard

Structural Fill should be free of organic material or debris and have a maximum particle size of 4 inches. The material should contain less than five percent fines (soil particles passing the US Standard No. 200 sieve) by weight relative to the portion finer than the ¾-inch sieve. If earthwork is done during generally dry weather conditions, the fines content may be increased.

As a guideline, Structural Fill should be placed in horizontal lifts which are 10 inches or less in loose thickness. The actual lift thickness depends on the quality of the fill material and the size of the compaction equipment.

We recommend that Structural Fill be uniformly compacted to at least 95 percent of the MDD obtained in general accordance with ASTM Test Method D 1557.

8.2.3 Permanent Slopes

We recommend that permanent fill slopes be constructed no steeper than 3H:1V. We recommend that the final slope face be mounded to encourage surface runoff to disperse to the sides of the "slot" Fills. The vegetation at the edges should be maintained to the extent practical, and may require brush/slash traps, and erosion control product or quarry spalls to prevent erosion at this seam. The finished slope face should be compacted by track-walking with the equipment running perpendicular to the slope contours so that the track grouser marks will help provide an erosion resistant texture.

Steeper slopes (40-percent grade/2.5H:1V or 50-percent grade/2H:1V) can be considered on a case-by case basis but will require consultation with the geotechnical engineer and should be placed as Structural Fill as described in section **8.2.2.2** of this report.

8.2.4 Erosion and Sediment Control

Temporary erosion protection should be placed and maintained during construction to protect exposed soil areas. We recommend use of straw, jute matting, or equal, as temporary erosion protection. Ample supplies for straw should be maintained in a dry area on site for liberal use in bare soil areas on slopes. Straw mulch, when used, should be spread at least 4-inches thick to be effective. Other erosion control products (Best Management Practices - BMPs) including silt fencing, quarry spalls, wattles and other products should be on hand for use as needed. King County may also include other BMPs as permit conditions including a Temporary Erosion and Sediment Control (TESC) plan.

For earthwork during the drier months, blowing dust can be a significant erosional process. We recommend that soil stockpiles be covered and bare surface roads be watered or otherwise protected (such as crushed rock placement) to reduce blowing dust.

Final fill surfaces should be significantly mounded to accommodate settlement of the fill (estimated at 5 to 10 percent of the total fill thickness) and to promote dispersion of surface water runoff to the edges of the fill area. It is imperative that surface runoff to the lateral edges of the fill surface be maintained to disperse stormwater runoff. If mounding of the new fill is not possible then a series of benches may be necessary to intercept surface water runoff.

We suggest that that finished fill areas should be seeded and covered in straw mulch. An action plan to remove invasive plants (especially blackberry vines) should be prepared and implemented. We strongly recommend that an approved herbicide (similar to that routinely used in Forest Practices) be used not only in newly vegetating areas, but in other finished trench areas to reduce the blackberry vine infestation. We observed areas where the blackberry vines are inhibiting or eliminating the growth of tree seedlings that have been planted as part of the long-term forest management plan.

If hydroseed is used, we recommend Bonded Fiber Matrix (BFM) rather than the more common (and susceptible to erosion) hydroseed with tackifier. We have observed excellent results using BFM on road embankments (resists rilling and gullying).

Maintenance and reseeding as necessary must be planned and implemented until the vegetation is established.

8.2.5 Construction Observation

As previously described, sufficient observation and testing of compaction during trench filling should be provided by ICE. The frequency of monitoring is typically more during the initial phase of earthwork to establish an appropriate methodology used by the contractor to achieve the planned result. This may require full time monitoring for several days during intensive Trench filling then taper to random site visits as the Trench filling progresses.

When the design has been finalized, we recommend that we be retained to review those portions of the specifications and drawings which relate to geotechnical considerations to see that our recommendations have been interpreted and implemented as intended.

8.3 PRELIMINARY PLANS REVIEW

We completed an initial review of the project plans by Contour Engineering LLC dated June 17, 2020. Sheet C3 of the project plans has a brief list of Geotechnical Notes. We suggest that these notes be expanded to include specific recommendations presented in section **8.0** of this report. Once this is completed, ICE will complete a more formal review of the project plans.

Based on our preliminary review of the other plan sheets, it appears that additional revisions will be needed to accommodate final slopes that are no steeper than 3H:1V along with a widely crowned (divergent) slope face to encourage dispersive drainage to the sides of the fill.

We recommend that slopes steeper than 4H:1V should be hydroseeded with a bond fiber matrix (BFM) type of mix. Winterizing the site for extended periods of wet weather should be completed by October 1. Straw mulch applied at least 4-inches thick is effective in all areas to reduce erosion. Additional erosion and sediment control measures may be required based on the performance of in-place Best Management Practices.

We note that on Sheet C3 there are several BMPs mentioned with no specific details of what these BMPs should consist of.

8.4 OTHER CONSIDERATIONS

For project such as this, the character of the materials being imported to the site will vary. This variability may necessitate the need for substantial modifications to the recommendations provided in this report.

9.0 USE OF THIS REVISED REPORT

We have prepared this revised report for use by Ravensdale LLC and their engineers to supplement the Grading Permit process for the Ravensdale Reclamation Trench Filling and Restoration Project at the Ravensdale LLC Property. This report is not applicable to other locations or for other purposes. Our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time this report was prepared. No warranty, express or implied, should be understood.

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We trust this revised report meets your present needs. Please call if you have any questions or need additional information.

Yours very truly,
Icicle Creek Engineers, Inc.

Kathy S. Killman, LEG
Principal Engineering Geologist

Brian R. Beaman, PE, LEG, LHG
Principal Engineer/Geologist/Hydrogeologist

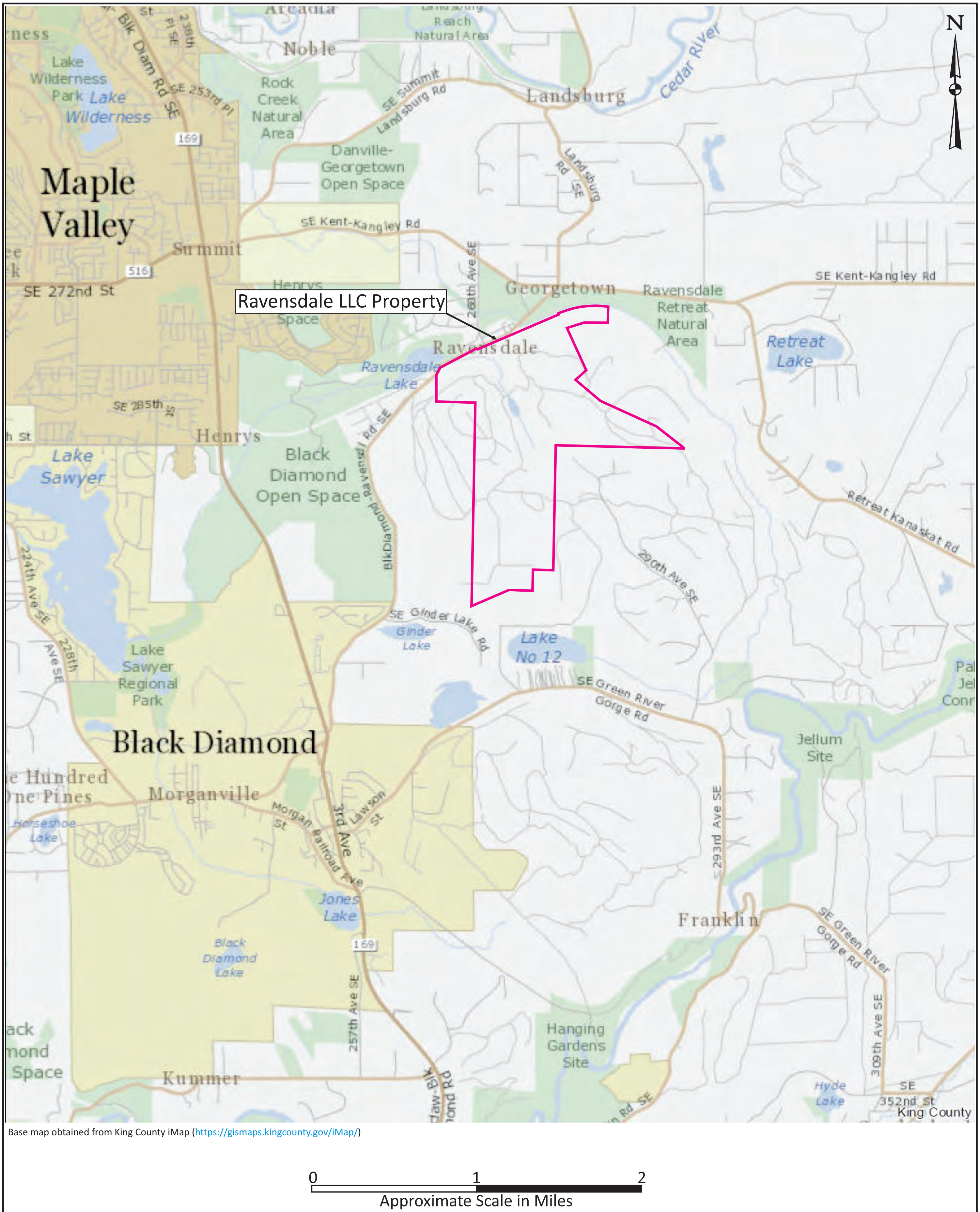
Document ID: 1352001.RevisedReport

Attachments:
- Vicinity Map – Figure 1
- Site Plan – Figure 2
- Coal Mine Hazards Map – Figure 3
- Trench A (West), Trench A (East) and Trench A (North) – Figure 4
- Trench B – Figure 5
- Trench C (West) and Trench C (East) – Figure 6
- Trench E – Figure 7
- Trench F – Figure 8
- Trench G – Figure 9
- Trench H (North) and Trench H (South) – Figure 10
- Trench I – Figure 11
- Trench J – Figure 12

Submitted via email (pdf) and surface mail (one original copy)

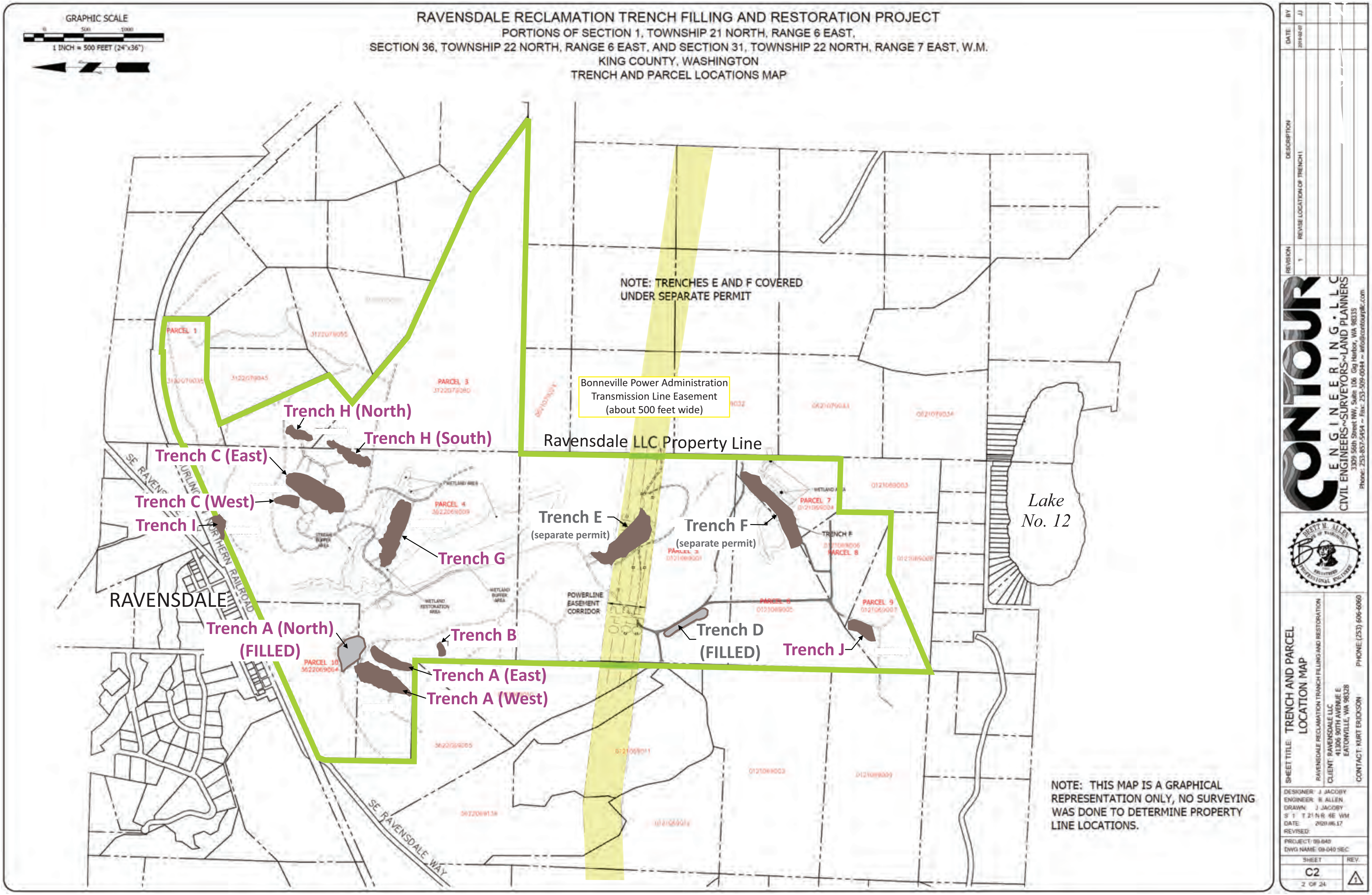
cc (email): Brett Allen, Contour Engineering LLC; Matt DeCaro, Soundview Consultants; David Toyer, Toyer Strategic Advisors, Inc.

FIGURES



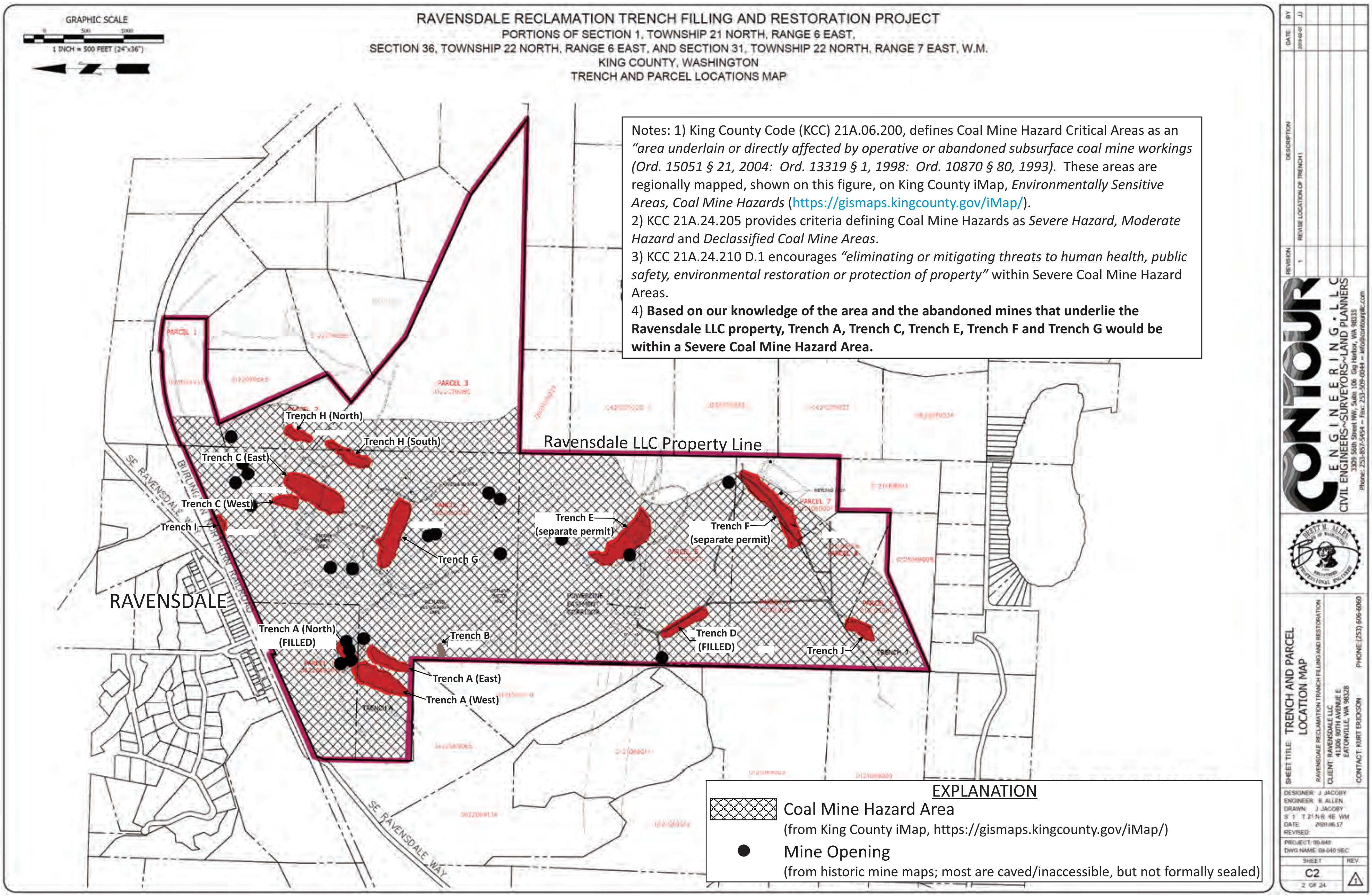
Base map obtained from King County iMap (https://gismaps.kingcounty.gov/iMap/)

VICINITY MAP	ICICLECREEK ENGINEERS 29335 NE 20th Street Carnation, Washington 98014 (425) 333-0093	SCALE: As Shown DESIGNED: --- DRAWN: BRB CHECKED: KSK DATE: 06/29/20	ICE FILE NO. 1352-001 Figure 1
RAVENSDALE RECLAMATION TRENCH FILLING AND RESTORATION PROJECT RAVENSDALE AREA, KING COUNTY, WASHINGTON			



Base map provided by Contour Engineering LLC

SITE PLAN	ICICLECREEK ENGINEERS	SCALE: As Shown	ICE FILE NO.
RAVENSDALE RECLAMATION TRENCH FILLING AND RESTORATION PROJECT RAVENSDALE AREA, KING COUNTY, WASHINGTON	29335 NE 20th Street Carnation, Washington 98014 (425) 333-0093	DESIGNED: --- DRAWN: BRB CHECKED: KSK DATE: 06/29/20	1352-001 Figure 2



Base map provided by Contour Engineering LLC

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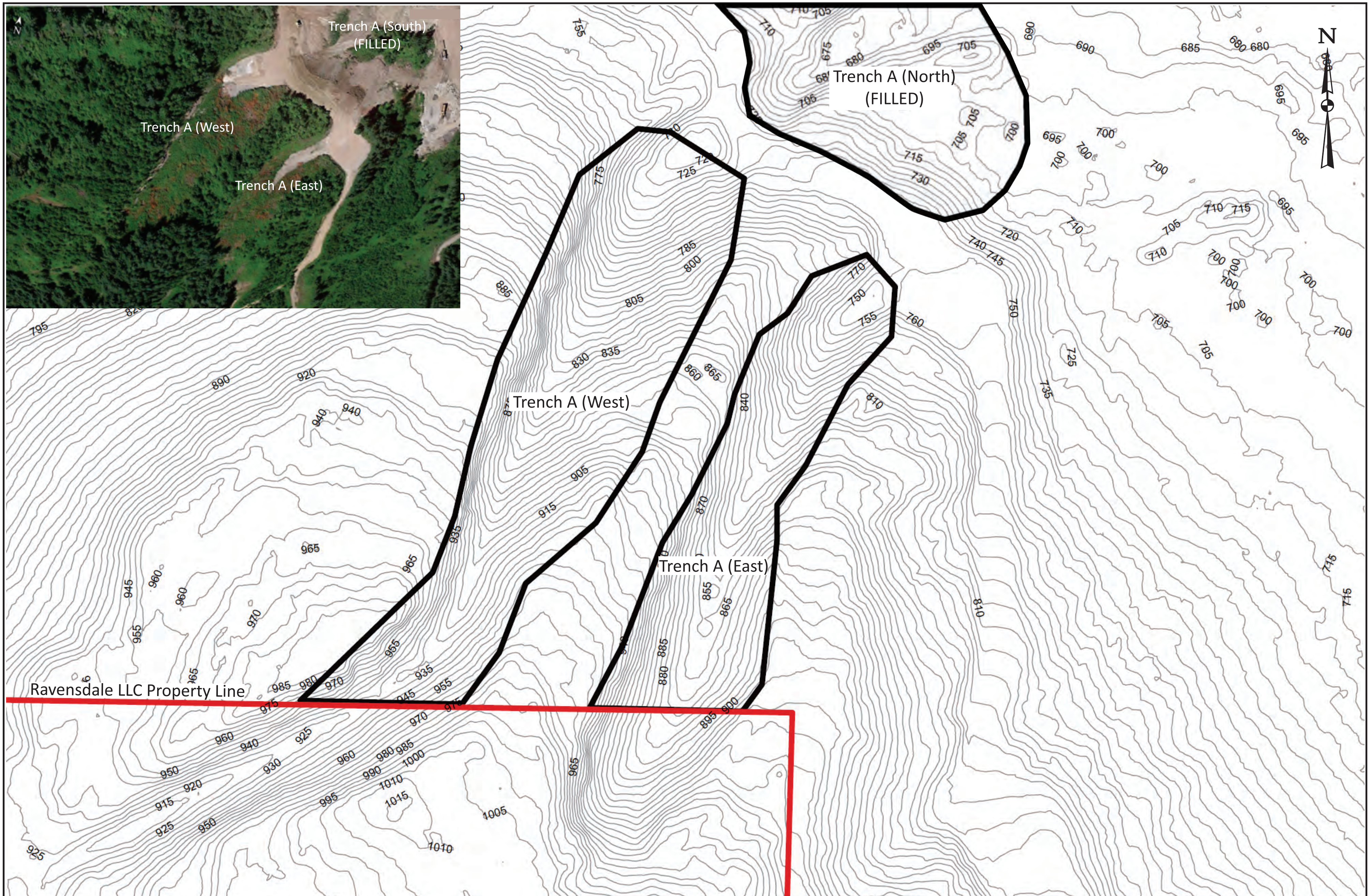
COAL MINE HAZARDS MAP	ICICLECREEK ENGINEERS	SCALE: As Shown	ICE FILE NO.
RAVENSDALE RECLAMATION TRENCH FILLING AND RESTORATION PROJECT RAVENSDALE AREA, KING COUNTY, WASHINGTON	29335 NE 20th Street Carnation, Washington 98014 (425) 333-0093	DESIGNED: --- DRAWN: BRB CHECKED: KSK DATE: 06/29/20	1352-001 Figure 3



LiDAR-based data (King County 2016 acquisition) obtained from the Washington State Department of Natural Resources, Washington LiDAR Portal (https://lidarportal.dnr.wa.gov/); processed by ICE for 5-foot topographic contour interval using Esri ArcGIS 10.6.

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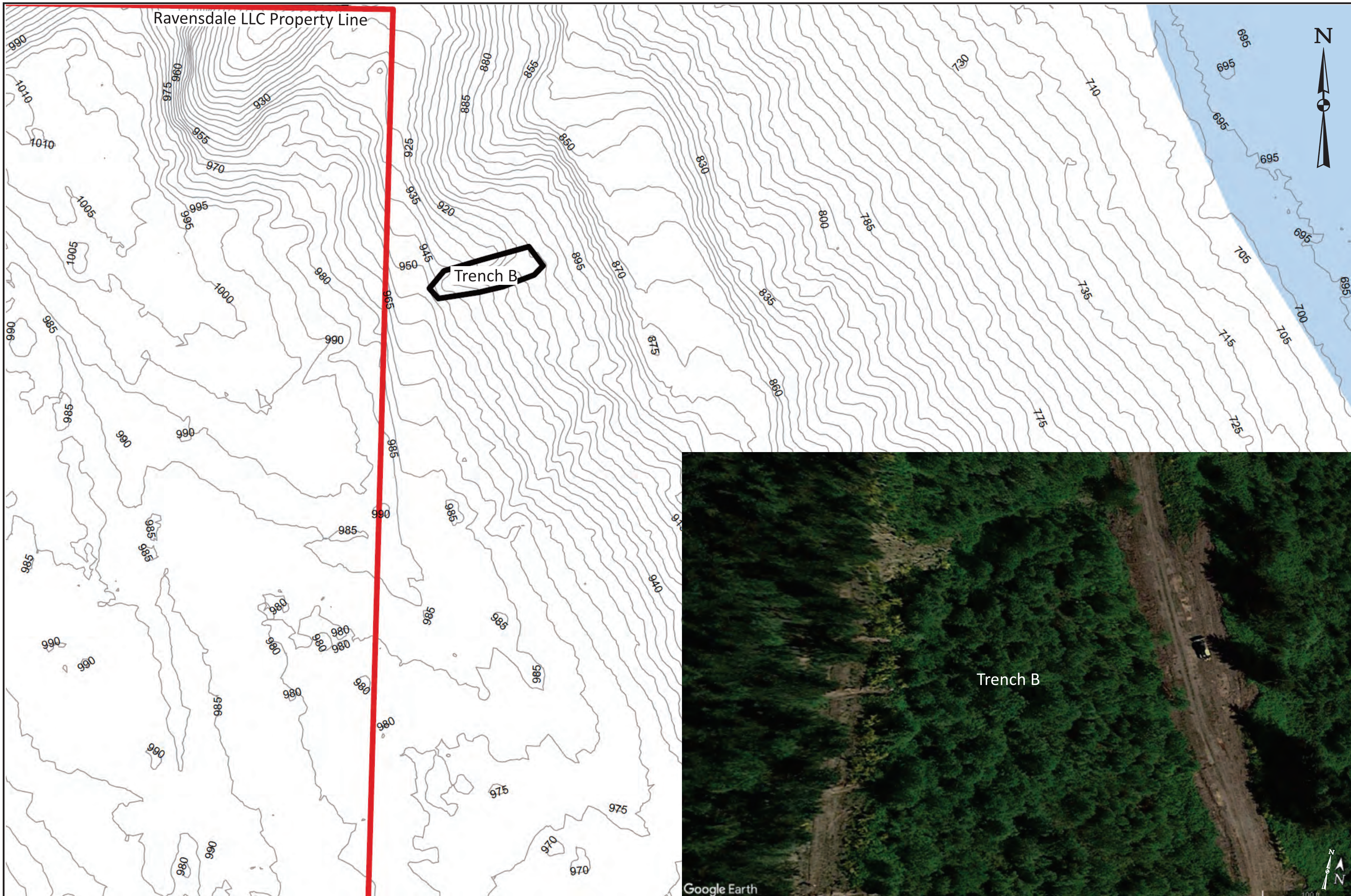
Approximate Scale in Feet

TRENCH A (WEST), TRENCH A (EAST) AND TRENCH A (NORTH) RAVENSDALE RECLAMATION TRENCH FILLING AND RESTORATION PROJECT RAVENSDALE AREA, KING COUNTY, WASHINGTON	ICICLECREEK ENGINEERS 29335 NE 20th Street Carnation, Washington 98014 (425) 333-0093	SCALE: As Shown DESIGNED: --- DRAWN: BRB CHECKED: KSK DATE: 06/29/20	ICE FILE NO. 1352-001 Figure 4



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Approximate Scale in Feet

TRENCH B

RAVENSDALE RECLAMATION TRENCH FILLING AND RESTORATION PROJECT
RAVENSDALE AREA, KING COUNTY, WASHINGTON

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29335 NE 20th Street
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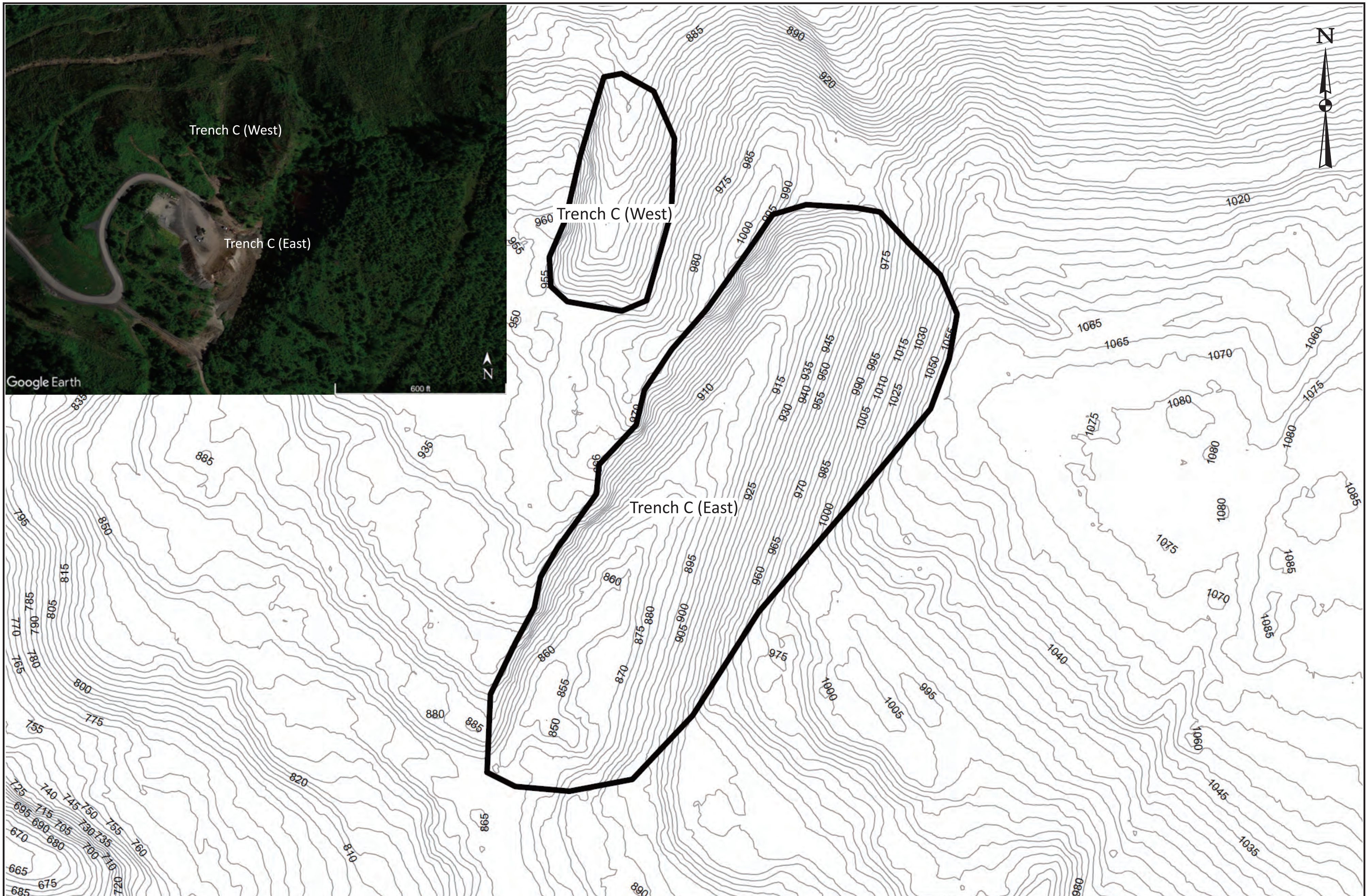

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TRENCH C (WEST) AND TRENCH C (EAST)	ICICLECREEK ENGINEERS	SCALE: As Shown	ICE FILE NO.
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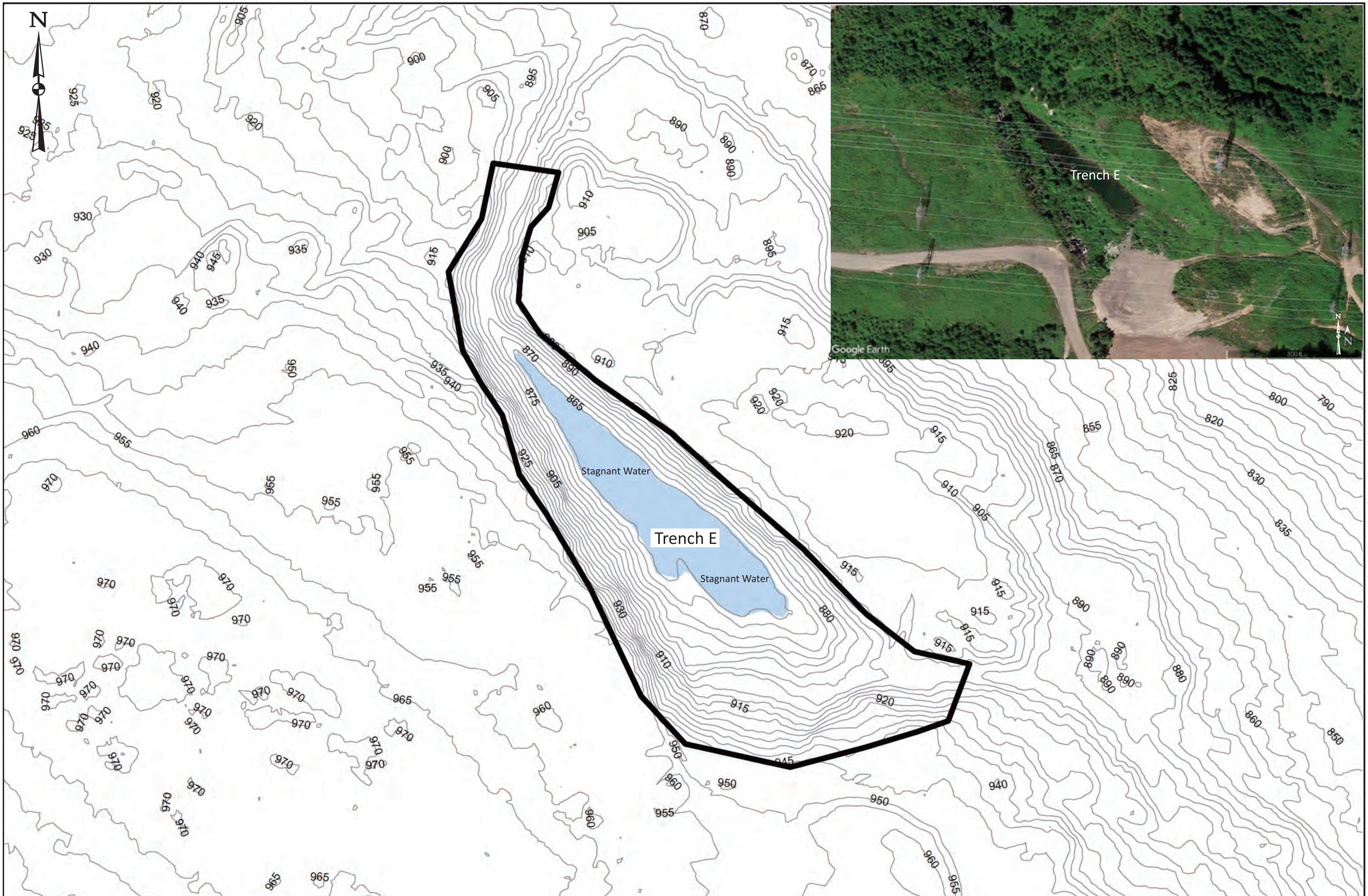

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TRENCH E

RAVENSDALE RECLAMATION TRENCH FILLING AND RESTORATION PROJECT
RAVENSDALE AREA, KING COUNTY, WASHINGTON

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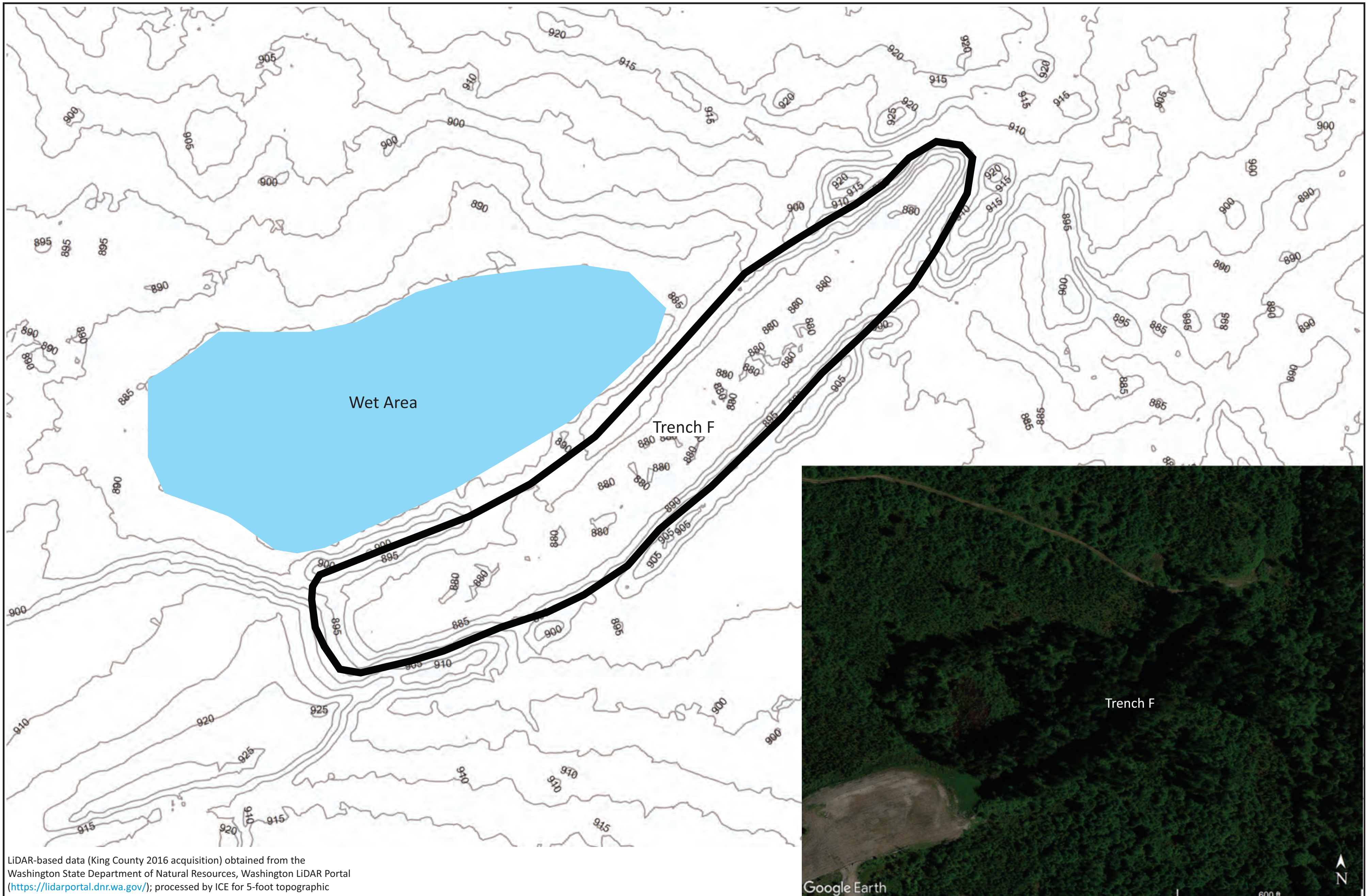

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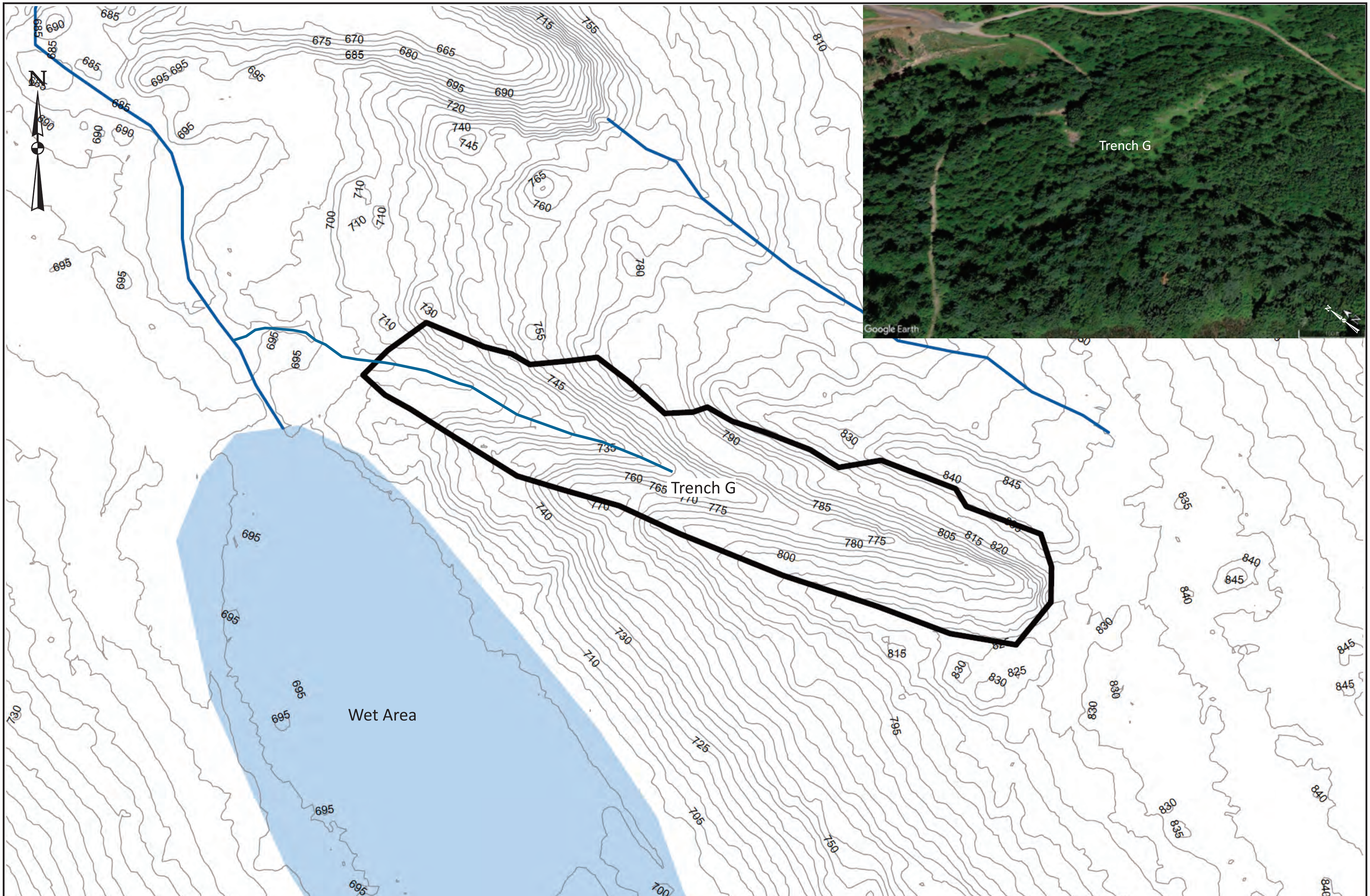

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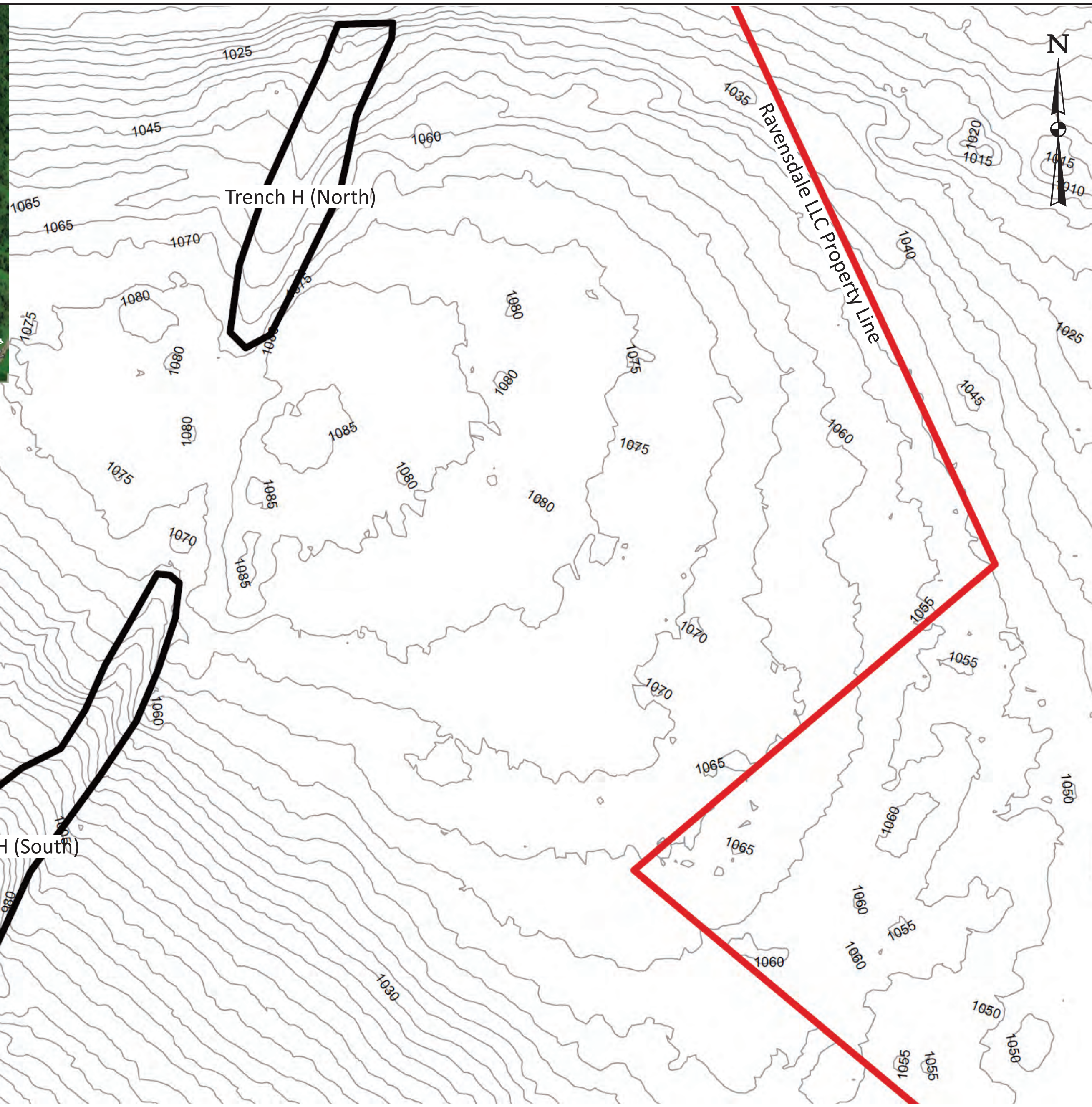

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TRENCH H (NORTH) AND TRENCH H (SOUTH)

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RAVENSDALE AREA, KING COUNTY, WASHINGTON

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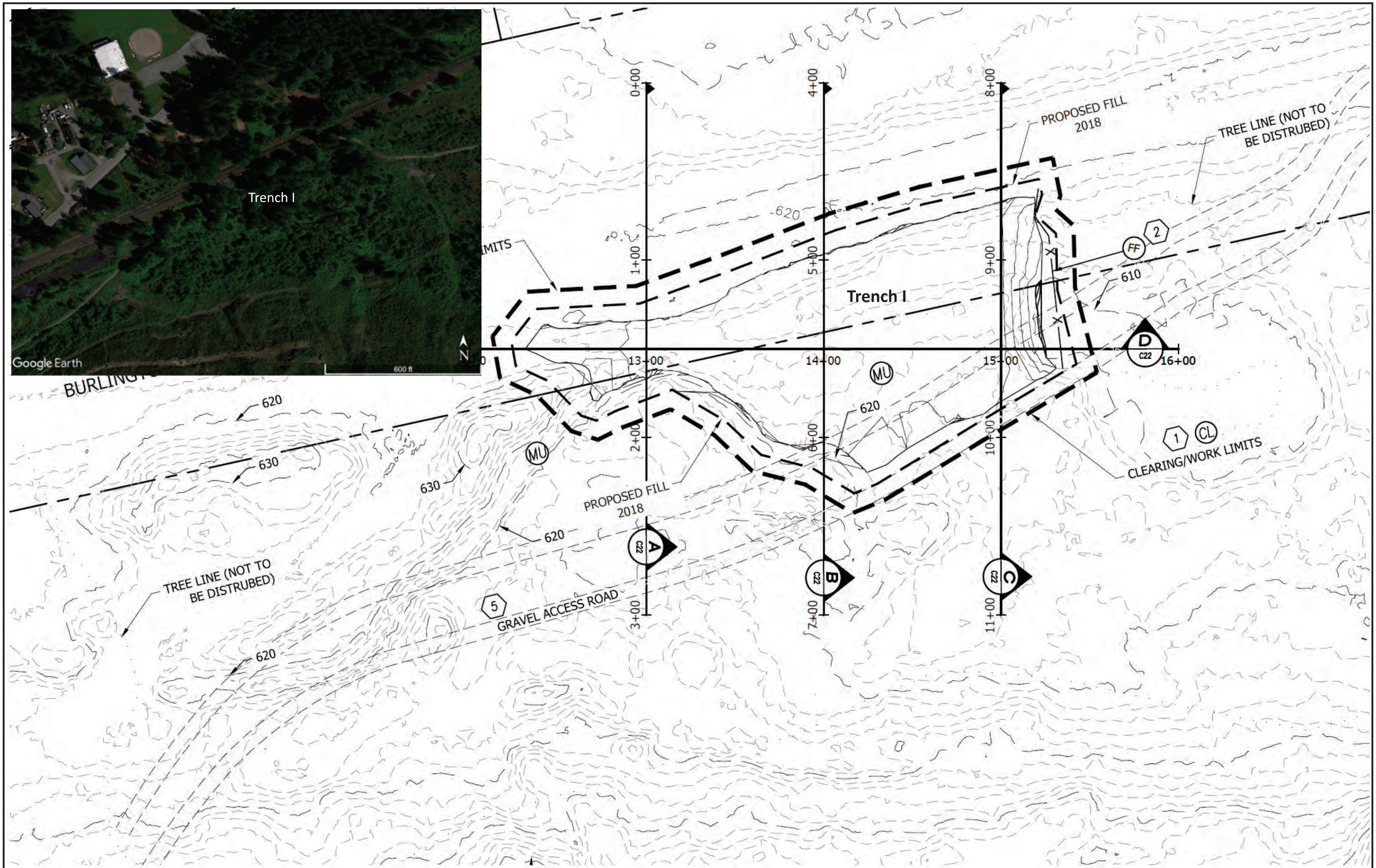

Based map provided by Contour Engineering LLC.

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Approximate Scale in Feet

TRENCH I

RAVENSDALE RECLAMATION TRENCH FILLING AND RESTORATION PROJECT
RAVENSDALE AREA, KING COUNTY, WASHINGTON

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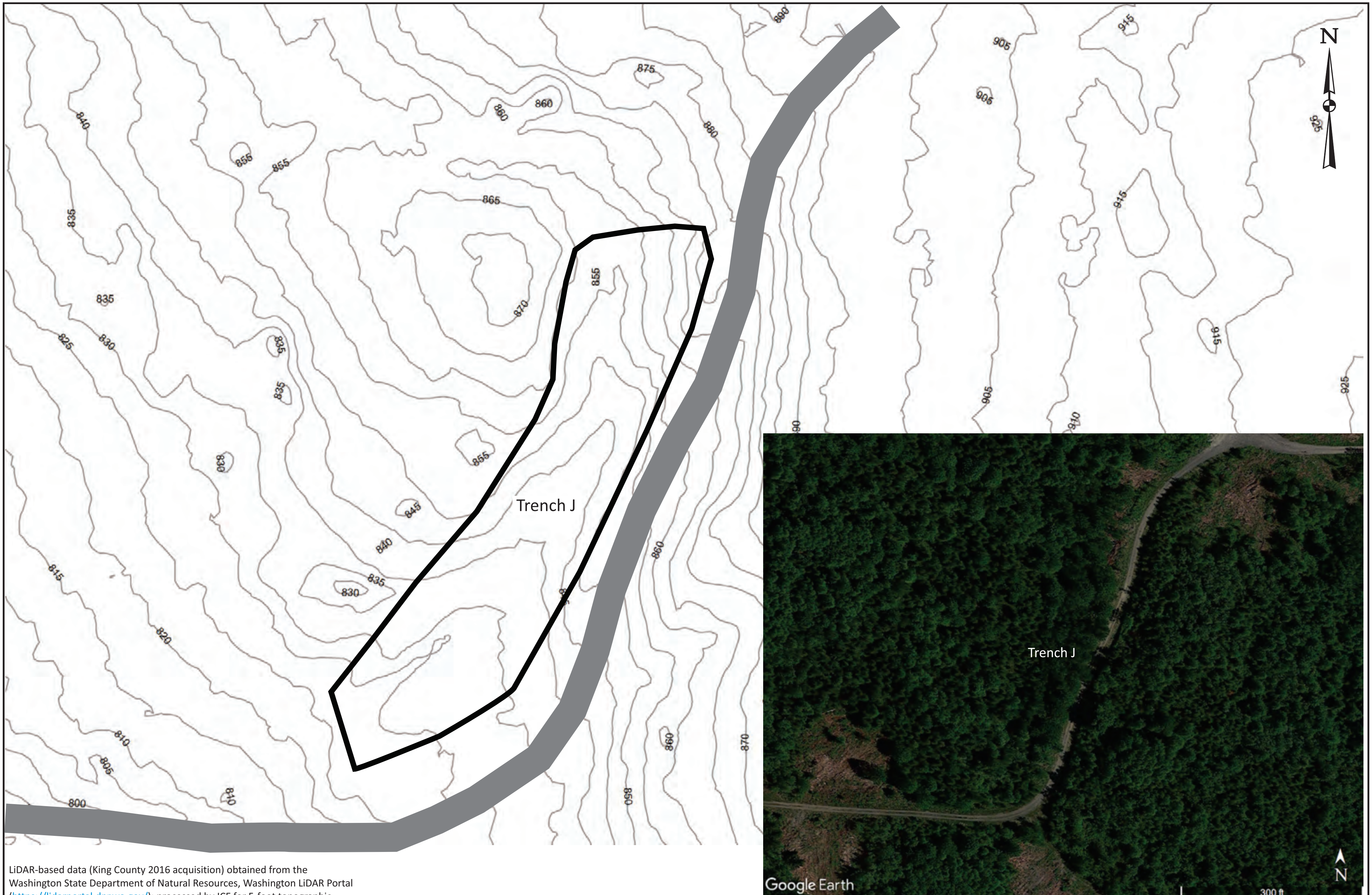

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TRENCH J

RAVENSDALE RECLAMATION TRENCH FILLING AND RESTORATION PROJECT
RAVENSDALE AREA, KING COUNTY, WASHINGTON

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