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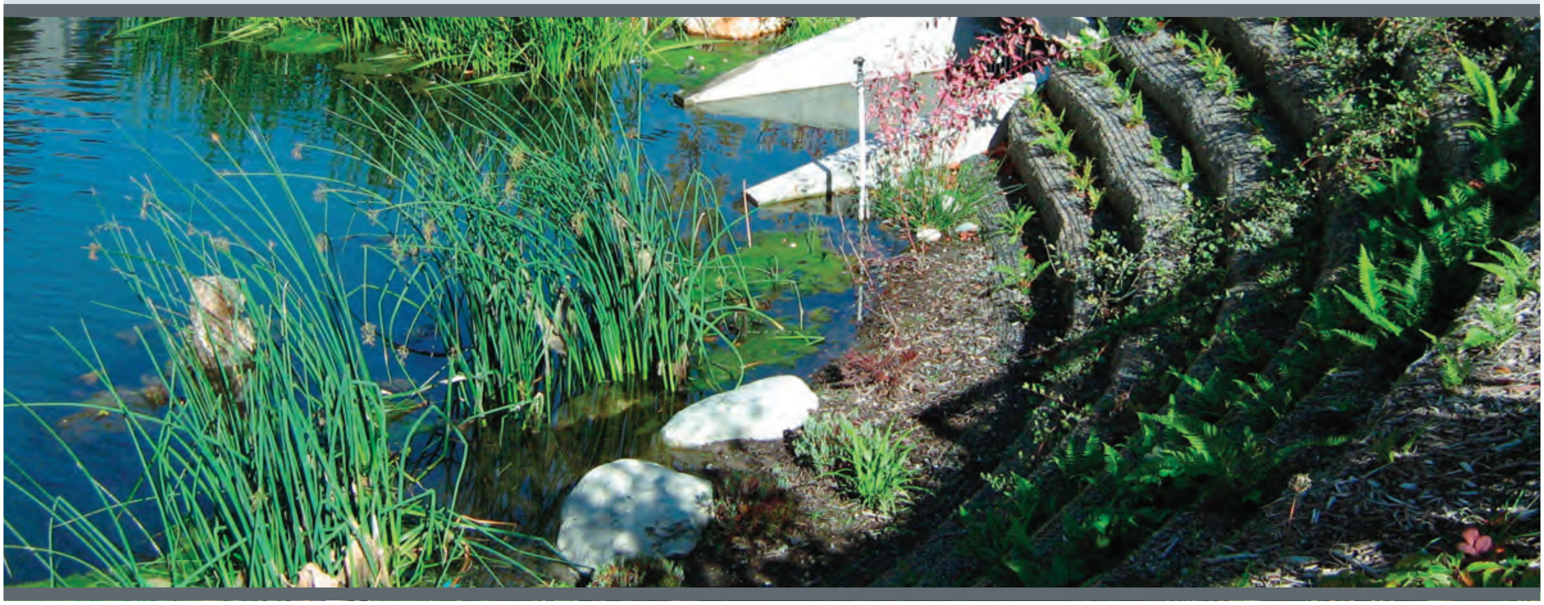


Earth and Water Affected Environment Technical Report

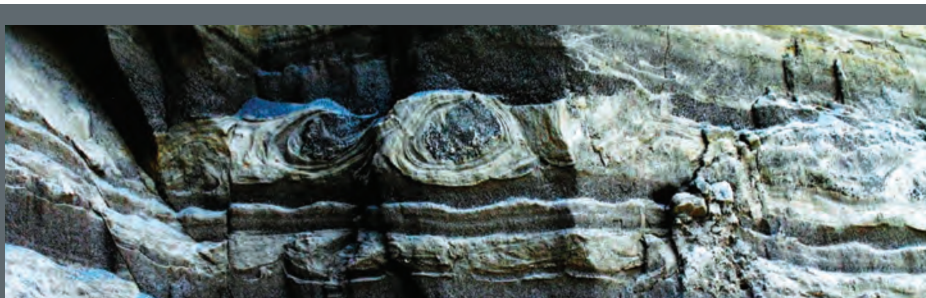
CUMBERLAND PROPERTY

King County, Washington

Prepared For

SEGALE PROPERTIES LLC

Project No. 20200367H001
June 13, 2023



Associated Earth Sciences, Inc.

www.aesgeo.com

Kirkland | Mount Vernon | Tacoma

associated earth sciences incorporated

June 13, 2023
Project No. 20200367H001

Segale Properties LLC
5811 Segale Park Drive C
Tukwila, Washington 98188

Attention: Mr. Mark Segale

Subject: Earth and Water Affected Environment Technical Report
Cumberland Property
King County, Washington

Dear Mr. Segale:

We are pleased to present the enclosed copy of our Earth and Water Affected Environment Technical Report for the Cumberland Property site. The purpose of this study was to document existing soils, geology, geologic hazards, surface water, groundwater, water use, water rights, and water quality conditions at the Cumberland Property and immediate vicinity. It is our understanding that this information will be utilized as a guidance document for technical information pertaining to the earth, groundwater, and water quality conditions at the proposed site. Additional field exploration, testing, monitoring, data analysis, and modeling are planned as future work to be compiled into a supplemental document intended to analyze potential impacts and provide applicable mitigation recommendations for the proposed surface mining activities.

If you should have any questions regarding this report or if we can be of additional help to you, please do not hesitate to call.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Kirkland, Washington

Curtis J. Koger, L.G., L.E.G., L.Hg.
Senior Principal Geologist/Hydrogeologist

CJK/ld - 20200367H001-011

EARTH AND WATER AFFECTED ENVIRONMENT TECHNICAL REPORT

CUMBERLAND PROPERTY

King County, Washington

Prepared for:
Segale Properties LLC
5811 Segale Park Drive C
Tukwila, Washington 98188

Prepared by:
Associated Earth Sciences, Inc.
911 5th Avenue
Kirkland, Washington 98033
425-827-7701

June 13, 2023
Project No. 20200367H001

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I. INTRODUCTION

1.1 PROJECT DESCRIPTION

The proposed Cumberland Property development encompasses about 990 acres of land that lies on a glaciated bedrock terrane in unincorporated King County, Washington (Figure 1) (portions of Sections 9, 15, 17, and 21, Township 21 North, Range 7 East, Western Mercator). The property lies north of the town of Cumberland, Washington and south and east of the Green River. The Green River has deeply incised into the bedrock and overlying unlithified deposits. The valley walls are steep sided along a section of the river known as the Green River Gorge, which stretches from Palmer Junction to Flaming Geyser State Park. Bedrock mountains border the eastern side of the site and form the headwaters of Deep Creek.

The Cumberland Property will be referred to in the remainder of this report as the “Segale Property,” and those portions of the property located in Sections 9, 15, 17, and 21, will be referred to as the northern, eastern, western, and southern Segale Property, respectively. Segale Properties LLC (Segale) owns the following parcels, but only the proposed development boundary is shown on Figure 1 and subsequent figures. For parcels that are located on either side of Cumberland-Kanaskat Road SE, the development area only includes the portion of the parcel area west of the roadway.

- Northern Segale Property: 921079001
- Western Segale Property: 1721079001
- Eastern Segale Property: 1521079007, 1521079009, 1521079008, 152107UNKN, 1521079020
- Southern Segale Property: 2121079001, 2121079005, 2121079006, 2121079008, 2121079009, 2121079015, 2121079016, 2121079029, and 2121079030

The irregularly-shaped Segale Property surrounds an approximately 599-acre parcel that occupies most of Section 16 that is owned by the Washington Department of Natural Resources (DNR). This parcel will subsequently be referred to in this report as “DNR Property 16.” A 40-acre outparcel is present within the NW¼, SE¼ of Section 16 and is not part of DNR Property 16. An approximately 571-acre parcel owned by the DNR that occupies most of Section 20, located west and south of Segale Property, will be referred to as “DNR Property 20.” DNR Properties 16 and 20 are not included in current development plans.

State-owned lands lie between the northern and western Segale Properties and the Green River. These lands include the Kanaskat-Palmer State Park and Recreation Area.

Site development plans are preliminary and subject to change. Preliminary plans include development of the Segale Property for natural resources (sand and gravel extraction). Mining and site-development will be done under a staged approach. For the purposes of this report a sand and gravel mine area is referred to as a “pit.” Anticipated mining-related facilities include on-site crusher(s), wash plant(s), process water control plant, and an asphalt plant. The processing plant (crusher, wash plant, and process water control plant) is anticipated to operate within the northern Segale Property and may be moved during later stages to the western Segale Property to minimize haul distances. The asphalt plant is anticipated to operate near the southeastern corner of the northern Segale Property based on conceptual development plans. A copy of the current Conceptual Development Plan, dated July 15, 2022, is included in Appendix A.

1.2 PURPOSE AND SCOPE

The purpose of this study was to record existing soils, geology, geologic hazards, surface water, groundwater, water users, water rights, and water quality conditions in the site vicinity. These data were used to study the potential affected environment of the proposed mining activities. It is our understanding that this information will be utilized to provide technical information for the earth, groundwater, and water quality conditions at the site.

Our scope of work included review of applicable published geologic literature, consultant-prepared reports, mine records, visual reconnaissance of the site, the advancement of borings and installation of monitoring wells, acquisition of geophysical data, assessment of nearby water well logs and water rights from the Washington Department of Ecology (Ecology), stream flow measurements, and monitoring the quantity and quality of water resources in the site vicinity. With this data, the type, thickness, distribution, and physical properties of the subsurface sediments and groundwater conditions were evaluated.

Site topographic maps and survey data were provided by Segale and utilized in our study. Survey data was provided in the North American Vertical Datum of 1988 (NAVD88). The locations of the explorations completed for this study and previous explorations completed by others are shown on Figure 2. Exploration logs prepared by Associated Earth Sciences, Inc. (AESI) are included in Appendix B. Laboratory testing results are shown in Appendix C. Exploration logs prepared by others are included in Appendix D. Geophysical exploration locations are summarized on Figure 3. The Geophysics report is attached as Appendix E.

1.3 AUTHORIZATION AND LIMITATIONS

Our study was accomplished in general accordance with the scope of services outlined in our proposal dated October 27, 2021. This report has been prepared for the exclusive use of Segale, and its agents, for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geologic, hydrogeologic, and geotechnical engineering practices in effect in this area at the time our report was prepared. Our observations, findings, and opinions are a means to identify and reduce the inherent risks to the owner. No other warranty, express or implied, is made.

The conclusions and recommendations presented in this report are based on the explorations completed for this study. The number, locations, and depths of the explorations were completed within site and budgetary constraints. Because of the nature of exploratory work below ground, extrapolation of subsurface conditions between field explorations is necessary. It should be noted that differing subsurface conditions may sometimes be present due to the random nature of deposition and the alteration of past topography.

II. FIELDWORK SUMMARY

This section summarizes fieldwork completed by AESI, including geologic reconnaissance, observations of exploration borings, monitoring well installation and development. The methodology of geophysical exploration is included in the report attached as Appendix E. Our explorations were used to assess the geologic and hydrogeologic conditions at the site. Monitoring procedures and data or literature review are outlined in their respective sections later in this report.

2.1 GEOLOGIC RECONNAISSANCE

AESI completed several days of site and slope reconnaissance between May 2021 and March 2022. The purpose of the geologic reconnaissance was to identify surface water features (streams), groundwater discharge locations (springs), geologic outcrops and contacts, and document existing slope and general landform conditions. Streams identified during our reconnaissance are shown on Figure 2. In addition to stream reconnaissance, AESI walked the slopes above the Green River adjacent to the northern and western Segale Properties within the state-land areas, the deep kettles located in the northwest corner of DNR Property 16, the bedrock knob located in the northern area of the western Segale Property, and the flanks and ridges along Lizard Mountain. Field-located seepage areas were flagged and later surveyed by Segale, shown on Figure 2. Recent shallow landslides were also observed during our reconnaissance, and their locations are shown on Figure 4. The obtained information was used to supplement our broader subsurface investigation.

2.2 EXPLORATION BORINGS, MONITORING WELLS, AND WELL DEVELOPMENT

AESI observed advancement of 13 borings and well installation and development of 12 monitoring wells on the Segale Property for this study (Figure 2). All borings were completed as monitoring wells except EB-13. The wells include EB-1W through EB-12W. Installation of monitoring well EB-1W was observed by AESI in November 2021. Wells EB-2W through EB-9W were installed between December 2021 and February 2022. Well EB-10W was installed in July 2022. Wells EB-11W and EB-12W and boring EB-13 were completed in August 2022. Borings B-1 through B-7 were drilled under a separate drilling program initiated by GeoDesign Inc. (currently NV5). Four of the borings were completed as wells including B-2, B-3, B-4, and B-5. AESI observed well development of B-3, B-4, and B-5. Well B-2 was not developed since it has been dry since installation.

Borings EB-1W, EB-3W, EB-5W, and EB-7W were drilled by Cascade Environmental of Woodinville, Washington and borings EB-2W, EB-4W, EB-6W, EB-8W, EB-9W, EB-10W, EB-11W, EB-12W, and EB-13 were drilled by Holt Services, Inc. of Edgewood, Washington. The borings were advanced using a Terra Sonic 150CC drill rig. The sonic drilling method uses sonic frequencies generated by a high-power oscillator to rotate and vibrate the drill rods, core barrel, and casing into the subsurface. The driller used 6-inch-diameter casing for 2-inch well completions (EB-1W) and 8-inch-diameter casing for 4-inch well completions (EB-2W through EB-12W). Samples were retrieved using a core barrel about 2 inches smaller in diameter than the casing. Sonic samples consist of nearly continuous, somewhat disturbed samples of the subsurface. The degree of recovery, or how much sample is retrieved from the drilled interval, depends on several factors, including relative sediment size, gradation, and fines content, in situ moisture, and density. In loose, gravelly unconsolidated formations, large gravel and cobbles may be pulverized, biasing (increasing) the apparent fraction of fines present in the core samples, or pushed out into the formation resulting in low recovery. Boulders that are much larger in diameter than the casing are difficult to advance through.

Representatives from AESI continuously observed drilling and logged the recovered core. Sediment samples were placed onsite and arranged by depth for logging and photography. AESI visually classified the soil cores onsite and selected samples were retained in moisture-tight containers to be transported to our laboratory for further classification and laboratory testing.

Representatives from AESI observed well installation. Wells were constructed with polyvinyl chloride (PVC) materials, with varying lengths of 0.010-inch or 0.020-inch machine-slotted well screen, and an above-ground steel monument with bollards. The annular space within the screened interval and extending to at least 2 feet above the screen was backfilled with silica sand. The remaining annular space was sealed with bentonite chips or a combination of bentonite chips and a bentonite slurry. Concrete was placed near the surface during the installation of the above-ground monument and bollards.

A representative from AESI observed the development process, which included surge and bail techniques followed by pumping. Well development was accomplished using a pump service truck, stainless steel bailers, a surge block mounted to a stainless steel tube, and a temporary submersible pump. Development started by bailing water and sediment from the well. In between rounds of bailing, the well screen was surged with a surge block attached to a winch line. At the location of well EB-5W, site conditions prevented truck access to the wells. Development of this well was conducted using manually operated surging and bailing equipment. After surge and bail techniques, water was pumped from each of the wells using a submersible pump. AESI monitored the discharge rate, sand fraction, turbidity during pumping, and well development was considered adequate when the turbidity readings stabilized. In two of the deepest wells (EB-4W and EB-9W) the turbidity readings were slow to improve beyond an average of approximately 300 nephelometric turbidity units (NTU). The high turbidity values are likely a result of fine-grained clay particles (colloids) that settle out of suspension inside the well with time.

III. EXISTING CONDITIONS

3.1 SITE TOPOGRAPHY AND SLOPES

3.1.1 Topography

The site lies on a glaciated bedrock terrane and is situated north of the town of Cumberland, Washington above the Green River valley (Figure 1). Topographic features on this land surface were primarily formed by various glacial processes and older bedrock faulting and folding and volcanic intrusions.

Lizard Mountain is a significant bedrock feature contained within the southern Segale Property and DNR Property 16. Lizard Mountain has a peak elevation of about 1,465 feet, a relief of about 650 feet above the glacial outwash plain surface which generally lies in the low to mid-800-foot elevation range across the Segale Property and DNR Property 16 (Figure 2). Subsidence features and land modification of Lizard Mountain is related to past coal mining activities, which is discussed later in this report.

Other bedrock-influenced features include a smaller bedrock knob within the northern area of the western Segale Property (about 80 feet of relief) and an elongated bedrock ridge within the western portion of DNR Property 20 (about 170 feet of relief). The glacial outwash plain surface is partially eroded to about 750 feet elevation within the broad west-central portion of DNR Property 20 adjacent to the elongated bedrock ridge.

The outwash plain surface is pitted with depressions (glacial kettles) formed by blocks of melting ice and terraces formed by flow in meltwater channels. Kettles are found across the northern, western, and southern Segale Properties; however, the deepest kettles are located in the southwestern corner of the northern Segale Property/northwestern area of DNR Property 16 and the northern area of DNR Property 20. The bottoms of these kettles are present up to approximately 100 feet below the surrounding topography (about 740 feet to below 700 feet elevation).

Past incision by meltwater prior to the formation of the modern Green River eroded a terrace into the outwash plain to about 700 feet elevation in the northwest area of the northern Segale Property. Recent incision by the modern Green River formed the gorge with approximately 150 to more than 200 feet of relief along sections of the river.

The Segale Property is primarily undeveloped and forested with the exception of a prefabricated steel building, a powerline easement, and a network of unpaved roads and informal trails. The existing building, which is described in King County (2022a) records as a storage warehouse, is located in the southern Segale Property. DNR Properties 16 and 20 are also forested and undeveloped and traversed by a network of gated, unpaved roads and informal trails.

3.1.2 Slopes

The topography of the Segale, DNR Property 16, and adjoining state-owned lands is mostly flat to moderately sloping but steepens to in excess of 40 percent in several areas (Figure 4). These areas include steep slopes along the Green River, the flanks of Lizard Mountain, the northern bedrock knob, the flanks of an alluvial terrace in the northern Segale Property, and two closed depressions located in the northern Segale Property and DNR Property 16. Scattered, smaller, localized areas of steep slopes are also found in a few other areas of the Segale and DNR 16 Properties. These smaller steep slope areas are generally less than 20 feet in height and either lie outside of the proposed mining limits or will be completely removed during mining.

Steep slopes which exceed 40 percent over a height of at least 10 feet classify as Steep Slope Hazard Areas under the *King County Code* and are shown on Figure 4. Also shown on Figure 4 are shallow landslide failures observed during our geologic reconnaissance and slide features shown on King County river corridor landslide mapping. The King County mapping identified a large, deep-seated landslide on the east bank of the Green River, west of the north side of the western Segale Property. This landslide is identified as Landslide 1 on Figure 4. It should be noted that King County landslide mapping is based on a desktop review of Light Detection and Ranging (LIDAR) and aerial imagery and these landslides are not field-verified.

During our visual reconnaissance of the area of Landslide 1 we did not identify any indicators of recent or active slope movement, such as unusually distorted tree trunks, slide scarps, tension cracks, or recently exposed soil, consistent with the mapped landslide. No geomorphic features consistent with the mapped landslide area were evident during our review of a LIDAR-based shaded relief map of the area, and the presence of a previous landslide at this location has not been confirmed. It should be noted that the mapped location of this landslide is entirely outside of the Segale Property. An area with unusual tree trunk distortion, potentially indicative of accelerated soil creep/earth movement was observed near the mapped landslide. This area, which is identified on Figure 4 as Landslide 2, was small and located outside the mapped area of Landside 1.

No large deep-seated landslide areas were observed during our reconnaissance. We did observe several shallow slides in the steeply sloping areas above the river and one shallow slide along the western flank of Lizard Mountain. Some of these extended over heights of up to approximately 40 to 50 feet, but all were limited to only a few feet in depth and are interpreted to be shallow colluvial slides. All of these slides appeared to be fairly recent and either unvegetated or vegetated by young brushy growth. Three of the slides were co-located with groundwater seepage. These slides are identified on Figure 4 as Landslides 3 through 5. All of the slides observed during our reconnaissance were located outside of the Segale Property boundaries.

Areas of Holocene (post-glacial) landslide activity classify as Landslide Hazard Areas under the *King County Code*. All of the slide areas observed during our reconnaissance were located within areas which also classify as Steep Slope Hazard Areas.

3.2 SOILS

The soil types on the site are mapped by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The soil map for the Segale Property is included in Appendix F. The regional hydrologic soil groups are shown on Figure 5. Soils mapping identified five soil units on the site and immediate vicinity. These units include:

- Barneston Series
- Beausite Series
- Chuckanut Series
- Arents
- Norma Series

3.2.1 Barneston Series (Hydrologic Group A)

The Barneston gravelly coarse sandy loam soils form in glacial outwash terraces and terrace escarpments of 0 to 65 percent. These soils are characterized by dark grayish brown gravelly coarse sandy loam 9 inches thick. The subsoil is dark yellowish brown very gravelly sandy loam 5 inches thick. The upper 7 inches of the substratum is dark brown extremely gravelly sand. The lower part to a depth of 60 inches is dark yellowish brown extremely gravelly sand. The Barneston Series soils are mapped along the glacial outwash terraces and terrace escarpments within the proposed mine area. Barneston soils are classified under the Group A hydrologic soil group and are described as “somewhat excessively drained.” They constitute about 78 percent of the soil on the Segale Property (Appendix F).

3.2.2 Beausite Series (Hydrologic Group C)

The Beausite Series soils form in glacial till and colluvium derived predominantly from sandstone. The soils are moderately deep (24 to 40 inches) to sandstone and present on foothills on slopes of 6 to 90 percent. These soils are characterized by 5 inches of black gravelly loam over dark brown gravelly sandy loam 6 inches thick. The subsoil is dark brown 10 inches thick and dark yellowish brown 8 inches thick of extremely gravelly sandy loam. The substratum is light olive brown extremely gravelly sandy loam to a depth of 36 inches. The Beausite Series soils are mapped along the flanks of Lizard Mountain. Beausite is classified under the Group C hydrologic soil group and is described as “well drained.” The runoff potential of Beausite Series soils varies with slope inclination. They constitute about 10 percent of the soil on the Segale Property.

3.2.3 Chuckanut Series (Hydrologic Group B)

The Chuckanut Series soils form in colluvium derived from glacial till and sandstone. The soils are present on the back and toe of slopes on foothills of 6 to 65 percent. These soils are characterized by a topsoil containing 8 inches of dark brown loam. The subsoil is composed of three layers including dark yellowish brown gravelly loam 9 inches thick, pale brown to dark brown gravelly sandy loam 7 inches thick, and light brownish gray gravelly loam 11 inches thick. The upper 10 inches of the substratum is light brownish gray gravelly loam. The lower part to a depth of 50 inches is light gray gravelly loam. The Chuckanut Series soils are mapped along the top and eastern flanks of Lizard Mountain. Chuckanut Series soils are associated with Beausite, Bellingham, and Tokul Series, and rock outcrops (no soil). Chuckanut soils are classified under the Group B hydrologic soil group and are described as "well drained." Runoff erosion hazard is low for slopes under about 20 percent and moderate for slopes over 20 percent. They constitute about 10 percent of the soil on the Segale Property.

3.2.4 Arents (Hydrologic Group A)

Arents Series soils form in a mixture of volcanic ash and a variety of other deposits. They occur over terraces and drift plains at slopes ranging from 0 to 8 percent. No single profile is representative of these soils, and they are typically anthropogenically disturbed. Arents soils are mapped in a limited area on the Segale Property southwest of Lizard Mountain, along forest roads near the storage warehouse. In general, Arents Series are classified as Group A hydrologic soils and are described as "moderately well drained to somewhat excessively drained." Runoff from Arents soils is considered to be slow. They constitute about 2 percent of the soil on the Segale Property.

3.2.5 Norma Series (Hydrologic Group B/D)

The Norma Series consists of very deep, poorly drained soils in alluvium. Norma soils form in depressions on ice-contact terrane. These soils are characterized by a dark grayish brown loam topsoil 9 inches thick. The upper subsoil is dark grayish brown and dark brown gravelly loam with strong brown mottling 8 inches thick. The lower subsoil is dark grayish brown gravelly loam with dark yellowish mottling 16 inches thick. The substratum is dark grayish brown very gravelly sandy loam with strong brown mottles to a depth of 60 inches. The Norma Series soils are mapped along Deep Creek at the southeast corner of the southern Segale Property. Norma is classified as a split (B/D) hydrologic soil group with Class B extending to 40 inches and Class D below 40 inches. In these areas, the high water table is as high as 1 foot above to 1 foot below the surface of the soil at times from November to April unless drained. Norma Series soils exhibit slow to ponded runoff. They constitute less than 0.1 percent of the soil on the Segale Property.

3.2.6 Soils Map Summary

The soils within the proposed pit areas (Appendix F) are predominantly Barneston Series. The Barneston Series is characterized as a Group A hydrologic soil and transmits water relatively rapidly through the soil under existing conditions. The soils mapping is generally consistent with our explorations and geologic reconnaissance. The soils mapping does not account for spoils piles related to past mining or road building activities. Spoils piles have covered the previous soil horizon and may have partially developed soils at their surface. Observed spoils piles are primarily in the Lizard Mountain area, with limited spoils piles within the southern Segale Property, northern bedrock knob, DNR Property 16, and DNR Property 20.

3.3 REGIONAL GEOLOGIC SETTING

The project site lies within the Puget Sound Lowland, which is a broad topographic and structural basin extending generally north-south between the Cascade Range on the east to the Olympic Mountains on the west. The project site was part of several previous geologic studies including Evans (1912a), Warren et al. (1945), Gower and Wanek (1963), Luzier (1969), Wanek and Vine (1969), Vine (1969), Frizzell et al. (1984), Phillips (1984), Tabor et al. (2000), and AESI (2003). The geology in the vicinity is complex with a range of geologic units exposed in close proximity to the site. The surficial geologic map of the area titled *Geologic Map of the Cumberland, Hobart, and Maple Valley Quadrangles, King County, Washington* by Wanek and Vine (1969) is shown on Figure 6. The geology in the vicinity of the site is shown on Figure 6, geologic cross-section locations are shown on Figure 7, and geologic cross-sections are shown on Figures 8 through 23.

The project site lies near the Green River Gorge, a section of the Green River characterized by exposures of steep bedrock cliffs. This bedrock is known as the Puget Group and consists of sedimentary rocks of Eocene age (56 million to 34 million years ago (Ma)). The Puget Group rocks outcrop in places throughout the vicinity of the site. Upstream areas along the Green River within the Cascades include exposures of younger volcanic and volcanic sedimentary rocks of Oligocene to Miocene age (34 to 5 Ma). The Puget Group was intruded by intrusive igneous rock after deposition, and then faulted and folded into their present location. In the site vicinity, the Puget Group bedrock contains north-south trending fold axes and northwest-trending faults (Warren et al., 1945; Gower and Wanek, 1963).

Based on the referenced geologic mapping and AESI’s work in the area, a buried erosional valley incised into the bedrock has been identified in the site vicinity. An ancient river, possibly analogous to the modern Green River, established course(s) through a bedrock valley in the immediate vicinity of the site. This paleo-valley was aggraded with sediments derived primarily by fluvial deposition processes and include fluvial sands and gravels and lacustrine silt/clay. Boring and geophysical data indicate that the depth and width of the buried valley is similar to that of the modern-day Green River Gorge.

Glacial ice has advanced southward from British Columbia into the Puget Lowland multiple times within the last 2 million years. The ice was part of the widespread Cordilleran continental ice sheet that covered much of northwestern North America and periodically extended down into the Puget Sound as a broad, tongue of ice commonly referred to as the Puget Lobe. The glacial sediments in the region of the site are a record of the Vashon-age Puget Lobe, which deposited glacial till, ice-contact deposits, and outwash sand and gravel. The Segale Property is located near the lateral margin of the Vashon-age Puget Lobe where the ice was thinner than it was in the Puget Sound area. Vashon-age glacial till drapes the irregular pre-Vashon topography locally in erosional contact with the underlying pre-Vashon sediments and bedrock. Ice-contact kettles are scattered throughout the landscape and indicate where large, stagnant blocks of ice were buried during rapid deglaciation. Sand and gravel were deposited onto outwash plains by meltwater flowing off the retreating ice. This meltwater simultaneously eroded into the landscape.

Post-glacial modification of the landscape is primarily from the modern Green River. The modern Green River has its source near the summit of the Cascades and flows westward entering the study area near Palmer Junction, located approximately ½ mile east of the site. From this point the modern Green River flows westward and southward from Palmer Junction and has incised into the thick sequence of deposits as it adjusted to the abrupt change (lowering) in regional surface water drainage "base-levels" of the Puget Lowland following Vashon deglaciation. The Vashon glacial deposits buried and preserved the pre-existing deposits and prevented the pre-Vashon rivers, including the ancient valley traversing the site vicinity, from re-establishing their pre-glacial courses. River incision, including large late Vashon-age recessional terraces carved into earlier Vashon-age sediments, was influenced by the occurrence of resistant bedrock progressively exposed during river erosion. Continued post-glacial incision was restricted within bedrock canyons that eroded deeper into the underlying bedrock forming the present Green River Gorge located west and northwest of the site (Figure 6).

3.4 SITE GEOLOGY/STRATIGRAPHY

We reviewed previous geologic studies completed in the vicinity of the Segale Property. Three hydrogeologic reports pertaining to the Metro Seattle's forest biosolids/sludge application or "Silvigrow" project were available from local libraries and on file with King County. The studies were completed as part of a joint effort to characterize the hydrogeology of the DNR Properties 16 and 20 and assess what impact the Silvigrow project would have on the surrounding area. The earliest study was completed by Brown and Caldwell, Municipality of Metropolitan Seattle, and TCW Associates, Inc. in March 1989 for the City of Black Diamond and included water quality information and spring discharge rates for the major springs along the Green River (Brown and Caldwell et al., 1989). The Brown and Caldwell et al. (1989) report includes a summary and conclusions section prepared by TCW Associates, Inc. (1989a). The second study was completed by TCW Associates Inc., Harper-Owes, and University of Washington and others in December 1989 for the Seattle King County Health Department and included nine borings, one of which was completed as a monitoring well (TCW Associates, Inc. et al., 1989b). The third report was prepared by CH2M Hill and Hong West & Associates (HWA) in October 1991 for the Municipality of Metropolitan Seattle and was the most comprehensive study with the addition of nine borings completed as monitoring wells (CH2M Hill and HWA, 1991). Data from these studies was incorporated into our broader subsurface investigation. Logs for these wells are included in Appendix D.

It should be noted that the HWA wells (MW-1 through MW-9) are surveyed but no datum is given. Based on review of the National Oceanic and Atmospheric Administration (NOAA) geodetic survey markers, the nearest reference station that existed at that time is SX1361 located in Kanaskat-Palmer State Park near Cumberland-Kanaskat Road SE. The marker was surveyed in 1986 under the National Geodetic Vertical Datum of 1929 (NGVD29) and reported to the nearest foot ("approximate height" station). The station's NGVD29 benchmark was superseded in 1991 by the NAVD88 datum, but no month is given. The datum cannot be determined from the available information and according to SX1361 the difference between NGVD29 and NAVD88 is 4 feet. In addition, the reported surface elevation reference (and therefore groundwater elevation) at MW-6 (CH2M Hill and HWA, 1991) is significantly different (≥50 feet) than the surface elevation where the well plots on current topographic maps and groundwater measured in nearby well EB-4W; therefore, the reported groundwater elevations in MW-6 are not included in our assessment.

Our work also included a review of well reports on file with Ecology in the project vicinity and on the same side of the Green River. Wells within approximately ½ mile of the boundaries of the proposed mining area were identified. The locations of these wells are shown on Figure 7 and their logs are presented in Appendix G. Most well logs on file with Ecology are prepared by non-geologists, and standardized geologic descriptions commonly are not used. The interpretations from these well data are considered a rough approximation of subsurface conditions and in many cases provided approximate subsurface bedrock elevations from off-site areas. We reviewed well logs located in Sections 10, 20, 21, 28, and 29 of T21N R7E W.M. Well reports are discussed further in the "Water Users" section of this report.

Stratigraphic details for each exploration boring completed by AESI for this study are provided in Appendix B. The geologic units within the study area include the following, from stratigraphically oldest to youngest:

1. Puget Group Bedrock
2. Intrusive Igneous Bedrock
3. Ohanapecosh Bedrock
4. Regolith
5. Pre-Vashon Deposits
6. Vashon Lodgement Till
7. Vashon Ice-Contact Deposits and Recessional Outwash
8. Lacustrine Deposits
9. Alluvium
10. Existing Fill/Disturbed Ground

Descriptions of each of these geologic units are provided below. Geologic cross-sections through the subject site and surrounding area are shown on Figures 8 through 23. The locations of the cross-sections, identified as Cross-Sections A-A' through H-H', are shown on Figure 7.

3.4.1 Eocene Puget Group Bedrock (Tp)

The deepest and oldest unit encountered beneath the site includes sandstone, siltstone, coal, and carbonaceous shale that are correlated to the Eocene-age Puget Group. Regional descriptions by Vine (1969) indicate the Puget Group also contains minor amounts of claystone and conglomerate. The total thickness exceeds 6,000 feet in the Green River area (Vine, 1969). With the exception of EB-1W, EB-7W, and EB-11W, our on-site borings were terminated in Puget Group bedrock. We interpret the bottom of EB-7W was terminated in regolith overlying the bedrock surface. The explorations completed for this study when correlated with geologic reconnaissance, geophysical data, and geologic maps of the vicinity, indicate significant relief on the bedrock surface (Figure 24).

The Puget Group within the Green River District has been extensively mined for coal resources beginning in the 19th century. Areas of historic coal mining include Lizard Mountain, outcrops along the Green River Gorge, and in other nearby locations east, south, and west of the project site. More detail about past coal mine activities is included later in this report.

Puget Group rocks in the Green River Gorge are a continuous sequence of north-south trending folds (Vine, 1969). Of these is a notable fold named the Lawson Anticline, which extends under the western Segale Property and outcrops to the north along the Green River. According to Vine (1969), the oldest rocks of the Puget Group occur along the axis of the Lawson Anticline. These folds are broken by northwest-trending faults, two of which are mapped in the western Segale Property.

East of the Lawson Anticline are a series of asymmetric southward plunging folds (Vine, 1969). One of these folds is an unnamed syncline on the south side of Lizard Mountain in the southern Segale Property. Another unnamed syncline and anticline are mapped beneath the eastern Segale Property. These folds are broken by northwest-trending faults.

Building upon previous geologic mapping, Phillips (1984) extended the two northwest-trending faults that offset the Lawson Anticline and other folds to the southeast and northwest. Phillips (1984) connected the northern fault to the fault that bisects Lizard Mountain as shown on Figure 6. Phillips (1984) connected the southern fault to a fault located northwest near Lake Number 12 east of Black Diamond and to another fault located southeast of the southern Segale Property.

A pre-glacial course of the Green River was first depicted by Warren et al. (1945). The variations in relief of the top of the bedrock indicate that a potential bedrock valley, the extent of which is interpreted on Figure 24, is likely more complex than depicted in this study or by Warren et al. (1945). Evidence for an ancient valley system and/or localized bedrock lows onsite include data obtained from exploration borings (Appendices B and D), radiocarbon dating (Appendix C), seismic refraction profiles, and electrical resistivity profiles (Appendix E).

3.4.2 Eocene to Oligocene Intrusive Igneous Bedrock (Ti)

Most of the intrusive igneous rocks in the area are porphyritic andesite sills that intruded into bedding planes of the Puget Group. They are inferred to post-date the Puget Group and likely pre-date major deformation and are interpreted as Eocene to Oligocene in age (Gower and Wanek, 1963; Vine, 1969; Tabor et al., 2000). The intrusive bodies were not encountered in explorations but are mapped along the Lawson Anticline along the Green River and on the elongated bedrock ridge in the eastern side of DNR Property 20. Associated hydrothermal deposits are related to the intrusions and consist of metals suspended in a calcite or quartz matrix. Metallic minerals such as realgar, orpiment, stibnite, marcasite, and cinnabar are associated with some of the intrusions. These deposits were mined for cinnabar (Evans, 1912a; Dillhoff and Dillhoff, 1991).

3.4.3 Oligocene Ohanapecosh Formation Bedrock (To)

The geologic map (Figure 6) also depicts a small area on the east flank of Lizard Mountain that is underlain by "unnamed volcanic rocks." The Wanek and Vine (1969) map indicates that these rocks consist of volcanic sandstone, conglomerate, breccia, tuff, and basaltic lava flows that are interbedded within the upper portion of the Puget Group rocks. The thickness of these deposits is about 5,000 feet near the southeast corner of the Cumberland Quadrangle (Vine, 1969).

These rocks have since been correlated to the Oligocene-aged Ohanapecosh Formation (Tabor et al., 2000). The Ohanapecosh Formation is younger than the Puget Group which indicates the interbedding shown on the geologic map by Wanek and Vine (1969) requires revision. We interpret the upper 4 feet of volcanic sandstone bedrock encountered in EB-3W is Ohanapecosh Formation because it directly overlies Puget Group bedrock. Ohanapecosh bedrock was not encountered in our other explorations and was not observed during our geologic reconnaissance. The occurrence of Ohanapecosh in this boring suggests that it may have been preserved on the hanging wall of a fault such as the patch of Ohanapecosh on Lizard Mountain mapped abutted to a fault line in the southeastern corner of DNR Property 16.

3.4.4 Regolith (Tp)

Regolith describes a heterogenous deposit containing a high percentage of residual weathered bedrock, which is locally derived but does not typically retain structure of the underlying bedrock. Sediments interpreted to be regolith were encountered in EB-6W and EB-7W. The sediments were generally silty/clayey sand with angular, locally derived gravel. These sediments are generally dense since they have been over-consolidated by overriding ice during one or more glaciations. Regolith observed in EB-7W was observed in the bottom ½ foot of the boring and was about 2 feet thick in EB-6W. Locally the regolith may range up to several feet in thickness.

3.4.5 Pre-Vashon Deposits (Qpv)

Pre-Vashon deposits were encountered deep in several of the exploration borings. They have been observed in several on-site borings and where encountered, they directly overlie bedrock or regolith. The maximum thickness encountered was about 91 feet in EB-7W. The pre-Vashon deposits are distinctly dark gray to greenish gray in color and are made up of sediments locally derived from central Cascade Range rocks. We interpret these deposits to have accumulated in alluvial/fluvial environments from the ancient Green River prior to the Vashon Glaciation. They ranged from fluvial sand and gravel to lacustrine silts and clays, with occasional organic matter and wood fragments. The pre-Vashon deposits were encountered deep below ground surface, ranging from up to about 150 feet in depth in the on-site explorations. These sediments were generally dense since they have been over-consolidated by overriding ice during glaciation(s). The upper surface of the pre-Vashon sediments is somewhat variable due to inferred erosion by meltwater from the advancing and receding Vashon ice. Vashon glacial till mantles pre-Vashon deposits in EB-7W, EB-8W, EB-9W, and EB-12W, but the till was apparently eroded in EB-1W and EB-4W.

The deposits are in part correlated to the Olympia Formation based on radiocarbon dating of a piece of wood collected at a depth of approximately 162.5 feet in EB-7W. The Olympia Formation spans interglacial time between approximately 18,000 and 60,000 years ago (Troost, 2016). The calibrated age of the wood is about 18,000 years ago (Appendix C) and corresponds to late Olympia time when the Vashon-age Puget Lobe had advanced southward to about Seattle (DNR, 2022).

3.4.6 Vashon Lodgement Till (Qvt)

Vashon lodgement till drapes the irregular pre-glacial topography locally in erosional contact with the underlying sediments and bedrock. The till is usually present near ground surface along bedrock uplands and present at depth below the Vashon ice-contact and recessional outwash deposits. Lodgement till was encountered in explorations EB-3W, EB-5W, EB-6W, EB-7W, EB-8W, EB-9W, and EB-12W and observed in exposures on the flanks of Lizard Mountain and the Green River valley. In general, the deposits are massive diamictons, which are an unsorted mixture of gravel, sand, silt, and clay and are typically discontinuous. They are glacially consolidated into a dense condition by the weight of the overlying ice sheet. The till is typically gray to dark gray in color and may contain stratified lenses of granular material near their base such as in EB-3W. Lodgement till typically has a very low permeability due to high fines content and consolidation consistency.

3.4.7 Vashon Ice-Contact Deposits (Qvic) and Recessional Outwash (Qvr)

Ice-contact sediments were observed in all on-site explorations and along the Green River valley. Their surface topographic expression, which is characteristically pitted (kettled) and hummocky, was created from collapsed outwash and stranded stagnant ice as the Vashon ice sheet rapidly receded. Locally, their maximum thickness can exceed 100 feet (Booth, 1984), which is consistent with the depth of the kettle in the northwestern portion of DNR Property 16 and deposits observed in exploration borings.

Ice-contact deposits can exhibit abrupt lateral changes in grain size due to deposition within, upon, or near glacial ice. Ice-contact deposits include diamictons, supraglacial sediments, and fluvial and lake deposits in close proximity to ice. Diamictons may be classified as an ablation till, which is formed from sediment released by melting of stagnant or slowly moving debris-rich glacial ice, or flow till, which is formed from debris flows along the ice margin. They are chaotically emplaced due to the uneven nature of rapid deglaciation near the end of the Vashon Stade. Their consolidation, sorting, and degree of stratification is varied due to their complex origin within englacial (within-ice), supraglacial (above ice surface), or ice-marginal environments. The deposits observed at the site range from boulder lag deposits to clayey diamictons and silt. In general, the deposits are interpreted as moderate to very high permeability, with less extensive deposits of low-permeability sediments including ablation till and clay/silt.

Vashon recessional outwash was deposited by meltwater flowing from the retreating Vashon glacier during the last stages of glaciation. It typically comprises a loose to medium dense, stratified mixture of sands and gravels, with variable silt, cobbles, and boulders. The recessional outwash has not been overridden or consolidated by glacial ice. Locally, thicknesses can range from a few feet to about 30 feet thick. These sediments typically exhibit moderate to very high permeability.

3.4.8 Lacustrine Deposits (Qvrl(?)/Qlc(?))

Lake (lacustrine) deposits were encountered in EB-10W and EB-11W located near Deep Creek in the southern Segale Property (Figure 7). The lake deposits consisted predominantly of rhythmite clay and silt with thin interbeds of fine sand and inclusions of woody material and organic sediment. The woody plant material yielded a calibrated radiocarbon age of about 14,300 to 14,900 years ago in EB-10W (Appendix C). These sediments are interpreted as either Vashon-age sediments deposited in an ice-dammed lake or lacustrine sediments deposited in a lake formed in a depression immediately following deglaciation at the end of Vashon time. The lateral distribution of these deposits is interpreted to extend to the east beneath Deep Creek. These sediments typically have a low permeability and are interpreted to limit vertical downward infiltration of precipitation and surface water where present.

3.4.9 Alluvium (Ha)

Alluvial deposits range from sandy gravel with cobbles, moved by high-gradient headwater creeks and mountain rivers, to silty or clayey overbank deposits laid down by rivers along low-lying terraces along valley floors.

Recent Green River channel deposits generally consist of sandy gravel with cobbles and low-lying terraces consist of overbank gravelly sand with variable silt. Modern Green River alluvium consists primarily of andesite (Borden and Troost, 2001). Outside of its mapped extent, the alluvium is generally limited to banks along the Green River.

Alluvium along smaller streams and creeks is generally confined to the channel and adjacent banks and floodplains and composed of sand with variable silt/clay and cobble content. Along some reaches of Deep Creek the sandy bed contains gravel and cobbles, such as upstream of SE Kuzak Road and downstream of 328th Way SE. The streambed in the Deep Creek reach that lies adjacent to Cumberland-Kanaskat Road SE along a shallow sloping terrace consists of sandy alluvium with interbeds of silt and clay as observed in EB-10W and EB-11W.

3.4.10 Existing Fill/Disturbed Ground

Fill materials (those not naturally placed) represent anthropogenically altered ground and are primarily associated with roads around the site and vicinity. Fill materials were encountered in one exploration (EB-7W) to a depth of 2 feet and generally consisted of silty gravelly sand, with abundant organics. Fill soils are likely to be encountered in areas mapped as Arents soils such as the roads near the prefabricated steel building in the southern Segale Property.

Stockpiles relating to former coal mining operations are present at multiple locations around the perimeter of Lizard Mountain (see Section 3.5 below). Some of these stockpiles were observed directly during our site reconnaissance and some were not observed directly but are visible on LIDAR-based shaded relief maps of the area. Fill may exceed several feet in thickness in these areas.

3.5 PAST MINING HISTORY - COAL MINES

3.5.1 Coal Mine Literature Review and Limitations

Various maps and reports obtained from the DNR were reviewed. These documents include Landes and Ruddy (1902), Smith (1911), Evans (1912a, 1912b, 1924), Green (1947), Warren et al. (1945), Gower and Wanek (1963), Vine (1969), Phillips (1984), and LaSalata et al. (1985). Coal mine locations on file with the DNR are shown on Figure 25. The Coal Mine Hazard Areas shown on Figure 25 were obtained from King County mapping and were intended for use by King County staff to identify areas that may warrant further coal mine hazard study. The extent of the Coal Mine Hazard Areas shown may not necessarily coincide with actual known locations of underground coal mine workings.

Coal mine maps obtained from the DNR depict the locations of the various mines within the vicinity of the Segale Property project area and details associated with the layout of entrances, airways, slopes, chutes, and pillars at various times. We understand the DNR coal mine map collection is incomplete because some of the original coal mine maps were damaged or destroyed in a fire. Washington State began requiring coal mines to file maps of their underground workings in 1910 (Botting, 1910). While in operation, the mine operators were required to produce inspector reports with production figures. State mine inspectors filed these reports and maps until the coal mines shut down. If the mine had shut down without notice, the state had no leverage to retrieve an updated mine map. Maps of the coal mines currently available through the DNR are included in Appendix H.

Coal on the Segale Property was extracted using both underground tunneling and open pit (strip mine) excavations. Underground mining in the area included both drift, or "water-level," and slope mines. Drift mines are self-draining mines in which the lowest point in the mine is the portal. A frequent practice was to first establish as a drift mine and later, when all coal above the level of the portal had been extracted, then convert to a slope mine. In slope mines, gangways along the strike of the coal bed are driven off the main slope at various levels. Slope mines may require continuous pumping to remove excess water.

In areas of King County, such as the subject site where the coal seams are dipping at a fairly steep inclination, underground coal mining was typically accomplished using the “chute and pillar” method. In this method, a “chute” consists of a passageway not over 12 feet wide that is driven up the dip of a coal seam from a gangway constructed along the strike of the seam. The chutes may be widened to form a “room” or “breast.” Additional passages, known as “counters,” “airways,” and “crosscuts” are used to provide ventilation for the mine. Crosscuts can also serve as manways. The remaining portion of the coal seam left in place between these passageways are known as “pillars." A diagram of typical chute and pillar coal mine workings is provided in Appendix H.

Coal mines extracted bituminous coal from the seams along Lizard Mountain. Coal consists of five components: moisture, volatile matter, fixed carbon, ash, and sulfur. Bituminous coal has less fixed carbon and more volatile matter than anthracite coal. Volatile matter usually consists of short and long chain hydrocarbons (organic compounds) and mineral matter. Coal in the Cumberland-Palmer area generally consists of 3.9-7.2% moisture, 24.9-38.6% volatile matter, 38.7-51.2% fixed carbon, 11.1-23.1% ash, and 0.5-1.2% sulfur (Green, 1947).

3.5.2 Lizard Mountain Geologic Structure

The bedrock exposed at Lizard Mountain can be divided into two regions that are separated by a west-northwest trending fault near the DNR Property 16 and southern Segale Property border. The regions are referred to as the northern Lizard Mountain and southern Lizard Mountain in subsequent sections. Evans (1912a) describes the fault as one with considerable vertical displacement and the block to the north has dropped considerably, although no estimate of the vertical offset is described in the reviewed literature.

Geologic mapping of northern Lizard Mountain by Vine (1969) identified six coal seams, although coal mine records of the area indicate that up to ten coal seams were encountered. The Occidental Mine is situated on the northern side of Lizard Mountain along the western limb of a syncline. Strike and dip measurements reported for the northern portion of Lizard Mountain (Evans, 1912b, Vine, 1969) indicate bedding dips 24 to 45 degrees to the southeast (Figure 6). A subset of strike and dip measurements are shown on Figure 6 due to map scale. Mapped coal seams include Occidental Nos. 1, 2, 3, 6, and 14 (Vine, 1969). The coal beds are offset by a northwest-trending fault of unknown displacement in the eastern side of the DNR Property 16. The fault is mapped as downward throw on the southwest side. Five of the six coal seams identified by Vine (1969) are mapped to extend into the eastern Segale Property and of these the Occidental No. 14 slope mine extends beneath the eastern Segale Property. A discussion of the Occidental Mine and underground workings is included in Sections 3.5.5. and 3.5.7., respectively.

Geologic mapping of southern Lizard Mountain by Vine (1969) identified two coal seams, named the Old Carbon and Cumberland. The bedding and coal seams dip towards a syncline located near the center of southern Lizard Mountain. The Old Carbon Mine is located on the eastern side of the syncline fold axis where bedding dips east about 50 to 75 degrees to the west (Evans 1912b, Vine 1969) (Figure 6). The Carbon Fuel Co. Mine No. 4 is located on the western side of the syncline fold axis where bedding dips about 37 to 47 degrees to the east (Evans, 1912b, Vine, 1969). The mines are mapped within the southern Segale Property. Coal mine maps are included in Appendix H.

3.5.3 Coal Mine Geologic Reconnaissance

AESI observed the surface expression of mine features around Lizard Mountain during our geologic reconnaissance and our observations are shown on Figure 26. Select reconnaissance photos are included in Appendix H. Reconnaissance of Lizard Mountain suggests that the actual extent of the coal mine workings in this area may be greater than depicted on the historical coal mine maps available through the DNR library. Unmapped mine features were also located during our reconnaissance and inferred to be prospects based on information provided in Smith (1911), Warren et al. (1945), and Vine (1969).

3.5.4 Old Carbon Mine

The Old Carbon Mine was the first coal mine in the area and began operations in 1895. It operated as a drift mine for about 3 years and then closed down. Limited information is available on mine workings and no coal production was documented likely because the mine closed prior to implementation of the state coal mine reporting regulations. The Old Carbon bed was estimated by Vine (1969) to be 5 feet 4 inches thick including impurities. We observed seepage near the mapped underground mine portal, which is covered, and is the primary source of surface water in Stream L.

West of the Old Carbon Mine, the Cumberland bed was strip-mined (Vine, 1969). The strip mine was confirmed by visual reconnaissance (Photo H-1, Appendix H) and is visible on LIDAR imagery (Figure 26), but no record of surface mining exists in the DNR mine map records. The Cumberland bed was estimated by Vine (1969) to be 7 feet 4 inches thick as exposed at the strip mine. We did not observe surface flow in the strip mine area during site visits on February 1 and March 24, 2022.

3.5.5 Occidental Mine

The Occidental Mine, also referred to as the Gibbons Mine, encountered ten coal-bearing seams and partially worked eight of them (Landes and Ruddy, 1902). It operated both slope and drifts. Primary coal beds worked at the Occidental Mine are the Occidental No. 1, No. 2, No. 3, No. 6, and No. 14 seams, which totaled about 23 feet 8 inches of coal (Evans, 1924). The greatest amount of workings have come from the No. 3 and No. 14 seams (Evans, 1924; Vine, 1969), about 4 feet 9 inches thick and 6 feet thick, respectively (Evans 1912b). The uppermost beds may have been surface-mined (Figure 26).

Most of the coal zones are irregular and average less than 2 feet in thickness separated by thin beds of shale and impure coal, commonly referred to in the mining literature as "bone." Mining practices extracted the entire bed including interbeds. Evans (1912b) reported the mine was opened in 1898 and according to the State Mine Inspector's Reports the coal mine began shipping in 1899. It is reported that in September of 1910 a slope that opened onto the No. 14 bed encountered groundwater and flooded an entire section of the mine (Evans, 1912a; Evans, 1912b; Evans, 1924). The mine closed 3 years later (Evans, 1924). Between 1899 to 1913 the Occidental Mine produced about 307,029 tons (Evans, 1924).

The Occidental Mine is reported to have been reopened subsequent to 1924 before closing permanently in 1945 (Kombol, 2021; LaSalata et al., 1985). The most recent mine map available from the DNR dated 1940 depicts a new slope opened onto Occidental No. 14 in DNR Property 16. Total production is reported at 709,433 tons (LaSalata et al., 1985).

3.5.6 Carbon Fuel Co. Mine No. 4

This mine, as named, is not listed in any of the above-mentioned reports. Only a coal mine workings map is available. The mine is located on the opposite (western) side of the Lizard Mountain syncline from the Old Carbon Mine and is associated with the same coal beds. The mine's location was confirmed by visual reconnaissance (Photo H-2) and LIDAR imagery (Figure 26).

Some seepage areas were observed that appear to be associated with unmapped mine features. Drainage from mapped mine portals was observed and are interpreted to be the primary source of surface water in Stream J. Drainage from a suspected mine opening at Stream K is shown in Photo H-3. Water quality analysis of the mine drainage is presented later in the report. The extent of prospect workings is unknown because they are undocumented. Review of LIDAR imagery clearly depicts a series of shallow depressions scattered around Lizard Mountain (Figure 26). Many of these depressions overlie areas of mapped underground coal workings and are suspected to be subsidence features (Photo H-4).

3.5.7 Underground Workings

The majority of the mine workings appear to be primarily limited to the area within Lizard Mountain and outside of the proposed sand and gravel mining area. This includes areas of mapped workings and associated coal mine features observed during our reconnaissance in the areas of the former Old Carbon Mine and Carbon Fuel Company Mine No. 4.

Workings associated with the Occidental Mine extend northeast of Lizard Mountain. The mapped workings in this area lie underneath the DNR Property in the eastern portion of Section 16 and a portion of the adjoining eastern Segale Property in Section 15 (Parcel No. 1521079009) where aggregate resource mining is proposed. Review of a 1932 map of the Occidental Mine obtained from the DNR coal mine map collection, indicates that the mine workings in this area are present between approximately elevation 480 feet and 760 feet. Due to the attitude of the bedding in the Puget Group bedrock in this area, the elevations of the coal mine workings increase toward the northwest. The datum on which these elevations are based is not stated on the mine map but given the elevations of other known features shown on the map, these elevations appear to be within 10 feet of the modern NAVD88 datum. Given the existing ground surface elevation in this portion of the Segale Property of approximately 840 to 860 feet, the mapped underground coal mine workings in this area are located approximately 80 to 380 feet below the existing ground surface. The condition of the underground coal mine workings in this area is unknown.

Mining in the area was typically conducted using the chute and pillar method, which is consistent with the layout of the coal mine workings shown on the mine maps (Appendix H). Late-stage mining practices often included removal of the pillars in a process known as retreat mining. Removal of the pillars would not increase the aerial extent of the mine workings, but it would typically result in their collapse due to the loss of the roof support provided by the pillars. Although mining operations at the Occidental Mine were known to shut down prior to 1932, some additional mining occurred subsequent to 1932. The most recent mine map produced in 1940 depicts workings in DNR Property 16; however, the maximum extent of the mine workings at the time of its permanent closure in 1945 is not known because the DNR coal mine map collection is incomplete. The production between 1940 and 1945 was 53,213 tons (LaSalata et al., 1985).

3.6 PAST MINING HISTORY - METAL MINES

3.6.1 Metal Mine Literature Review

Various maps, memos, and reports available with the DNR, U.S. Geological Survey (USGS), and University of Washington Libraries were reviewed. The reviewed reports include Huntting (1956), Livingston (1957), Rice (1962), Rice and Rector (1964), U.S. Bureau of Mines (1965), Livingston (1971), Derkey et al. (1990), and Dillhoff and Dillhoff (1991). Metal mines were developed in the area to extract specific metals from mineral deposits associated with faults and igneous intrusions within the Puget Group bedrock near the Green River. The primary metal of interest mined locally was mercury from cinnabar deposits. Other metallic deposits associated with the cinnabar in the area include realgar and orpiment, which contain arsenic, and stibnite, which contains antimony. According to Evans (1912a) the realgar and orpiment were prospected in 1888 and again in 1932 according to Dillhoff and Dillhoff (1991). Peak mining activity was related to the Royal Reward and Cardinal Reward Mines between 1957 and 1960 before these mines were abandoned due to the high arsenic content and spotty distribution of the ore. Approximate mine locations and metallic ore localities are shown on Figure 27. Metal mine maps are included in Appendix I.

3.6.2 Royal Reward Mine

The Royal Reward Mine was the first metal mine established near the Segale Property. It is located outside of the Segale Property on the south bank of the Green River in the NE¼ of the SE¼ of Section 8, T21N, R7E (Figure 27). Documents indicate a 110-foot adit was completed about 15 feet above river level (Livingston, 1957; Berkshire, 1957). Another source reported workings consisting of a two-compartment, 165-foot shaft with up to 330 feet of lateral workings about 135 feet below the shaft collar (U.S. Bureau of Mines, 1965). Records indicate the mine operated from 1957 to 1960 and about 20 flasks of mercury were extracted (Livingston, 1971). A flask is equal to 76 pounds of mercury. Only a set of hand sketches of the mine workings are available and are included in Appendix I.

Mineralization took place along the top of a tightly folded anticline known as the Lawson Anticline (Figure 27), which is cut by two faults one of which strikes parallel to its crest (Rice, 1962; Dillhoff and Dillhoff, 1991). The east side of the fold dips 30 to 40 degrees and the west flank dips about 80 degrees, indicating that the axial plane dips to the east (Vine, 1969). Metallic minerals occur in pods and veins, and are disseminated throughout the adjacent shale beds and fault breccia. Mineralization is also disseminated throughout the rock mass.

3.6.3 Cardinal Reward Mine

The Cardinal Reward Mine was founded by the owners of the Royal Reward Mine as they expanded their operations. It is located west of the Segale Property and about ½ mile southwest and about 1¾ miles downriver of the Royal Reward Mine (Figure 27). Several crosscuts and two adits were made to develop the ore bodies. A survey of the mine was done by Rice and Rector (1964) that details the underground passageways. The lower-level mine consisted of about 850 feet of lateral workings and an upper level with about 430 feet of lateral workings. The survey indicates the maximum extent of tunnels was less than a 350-foot radius from the mine portals, which are separated by approximately 88 feet in elevation. The extent of tunnels is limited to the state-owned lands along the Green River. Records indicate the mine operated from 1958 to 1960 with no official production quantity.

Mineralization at the Cardinal Reward Mine is reported to be similar to that found at the nearby Royal Reward site; however, there is no structural relationship between the two deposits. The bulk of the mineralization at the Cardinal Reward Mine occurs along steeply dipping carbonaceous shale beds, coal seams, and veins in the sandstone (Rice, 1962; Rice and Rector, 1964; U.S. Bureau of Mines, 1965). The bedding dips about 55 to 90 degrees (vertical) along a complex, north-south trending fold cut by two fault systems, one of which parallels the fold axis (Rice, 1962). Rice (1962) describes the fold as an anticline. Mineralization follows the northwest-trending fault as indicated by the abandoned arsenic mine across the Green River (Figure 27). The abandoned arsenic mine correlates to the arsenic prospect described in Evans (1912a). A large percentage of arseno-sulfides, such as realgar and orpiment, are associated with the mineralization (Rice, 1962).

3.6.4 Operations

Ore was processed by roasting the ore to volatilize the metals and sulfur, during which oxygen combines with the sulfur to form sulfur dioxide and remaining vapors are condensed to elemental metals. Both a retort and furnace were used in the mining operations and process ores differently.

Ore from the Royal Reward Mine was reportedly stockpiled and processed at the main camp located on a terrace next to the Green River in the present-day Green River Gorge State Park Conservation Area, approximately 2,000 feet due north of B-3. A small retort was located at the Royal Reward site (Figure 27). A few flasks of mercury are reported to have been processed at the retort (The Seattle Times, 1958; U.S. Bureau of Mines, 1965). In a retort, the ore is contained within a vessel that is externally heated to separate the mercury from the ore through distillation. Retorts process ores in batches and generally have a small capacity in comparison to furnaces.

Shortly before operations ceased, it is reported that ore was stockpiled and processed at a plant located on the southeast corner of the bedrock knob situated about 700 feet west of B-3 in the northwestern Segale Property (Figure 27). Approximately 500 tons to over 1,000 tons of ore are reported to have been stockpiled at the plant site (Western Mining Industrial News, 1959; U.S. Bureau of Mines, 1965).

A Nichols-Herreshoff multiple hearth furnace was located at the plant site (Dillhoff and Dillhoff, 1991). Remnants of the hearth furnace remain at the plant area. A multiple hearth furnace consists of a series of stacked kilns (hearths) with mechanical arms. Ore is charged through the top hearth and mechanical rotating arms are used to move the ore down through the stacked kilns. The ore is mixed with fuel (such as coke) that is combusted by hot air that is blasted up through the base of the furnace. The heat drives off mercury vapor from the ore where it is recovered in condensing tubes. A multiple hearth furnace allows continuous feed of ore and is more efficient than a retort for processing large volumes of ore. No plant production was reported. Production ceased due to spotty ore distribution and the elevated arsenic content of the ore. It is reported that the flues of the furnace quickly became clogged with arsenic (Dillhoff and Dillhoff, 1991).

3.6.5 Metal Mine Reconnaissance

The mine portals and plant area shown on Figure 27 were located during our geologic reconnaissance. The Royal Reward Mine portal is located about 15 feet above river level at the base of a cliff comprising the eastern limb of the Lawson Anticline. The portal is covered with rock rubble. Mineralized rock observed along outcrops at river level trends along the axis of the fold. The upper Cardinal Reward portal lies at approximately 640 feet elevation and is blocked by debris. The lower Cardinal Reward portal lies at approximately 550 feet elevation and is blocked by debris. Based on our visual estimate, about 0.01 cubic feet per second (CFS) of seepage emanated from the lower portal at the time of our site visit on August 17, 2022. The plant area consists of the old furnace foundation, support structure foundations, and stockpiles. The stockpile quantity estimated from field observations is on the same order of magnitude as reported in the reviewed references. Stockpiles observed on the Segale Property in the area of the former furnace appear to consist of both processed and unprocessed ore.

3.7 HYDROGEOLOGY

This section of the report provides information on surface water and groundwater resources. AESI's hydrogeologic study for the property included exploration and monitoring to develop an understanding of the groundwater system and groundwater-surface water interaction. Twelve groundwater monitoring wells were installed for this study to acquire information on the regional groundwater flow. We also monitored groundwater levels in four existing wells installed by NV5. Groundwater level data from the monitoring wells was supplemented by water level and flow data obtained from streams and springs identified during our geologic reconnaissance in the vicinity of the Segale Property. Groundwater and surface water data collected from this study are shown in Appendix J. Additional hydrogeologic information from off-site areas was reviewed and includes nearby hydrogeologic studies (Appendix K) and water well logs on file with Ecology (Appendix G).

The following sections describe our resource monitoring program, characterization of surface water and groundwater, and analysis of aquifer flow.

3.7.1 Resource Monitoring Program

A resource monitoring program was established to collect groundwater levels, observe seasonal fluctuations in surface water and stream flow, and to characterize existing water quality conditions, which are described in Section 3.10. This data was used to assess surface water-groundwater interactions and the fate and transport of groundwater. Water level and flow data included in this report is limited to the period up to early March 2023. Water quality data included in this report is limited up to March 2023. The monitoring program is ongoing.

Groundwater levels were collected in the monitoring wells installed for this study and from existing monitoring wells B-2, B-3, B-4, and B-5. We conducted site visits to collect manual groundwater level measurements with an electronic water level tape. A pressure transducer/ data logger collected continuous water level measurements on an hourly basis between site visits. The monitoring wells were surveyed by Segale after installation and wellhead elevations were provided to AESI to the nearest 0.01 foot. Groundwater hydrographs are presented in Appendix J (Figures J-1, J-2, and J-5).

Surface water monitoring began in December 2021 to document seasonal flow fluctuations and to assist in the assessment of recharge to and discharge from groundwater within the regional aquifer. Select surface water streams and springs and Deep Lake were monitored on a monthly basis (Figure 28). Visual observations were supplemented by stream flow gauging methods in general accordance with USGS (Rantz, 1982) and U.S. Bureau of Reclamation (USBR, 2001) standard practices. Surface water hydrographs are plotted in Appendix J (Figures J-2, J-3, J-4, J-5, and J-6). Table J-1 in Appendix J summarizes surface water flow rates. Table J-2 summarizes Deep Lake measurements.

3.7.2 Surface Water

Surface water features in the vicinity of the site include the Green River, Deep Creek, Deep Lake, Hyde Lake, and several springs and streams in or near the subject site (Figure 28). Significant springs located more than 1 mile from the site area include the Black Diamond Springs and Icy Creek Spring, which are discussed in "Water Users," Section 3.8. The Green River lies north and west of the proposed site and forms a natural hydrologic study area boundary.

Deep Creek originates from the bedrock mountains east of the project site, flows west and southwest adjacent to the southern Segale Property, through the town of Cumberland, and into Deep Lake. Deep Creek is the only surface water inlet to Deep Lake, which has no surface water outlet. Prior to discharging into Deep Lake, a small unnamed stream (Stream F) forks off of Deep Creek and flows into Hyde Lake. Stream F is the only surface water inlet to Hyde Lake, which has no surface water outlet. Regional geology indicates both Hyde Lake and Deep Lake are formed in glacial kettles.

Streams D, E, H, J, K, L, M, and other unnamed streams flow off of Lizard Mountain and represent local groundwater discharge and coal mine drainage. These streams infiltrate into the subsurface in the permeable glacial outwash sediments adjacent to Lizard Mountain.

Streams A, B (Resort Spring), B2, and C, Spring 3, and the Black Diamond and Icy Creek Springs represent groundwater discharge from the regional aquifer.

(A) Green River

The Green River originates in the high Cascade Mountains. Howard Hanson Dam is located upstream of the study area at approximate river mile 64.5. The City of Tacoma maintains a municipal water supply diversion about 3.5 miles downstream of the dam. Below Howard Hanson Dam, until the Green River emerges from the gorge near Flaming Geyser State Park, the channel gradient is moderately steep as the river winds its way between narrow, steep-sloped valley walls. The stream bottom throughout the gorge is composed of boulders, bedrock rubble, and patches of gravel. The river gradient in the gorge averages 80 feet per mile (ft/mi) (Williams and Phinney, 1975). The section adjacent to the Segale Property is approximate river miles 55.7 to 51.6.

River stage and discharge is monitored at approximate river mile 60.4 by the USGS at station 12106700 (Palmer Gauge). The Palmer Gauge is located about 5 miles upstream of the site at the Tacoma Public Utilities (TPU) Green River Filtration Facility. Over the last 58 years on record, the monthly average discharge ranges from about 160 CFS in August to 1,660 CFS in January. The lowest average monthly flow on record is about 100 CFS.

River stage and discharge is also monitored at approximate river mile 32.0 by the USGS at station 12113000 (Auburn Gauge). The Auburn Gauge is located about 20 miles downstream of the site. Over the last 60 water years on record, the monthly average discharge ranges from about 310 CFS in August to about 2,400 CFS in January. The lowest average monthly flow on record is about 220 CFS. Tabular monthly summaries of gauge data obtained from the USGS website are included in Appendix J (Table J-3).

(B) Deep Creek and Stream G

Deep Creek is approximately 4.8 miles long and is classified as a fish-bearing creek by the DNR forest practices water typing per Chapter 222-16-031 *Washington Administrative Code* (WAC). Its headwaters are in the bedrock uplands northeast of Cumberland. Stream G is a tributary to Deep Creek upstream of the Segale Property site. The creek ultimately drains into Deep Lake, and to a lesser degree Hyde Lake via Stream F.

AESI has observed stream flow at three locations along Deep Creek: at the crossing with 328th Way SE (DC-328TH), at the crossing with SE Kuzak Road (DC-KUZAK), and at Nolte State Park upstream of Deep Lake (DC-NOLTE) (Figure 28). The observations indicate a seasonal fluctuation of about 0.03 to 19 CFS (Figure J-4). During the seasonal low flow as observed on September 22, 2022, the flow into Deep Lake at DC-NOLTE was measured at 0.03 CFS. The Stream G tributary lies between DC-328TH and DC-KUZAK and seasonally fluctuates between 0 to about 0.3 CFS. Our observations between the three stations are summarized in Table J-1 and indicate that most of the surface water in Deep Creek ultimately discharges into Deep Lake. An unquantified amount of surface water flows into Hyde Lake. During dry periods, for example July through November

2022, most of the surface water infiltrates into the subsurface and recharges the groundwater system.

(C) Deep Lake

Deep Lake is a kettle lake with a surface area of about 39 acres, a mean depth of 33 feet, and a maximum depth of 76 feet (King County, 2022b; Brown and Caldwell et al., 1989). Deep Creek terminates at Deep Lake and serves as the primary surface water inflow.

A set of lake gauges were installed and surveyed by Lake Observations by Citizen Scientists and Satellites (LOCSS) in 2019. The gauges consist of two 3.33-foot fiberglass rulers mounted to posts driven into the lake bank. The lower staff gauge measures 0 to 3.33 feet and the upper staff gauge measures 3.33 to 6.66 feet, with 0.01-foot increments. Recent measurements indicate that Deep Lake seasonally varies up to about 8 feet which is slightly outside the range of the staff gauges. The seasonal low can dip slightly below the lower staff gauge and wet season levels occasionally rise above the top of the upper staff gauge. During site visits when the lake levels were observed to be above the staff gauge, the effective lake level was estimated to the nearest 0.1-foot based on the staff gauges. During high lake levels the upper staff gauge was visible beneath the lake surface. Our observations indicate that the lake surface elevation seasonally varies between approximately 765 to 773 feet (Appendix J).

Monitoring data indicates the high lake levels dissipate quickly, about 2 to 3 feet over a couple weeks, while the remainder below approximately 770 feet can take months to draw down. Based on the 4 years of monitoring data reviewed, Deep Lake typically reaches its lowest levels during September; however, during 2022 the lake reached its lowest levels in late October. This is the first year of AESI monitoring. The seasonal low in previous years may have occurred later than September and it would not have been recorded because lake levels fell below the staff gauges. The seasonal fluctuation and water elevation are interpreted to indicate that Deep Lake recharges regional groundwater and is hydraulically connected to the water table.

(D) Hyde Lake and Stream F

Hyde Lake (previously referred to as Lake Isabel or Isabella) is a kettle lake located approximately $^1/_3$ mile southwest of the southern Segale Property and about ½ mile north of Deep Lake. It has a surface area of about 5 acres. The lake is connected to Deep Creek by a surface water inlet located upstream of Deep Lake. This inlet, which is identified on Figure 28 as Stream F, consists of a small, ditched stream channel.

Stream F was observed to contain flowing water during our site visits on October 5, 2021, and October 27, 2022. The amount of flow in the stream could not be directly observed due its location on private property and therefore the seasonal fluctuation is unknown. Our stream flow monitoring of Deep Creek between DC-KUZAK and DC-NOLTE indicates diversion of water into Stream F and Hyde Lake is limited (Table J-1, Figure J-4).

Hyde Lake was not directly observed because lake access is restricted due to private property. Lake data such as seasonal fluctuation and depth is not reported in the available literature. The lake level, estimated from LIDAR imagery, is approximately 795 to 797 feet in elevation. The approximate lake level is higher than groundwater elevations in domestic wells completed around the lake, which range from about 730 to 750 feet elevation. Therefore, Hyde Lake is interpreted to be hydraulically disconnected from the regional groundwater table and exists as a perched water feature. We interpret that low-permeability sediments beneath the lake are able to support lake levels year-round and the lake slowly recharges groundwater.

(E) Northern Area (Stream A, Spring 3, and other unnamed springs)

A previously unmapped stream (Stream A) is present on a terrace located northwest of the northern Segale Property (Figure 28). Year-round stream flow is supported from a groundwater spring zone located at approximately 700 feet elevation, where the aquifer daylights at ground surface. Groundwater also intermittently discharges near the toe of a steep slope located approximately 600 feet southeast of the Stream A Spring near 710 to 720 feet elevation. Spring flow was noted concurrent with peak groundwater levels in Water Year 2022, but has not been observed to date in Water Year 2023.

Stream A flows offsite to the state-owned lands and discharges into the Green River. AESI observed flow prior to its discharge over a bedrock waterfall to the Green River Gorge. AESI measured flow rates in Stream A during monthly monitoring events over the period from January 2022 through March 2023 plus one additional event in May 2021. Measured flow rates generally ranged from about 0.04 to 0.6 CFS, although during periods of snowmelt the flow was as high as 1.3 CFS (Table J-1).

Spring 3 is located east of Stream A and is located at around 700 feet elevation (Figure 28). Our May 2021 reconnaissance indicated that Spring 3 is the 2nd largest spring, after Stream A, on the northern side of the study area. Spring flow has been observed to be about 0.07 CFS or less (Table J-1). Groundwater discharges above till and bedrock at Spring 3.

Several other unnamed springs were observed during our geologic reconnaissance. In general, these minor springs range from the low 600's to low 700's in elevation and either discharge above the bedrock surface or above till. Observed flow rates were about 0.03 CFS or less during our site visits in May 2021.

(F) Green River Gorge Resort Area (Streams B, B2, and C)

Streams formed from groundwater discharge in the vicinity of the Green River Gorge Resort Water System (GRGRWS) include Streams B, B2, and C. Stream B flows year-round and is associated with the GRGRWS, a Group A transient non-community water system. Streams B2 and C are nearby seasonally active streams (Figure 28). Streams B2 and C are interpreted to be seasonally active due to variations in groundwater levels with respect to the underlying subsurface bedrock topography. AESI has monitored surface flow at Streams B and C from October 2021 through March 2023.

AESI obtains Stream B flow measurements at weirs between instream ponds. Flow rates in Stream B have ranged from about 0.5 CFS to 5.9 CFS over the monitoring period of record (Table J-1). The stream ultimately discharges as a waterfall into the Green River. More information on Stream B and the GRGRWS is provided in Section 3.8.1, "Group A Water Supply Systems."

Stream B2 is a seasonally active stream that merges with Stream B downstream of the Stream B ponds and upstream of the gorge. It flows through a culvert underneath the roadway about 400 feet south of Stream B. No flow measurements were collected in Stream B2 due to access limitations.

Stream C is a seasonally active, spring-fed stream with its headwaters formed in the DNR-owned property in the NW¼ of Section 20 and the SE¼ of the SW¼ of Section 17 T21N R07E. The uppermost spring is located at approximately 710 feet elevation, although significant flow occurs around elevation 690 feet and below. Based on conversations with the Green River Gorge Resort owner (Jim Carter, 2022 personal communication), Stream C is typically dry from early July to December. During the 2022 water year the stream was dry at the time of our site visits in October, November, and December 2021 and September 2022. During the 2023 water year the stream was dry at the time of our site visits in October and November 2022, and February and March 2023. A small amount of water (<0.01 CFS) was observed during the site visit in December 2022. The stream flows through a box culvert underneath the Enumclaw Franklin Road SE roadway. AESI has been monitoring stream flow at the culvert area on a monthly basis from October 2021 through March 2023 and the flow rates have ranged from 0 to 3.1 CFS during this monitoring period. The stream discharges as a waterfall into the Green River.

(G) Lizard Mountain Area (D, E, H, J, K, L, and M and other unnamed streams)

Streams originating on Lizard Mountain are relatively small and represent discharge of groundwater perched on the bedrock surface and in some cases, discharge from mapped coal mines along Lizard Mountain (Figures 26, 28). Stream flow originates from small springs located on the flanks of the mountain and flow downslope above the bedrock surface and infiltrate into the outwash terrace at the base of the mountain. Flow rates in these streams are low, about 0.07 CFS or less (Table J-1). Additional unnamed streams were observed along Lizard Mountain during our geologic reconnaissance and contained very low-flow rates, about 0.01 CFS or less. The streams supply a small amount of localized recharge to the regional aquifer.

Based on geologic reconnaissance and mapped coal workings, Streams J and L are interpreted to be primarily sourced by coal mine discharge. Coal mine workings supply preferential storage and pathways for groundwater flow through the low-permeability bedrock. The mine workings drain through old portals or other surface openings. Flow rates in Streams J and L were observed to be 0.02 CFS or less (Table J-1).

3.7.3 Groundwater

Water that is present in the pore spaces of sediments or voids within bedrock is part of the hydrologic cycle. In the natural state, the hydrologic cycle begins with infiltration of precipitation (recharge) and ends with discharge to springs, streams, wetlands, or wells. Groundwater will flow under saturated conditions preferentially through materials with greater porosity and hydraulic conductivity, such as clean gravel and sand. Where geologic conditions limit natural discharge, groundwater accumulates in such zones, which, if they can support production from wells, are termed aquifers. The sustainability of wells, or the long-term aquifer capacity, depends on the extent of the aquifer, its rate of recharge, and the amount of withdrawal by producing wells.

The groundwater system present at the site can be divided into (1) an interflow zone, (2) perched groundwater above bedrock and till, (3) a regional aquifer present beneath the site and vicinity formed within unlithified sediments above the local bedrock, (4) limited groundwater present within discrete zones of bedrock, and (5) groundwater in the alluvium adjacent to the Green River.

(A) Interflow Zone

Interflow is the shallowest of all groundwater types. Rainfall will generally infiltrate into the ground through relatively permeable soil and weathered sediment until it encounters a low-permeability geologic material restricting further downward movement, at which point it flows laterally over the top of the less-permeable unit.

Unfractured bedrock typically behaves as a low-permeability barrier allowing for the development of an interflow zone. Bedrock fractures can provide pathways for limited groundwater flow into the rock mass.

During the winter water accumulates and travels horizontally in shallow soils above the less-permeable material as interflow. An interflow zone occurs in the Beausite Series soils along the slopes of Lizard Mountain. The soils function as a weathered geologic “skin” over the bedrock. Groundwater in the interflow zone travels much more slowly than surface water because it is flowing through soil that provides resistance to its movement.

Since interflow is rainfall-dependent, it occurs at different depths in the shallow soils depending upon the amount of rainfall in the recent past. Interflow zones may dry up altogether between periods of significant rainfall and therefore are not considered to be aquifers. Water usually leaves interflow zones by evapotranspiration, infiltrating along geologic contacts into permeable geologic deposits, discharging to springs, or entering surface water bodies.

(B) Perched Groundwater

A perched water zone forms when rainfall infiltrates into the coarse-grained sand and gravel deposits of the recessional outwash and ice-contact deposits and becomes perched on a barrier consisting of low-permeability sediments or very low-permeability bedrock. These groundwater-bearing intervals are considered “perched” where they are found above the regional water table. Areas of perched groundwater are often of limited lateral extent. Perched groundwater levels vary seasonally since recharge to the perched zones is through infiltration of precipitation or leakage from surface water bodies. When recharge accumulates above these low-permeability barriers it primarily flows laterally above the low permeability unit, which is typically non-horizontal. Water will flow downgradient until it encounters higher-permeability geologic contacts providing pathways to recharge deeper groundwater. Very slow leakage of groundwater occurs through the low-permeability sediments and fractures within the bedrock.

Perched groundwater was encountered at three intervals:

1. Above the silty/clayey alluvium and lacustrine deposits encountered in borings EB-10W and EB-11W. This perched groundwater interval is currently monitored in EB-11W. A discussion of perched groundwater elevation and Deep Creek elevation is provided in Section 3.9.7, “Surface Water-Groundwater Interaction.”

2. Above low-permeability Vashon ice-contact deposits and lodgement till when encountered above the regional water table. This includes the clayey Vashon ice-contact deposits in B-4 and Vashon till encountered in EB-8W and at Spring 3 (S-3). Clay or sandy clay was also described at shallow depths at some of the domestic wells (W-8, W-14, W-31, and W-32) situated south and east of Hyde Lake. Seepage was noted at a depth of 12 feet in the W-14 well. The clay sediments were not reported in wells situated north or northeast of the lake (W-5, W-17, W-23, or W-11 to W-13 wells), nor in on-site well EB-2W. Based on the available explorations and well logs, the low-permeability ice-contact deposits and till are laterally discontinuous.

3. On upslope areas of Lizard Mountain above the very low-permeability bedrock. Perched groundwater may persist in localized bedrock lows due to the highly irregular bedrock surface. The perched groundwater also discharges as springs which are the origin of some of the streams flowing off Lizard Mountain. Some of these streams are seasonally active which is consistent with seasonal perched groundwater conditions. The perched groundwater at Lizard Mountain may or may not emerge at spring zones along the mountain and is dependent on the local topography, soil thickness, and depth to bedrock.

(C) Regional Aquifer

The Regional Aquifer is developed in highly-permeable Vashon ice-contact deposits and underlying pre-Vashon sands and gravels. Locally, the lower section of the regional aquifer is partially confined below discontinuous low-permeability Vashon till and/or fine-grained pre-Vashon deposits. The upper and lower portions of the aquifer are hydraulically connected through windows in the Vashon till and where the fine-grained pre-Vashon deposits are absent. The saturated interval is generally thickest in bedrock lows and thins out towards discharge points along the Green River. The regional aquifer is discussed in more detail in Section 3.9, "Aquifer Recharge, Discharge, and Groundwater Flow."

Water users discussed in Section 3.8 include Group A and Group B water systems, private wells, and water rights. Private wells withdraw groundwater from the regional aquifer as shown on Figure 7. These wells include W-1, W-2, W-5 through W-11, W-14, W-17, W-19, W-23, W-24, W-26, W-28, W-31, W-32, W-33, W-35 through W-38, W-43, W-45, W-49, and W-53 (Appendix G). W-22 is not in use and W-48 is abandoned.

(D) Bedrock "Aquifer"

The term bedrock "aquifer" is used in this report; however, reported yields from area wells completed in the bedrock are small relative to the highly transmissive aquifer intervals in the overlying deposits. This characterization of groundwater in bedrock is consistent with previous studies within East King County (Turney et al., 1995).

Sedimentary bedrock present in the Green River area (fine-grained or cemented sandstone, siltstone, and shale) has very low hydraulic conductivities in the same range as glacial till (Freeze and Cherry, 1979; Domenico and Schwartz, 1990). Although the zones within sedimentary rock in the vicinity of the site are capable of supplying limited quantities to domestic wells, the bulk hydraulic conductivity of the rock mass is low, and the units typically behave as a barrier to groundwater flow. Sedimentary rocks such as the Puget Group rely on secondary permeability, or flow through joints and fractures, for groundwater flow and recharge. The distribution of groundwater within the bedrock is also influenced by large-scale stratigraphic and structural features such as bedding, folds, and faults. Bedding planes may provide preferential pathways for flow and recharge. Faults may increase permeability or form almost impermeable barriers depending on characteristics of the fault zone.

Groundwater flow through the bedrock occurs primarily through discontinuities within the rock mass and along coal seams and mine workings. Discontinuities in the rock mass include primarily fractures, faults, and bedding planes. Coal mine seams and workings also act as conduits for groundwater flow through bedrock. A study by the USGS (Harlow and Lecain, 1993) found bituminous coal seams have higher hydraulic conductivity than adjacent sedimentary rock. The thickness of coal seams and cross-sectional area of the coal mine workings are very small in comparison to the overall rock mass. While coal seams and workings have the capability to hydraulically connect discontinuities within the rock mass, discharge observed from mapped mines or suspected mine features was limited (Table J-1).

Water users include private wells that withdraw groundwater from Puget Group bedrock as shown on Figure 7 and discussed in Section 3.8.5, "Private Wells". These wells include: W-3, W-4, W-12, W-13, W-15, W-16, W-18, W-20, W-21, W-25, W-27, W-29, W-30, W-34, W-39 through W-42, W-44, W-46, W-47, W-50, W-51, W-52, and W-54 through W-58 (Appendix G).

(E) Green River Aquifer

The Green River Aquifer is located adjacent to the Green River and present within Recent alluvial deposits (Ha). This material generally consists of a sequence of channel sands and gravels interbedded with fine-grained overbank sand deposits. The aquifer was not encountered onsite and is interpreted to be present where alluvium deposits are mapped along the river, which is very limited along the Green River adjacent to the site. Alluvial deposits are mapped upstream of the gorge area at Kanaskat-Palmer State Park. This aquifer is in direct hydraulic connection with the Green River.

(F) Well Construction Data and Groundwater Levels

A summary of the well construction data for the monitoring wells installed for this study by AESI and NV5 is provided in Table 1. Copies of the AESI and NV5 well logs are included in Appendices B and D, respectively. Summaries of monthly to bimonthly groundwater levels for these wells are included in Tables 2A and 2B. Groundwater level hydrographs are included in Appendix J.

TABLE 1: WELL CONSTRUCTION DATA

Well	Date Well Installed	Ecology Well Tag No.	Top of Casing Elevation (feet)	Ground Elevation (feet)	Screen Interval Elevation (feet)	Screen Slot Size (inches)	Observed by
EB-1W	11/25/2020	BLZ356	832.97	830.02	677-707	0.01	AESI
EB-2W	2/2/2022	BNY894	827.38	825.05	754-764	0.02	AESI
EB-3W	12/22/2021	BNW200	782.52	780.52	716-726	0.01	AESI
EB-4W	2/8/2022	BNY896	793.51	790.80	641-651	0.02	AESI
EB-5W	12/21/2022	BNW198	774.31	771.00	699-709	0.01	AESI
EB-6W	2/4/2022	BNY895	827.87	825.95	702-712	0.02	AESI
EB-7W	12/17/2021	BNW199	847.27	844.90	624-634	0.01	AESI
EB-8W	1/31/2022	BNY893	848.66	845.61	705-715	0.02	AESI
EB-9W	4/28/2022	BPK505	810.42	807.77	618-628	0.01	AESI
EB-10W	7/22/2022	BPK530	852.64	850.22	790-799	0.01	AESI
EB-11W	8/26/2022	BPK532	852.95	849.92	830-835	0.01	AESI
EB-12W	8/22/2022	BPK533	845.46	842.83	750-755	0.01	AESI
B-2	7/18/2019	BLZ154	852.07	848.62	798-808	0.01	NV5
B-3	7/18/2019	BLZ155	846.53	843.68	746-756	0.01	NV5
B-4	7/15/2019	BLZ156	793.54	790.24	716-726	0.01	NV5
B-5	7/17/2019	BLZ157	810.17	806.87	779-789	0.01	NV5

TABLE 2A: GROUNDWATER MEASUREMENTS

Well	Completion Zone	Groundwater Elevation (feet) 02/11/2022	Groundwater Elevation (feet) 03/23/2022	Groundwater Elevation (feet) 05/13/2022	Groundwater Elevation (feet) 06/30/2022	Well Screen Interval (feet)
EB-1W	Qvic	717.3	718.1	717.1	717.2	677-707
EB-2W	Qvic	789.9	791.2	787.8	788.3	754-764
EB-3W	Qvic	742.9	743.6	741.4	741.7	716-726
EB-4W	Qpv	717.2	722.9	717.2	719.5	641-651
EB-5W	Qvic	703.9	704.2	704.0	704.1	699-709
EB-6W	Qvt	706.2	707.1	705.3	706.8	702-712
EB-7W	Qpv	724.3	724.3	723.6	724.3	624-634
EB-8W	Qpv	719.0	719.6	718.8	718.9	705-715
EB-9W	Qpv	-	-	730.2	732.2	618-628
B-2	Qvic	<798	<798	<798	<798	798-808
B-3	Qpv / Tp	763.5	764.5	764.4	764.0	746-756
B-4	Qvic	740.2	742.7	729.5	740.7	716-726
B-5	Qvic	791.3	794.9	794.6	793.0	779-789

TABLE 2B: GROUNDWATER MEASUREMENTS (CONTINUED)

Well	Completion Zone	Groundwater Elevation (feet) 08/17/2022	Groundwater Elevation (feet) 09/30/2022	Groundwater Elevation (feet) 11/15/2022	Groundwater Elevation (feet) 01/24/2023	Well Screen Interval (feet)
EB-1W	Qvic	715.9	714.6	713.3	713.5	677-707
EB-2W	Qvic	786.7	785.4	784.5	785.3	754-764
EB-3W	Qvic	737.6	733.4	731.4	731.8	716-726
EB-4W	Qpv	714.8	711.2	707.9	707.6	641-651
EB-5W	Qvic	703.6	703.6	703.4	703.6	699-709
EB-6W	Qvt	702.9	702.7	702.7	703.4	702-712
EB-7W	Qpv	722.3	720.2	718.0	718.8	624-634
EB-8W	Qpv	717.8	716.4	715.0	715.0	705-715
EB-9W	Qpv	727.6	724.0	720.8	723.4	618-628
EB-10W	Qvic / Tp	795.3	792.9	791.8	793.2	790-799
EB-11W	Qal	-	840.0	840.4	842.0	830-835
EB-12W	Qpv	-	761.8	761.8	763.2	750-755
B-2	Qvic	<798	<798	<798	<798	798-808
B-3	Qpv / Tp	763.2	762.8	762.7	763.6	746-756
B-4	Qvic	722.2	719.3	<717.5	726.6	716-726
B-5	Qvic	782.1	780.9	783.5	791.6	779-789

Qvic = Vashon Ice-Contact Deposits
Qpv = Pre-Vashon Deposits
Tp = Puget Group Bedrock
If blank (-) the measurement date precedes well installation date. If row is absent in Table 2A those measurement dates precede the well installation date.

3.8 WATER USERS

AESI reviewed available data sources for area water users located in the vicinity of the subject site. In the next section (Section 3.9), we compare our spring and surface flow measurements to those reported in the literature including the Group A Springs, Icy Creek, and Deep Creek.

3.8.1 Group A Water Supply Systems

(A) Green River Gorge Resort Water System (GRGRWS) - Transient Non-Community (TNC) System

The GRGRWS (origin of Stream B, Figures 29 and 30) located west approximately 1,250 feet (nearly ¼ mile) of the Segale Property consists of 50 gallons per minute (gpm) of spring flow that supplies 55 active service connections serving 24 full-time residents as well as many transient users (visitors) according to the Water Facilities Inventory (WFI) form and Washington Department of Health (DOH) records (Appendix L). The GRGRWS has the Public Water Source Identification (PWSID) #29487. The spring box is located at approximately 630 feet elevation above the eastern side of SE Green River Gorge Road. During the wet season groundwater discharge may also occur at higher elevations and flow downslope along the edge of the road downhill of the spring box. Stream flow is supplied by (year-round) overflow from the spring collection system and other (seasonal) groundwater discharge. Flow is conveyed through a small culvert underneath the road and into a series of ponds separated by weirs. This flow does not include diversionary uses into the water system distribution. Flow rates measured by AESI at the weirs have ranged from about 0.5 CFS to 5.9 CFS over the period of record (October 2021 to March 2023).

Based on information obtained from the DOH, the most recent water system report for the GRGRWS was prepared by D.R. Strong Consulting Engineers (D.R. Strong) in June 1990 (D.R. Strong, 1990b) (Appendix L). D.R. Strong also worked on the original design (D.R. Strong, 1982), water system expansion in January 1990 (D.R. Strong 1990a) and an ultraviolet (UV) disinfection system evaluation in the early 2000's addressing water quality concerns (D.R. Strong, 2001). A collection of documents obtained from the DOH are attached in Appendix L and provide information on the springs use through time. The water system was completed in May 1983 according to DOH records.

The spring area has been developed with a collection box consisting of a 4-foot-diameter corrugated metal pipe embedded 4 feet into the ground and a cast-in-place concrete ring and lid with seal over the box (D.R. Strong, 1990b). Spring water is conveyed into a pumphouse located downhill along SE Green River Gorge Road. The pumphouse contains UV lamps to provide disinfection of the source water.

(B) Black Diamond Springs - Community Water System

The City of Black Diamond collects spring water for municipal use about 1½ miles west-southwest (Figures 29 and 30) of the southern Segale Property. The water system (PWSID# 07220) is a

Group A non-transient community system with 1,355 active connections per the WFI form (Appendix L). The water is currently treated with chlorine and other treatments (Appendix L). They include four different springs: Sofa (#1), Mattress (#2), Leaf (#3), and Palmer (#4) Springs. The springs discharge at approximately 560 to 580 feet elevation (Icicle Creek Engineers, 2003). Springs #1, #2, and #3 have been developed using finger drains or underground perforated pipes (Icicle Creek Engineers, 2003). According to PacWest Engineering (2008), only Springs #1 and #3 are currently being used for domestic supply. Discharge measurements were reported in the Brown and Caldwell et al. (1989) report to range from 6.4 to 11.9 CFS. The City of Black Diamond provided the measurements to Brown and Caldwell et al. based on measurements at a rectangular weir for the junction box for Springs #1, #2, and #3. Flow data reported in Luzier (1969) ranges from 5 to 40 CFS. The range of flows reported by Luzier (1969) suggests surface water may be a contributor to the monitoring location. Surface water risks and GWI (groundwater sources under the direct influence of surface water) are identified in the Draft City Water System Plan prepared by RH2 Engineering Inc. (RH2; 2020). The flows reported in Brown and Caldwell et al. (1989) are considered most representative of groundwater discharge.

(C) Kanaskat-Palmer State Park Well - TNC System

Groundwater well AFJ213 (PWSID# SP627F) is a Group A water supply located about 1,600 to 1,700 feet east of the northern Segale Property (Figures 29 and 30). The well supplies water to the State Park and has 26 active connections serving two full-time residents and many transient users (visitors) according to the WFI form (Appendix L). The water is currently treated with chlorine. The well is 58 feet deep according to the DOH. An Ecology well log matching the well depth and location indicates the well was installed in 1981. The well house is situated adjacent to the Green River about 20 feet above river level on an area mapped as alluvium. The water level reported on the driller's log corresponds to an elevation of about 722 feet, similar to the Green River elevation due west of the well. The well is interpreted to be completed in the Green River Aquifer.

3.8.2 Icy Creek Spring and Pautzke Rearing Ponds

Icy Creek Spring forms the headwaters of Icy Creek and lies around an elevation of about 600 feet. Icy Creek flows towards the Green River where the Washington Department of Fish and Wildlife (WDFW) operates a salmon-rearing facility. The locations of the Icy Creek Spring zone, fish hatcheries, and rearing ponds are shown on Figure 31. The nearest downstream fish hatchery/rearing facility on the Green River below the project site is the Pautzke Rearing Ponds operated by WDFW at approximate river mile 48.5 (about 3 to 7 river miles downstream of the Segale Property). WDFW uses water from the Icy Creek Spring for fish propagation and the spring is located about 0.7 miles upstream of the creek's confluence with the Green River (Northwest Hydraulic Consultants, 2005).

Richardson et al. (1968) stated the Icy Creek Spring is the largest spring in King County. This assessment was based on data collected by the USGS at station 12107300 along Icy Creek. Mean monthly discharges over the period of record (09/1963 to 06/1968) range from 5.3 CFS in October to 48 CFS in February. The lowest mean monthly discharge was 0.9 CFS in October 1967. Flows of 7 to 51 CFS reported in Luzier (1969) are based on the USGS dataset. The spring flows were also monitored by WDFW and flow rates are shown in the *WRIA 9 Habitat Limiting Factors and Reconnaissance Assessment for Salmon Habitat* by Washington State Conservation Commission and King County (2000). In this report, data by S. Mercer (2000), a WDFW fish hatchery specialist, shows monthly flows range from a low of 1.6 CFS in October to a high of 12.1 CFS in March. The WDFW monitors flow using a piping system into the rearing ponds. During exceptionally high flows the piping system is topped out and the spring flow is estimated. The USGS dataset is substantially more variable (peakier) than the WDFW dataset.

The range of flows reported by the USGS suggests surface water should be a contributor to the stream system. Barghausen Consulting Engineers, Inc. (2001) conducted an upstream drainage analysis of the site. During extreme storm events Fish Lake is reported to overflow into an 18-inch culvert underneath Enumclaw Franklin Road which is a tributary to Icy Creek. These events are reported to have occurred in 1933, 1965, and 1996 (Barghausen Consulting Engineers, Inc., 2001).

3.8.3 Palmer Rearing Ponds

The Palmer Rearing Ponds owned by WDFW are located across the Green River upstream (approximately 0.8 miles) of the site at approximate river mile 56.5 (Figure 31). The facility consists of two earthen ponds and four (lined) round ponds, which are fed by springs emanating on the north side of the Green River. According to WDFW (2013) the facility is currently leased to the Muckleshoot Indian Tribe (MIT).

3.8.4 Group B Water Supply Systems

The DOH lists one Group B well system located north of Hyde Lake identified as W-17 (PWSID# 52236). The well is located about 1,800 feet southwest from the southern Segale Property boundary (Figures 29 and 30). The well is 95 feet deep and completed as an open bottom well at the bedrock surface. The water level was about 82 feet deep at the time of well completion (12/23/1987). This water level corresponds to an elevation of approximately 721 feet elevation. The well serves three active connections to eight residents. Well water treatment is not reported (Appendix L).

3.8.5 Private Wells

Numerous domestic wells are completed in the vicinity of Cumberland and Hyde Lake (Figure 7). Well reports obtained from the Ecology website were matched to specific parcels. The well locations are located near the parcel centroid. Several of the well locations were refined by reviewing the King County Onsite Septic System (OSS) records. The locations of the private wells were not field-verified. Domestic wells are either completed in the regional aquifer or within the Puget Group bedrock, as depicted on Figure 7.

It is important to note that wells that are "completed in bedrock" have their well completion depth extend into the bedrock as noted on the driller's log; however, a handful of these wells do not have their well casing extend into the rock and several do not have the well casing extending more than 5 feet into rock. Wells that are "completed in bedrock" may not be fully sealed off from the overlying regional aquifer. Example well logs include W-15, W-20, W-21, W-27, W-40, W-46, and W-50 (Appendix G).

All of the domestic wells completed within the regional aquifer are located more than 1,000 feet from the proposed pit area. Three domestic wells are approximately located within about ¼ mile of the proposed pit extent and include the W-5, W-23, and W-32 wells. The W-22 well located on the southern Segale Property is not in use. The W-48 is an abandoned resource protection well (Figure 7). The identified water well reports for wells located in the immediate vicinity of the subject site are included in Appendix G.

Private well records utilized in groundwater contouring depicted on Figures 29 and 30 were dependent on the season of well completion.

3.8.6 Critical Aquifer Recharge Areas

Critical Aquifer Recharge Areas (CARAs) are the geographic areas in Washington that have a "critical recharging effect on aquifers used for potable water" per *Revised Code of Washington* RCW 36.70A.030(5) and "where an aquifer that is a source of drinking water is vulnerable to contamination that would affect the potability of the water" per Chapter 365-190-030 WAC.

The site is not located within a sole source aquifer (SSA) area or within an assigned time-of-travel (TOT) of wellhead protection areas (WHPAs) for Group A water systems. The Group A water supplies in the area (Resort Spring and Black Diamond Springs) have an assigned TOT of 1,000 feet according to WDOH Source Water Assessment Program (SWAP) records. A more recent WHPA analysis was completed by RH2 (2022) using the U.S. Environmental Protection Agency (EPA) computerized analytical model and provided by the City of Black Diamond (Appendix M). The mapped WHPA is located south of the southern Segale Property.

Areas susceptible to groundwater contamination (ASGWC) are mapped by King County (2004) and categorized as high, medium, and low sensitivity to groundwater contamination. The mapping area does not extend into the Segale Property area but covers adjacent areas to the south and west. Based on the King County (2004) mapping, the adjacent groundwater areas would have a medium susceptibility to contamination. The site is located outside of King County's groundwater management areas.

3.8.7 Water Rights

A water right is a right to use a reasonable quantity of public water for a beneficial purpose during a certain period of time occurring at a certain place. A water right is generally represented by three types of documents: claims, permits, or certificates.

AESI has identified and reviewed the water rights appurtenant to the Segale Property and in neighboring areas. Water rights within a broad area around the subject site were queried from the Ecology Water Rights Tracking System (WRTS) and Geographic Water Information System (GWIS) database. The search was focused on the areas south and east of the Green River. The results of the water rights search are shown on Figure 32 and summarized in Appendix N. We identified thirteen water right certificates, no permits, and six claims.

A water right certificate is a legal record that authorizes a landowner to use water for beneficial use, subject to the conditions of the certificate. Certificates are issued by Ecology once they have confirmed that the conditions of a water right permit have been met. Washington's water law includes the principle that a water right is confirmed and maintained through beneficial use. A water right may be wholly or partially "relinquished" through extended periods of nonuse where the water is not being put to beneficial use for which that right was granted and where there is not a "sufficient cause" for that nonuse (RCW 90.14.140). Ecology's POL-1060 (2019) statement indicates relinquishment from nonuse occurs after 5 or more consecutive years after 1967. Specific water rights purposes are conditionally protected from relinquishment such as municipal use and hydropower. The purpose of relinquishment is to ensure that Washington's limited water resources are put to maximum beneficial use, both diversionary uses and retention of waters for instream and natural protection of water quality and quantity.

Details of water right certificates around the Gorge Resort, Black Diamond Springs, Deep Creek, and Kanaskat-Palmer State Park are included below. Water right certificates that include the area around the Palmer Rearing Ponds are considered hydraulically disconnected from the project site since the facilities are upstream and located on the opposite side of the Green River from the Segale Properties. However, the locations of the facility and associated water rights are shown on Figure 32 for review purposes.

Water right certificates are summarized in Table N-1 by order of priority date or seniority.

Water Right No. S1-*06885CWRIS

Water right S1-*06885CWRIS is a certificated surface water right with a priority date of January 31, 1946. The water right is appurtenant to the King County parcel number 1721079032. This water right is for domestic uses and limited to a maximum instantaneous quantity (Qi) of 0.02 CFS. The authorized point of diversion (POD) for the water right is from an unnamed spring. Based on review of DOH and water rights documents this POD is the Resort Spring.

Water Right No. S1-*07401CWRIS

Water right S1-*07401CWRIS is a certificated surface water right with a priority date of August 23, 1946. The water right is appurtenant to the King County parcel numbers 1721079017, 1721079021, 1721079026, and the parcel 1721079022 area south of SE Green River Gorge Road. This water right is for domestic supply for a resort and trout pools and limited to a Qi of 0.20 CFS. The authorized POD for the water right is from unnamed springs and stream. Based on review of water rights documents this POD is the Resort Spring.

Water Right No. S1-*07861CWRIS

Water right S1-*07861CWRIS is a certificated surface water right with a priority date of June 5, 1947. The water right is appurtenant to the King County parcel number 1721079026. This water right is for domestic supply and limited to a Qi of 0.005 CFS. The authorized POD for the water right is from an unnamed spring. Based on review of water rights documents this POD is the Resort Spring.

Water Right No. S1-*09013CWRIS

Water right S1 *09013CWRIS is a certificated surface water right with a priority date of August 17, 1949. The water right is appurtenant to the N ½ of NW ¼ of SE ¼ and NW ¼ of NE ¼ of SE ¼ located east of the Green River in Sec. 19, T21N R7E. This water right is for Qi of 0.01 CFS for domestic use and 1.99 CFS for fish ponds. The authorized POD for the water right is from an unnamed spring located north of the Black Diamond Springs.

Water Right No. S1-*09022CWRIS

Water right S1 *09022CWRIS is a certificated surface water right with a priority date of August 22, 1949. The water right is appurtenant to the SE ¼ of SW ¼ of Sec. 19, T21N R7E. This water right is for hydropower and limited to Qi of 2.93 CFS. The authorized POD for the water right is from an unnamed spring. Based on review of the Proof of Prior Appropriation, the PODs are the Black Diamond Springs #1 and #2.

Water Right No. S1-00506C

Water right S1-00506C is a certificated surface water right with a priority date of April 15, 1968. The water right is appurtenant to the area served by the Town of Black Diamond. This water right is for municipal supply and limited to Qi of 8.0 CFS and a maximum annual quantity (Qa) of 551.0 acre-feet per year (afy). The authorized POD for the water right is from three springs (Black Diamond Springs #1 through #3).

Water Right No. S1-*04884CWRIS

Water right S1-*04884CWRIS is a certificated surface water right with a priority date of June 22, 1939. The water right is appurtenant to the SW ¼ of SE ¼ of Sec. 21, T21N R7E. This water right is for mining (coal washing) and limited to Qi of 0.2 CFS. The authorized POD for the water right is from Deep Creek.

<u>Water Right No. S1-CV2P571</u>
Water right certificate of change S1-CV2P571 is a certificated surface water right with a priority date of March 9, 1959. The water right is appurtenant to the E ½ of NE ¼ Sec. 29, T21N R7E. This water right is for irrigation between April 15 and October 1 and continuously for fish propagation and limited to Qi of 0.256 CFS. The authorized POD for the water right is from Deep Creek, an unnamed stream, and Hyde Lake.

<u>Water Right No. G1-*08270CWRIS</u>
Water right G1-*08270CWRIS is a certificated groundwater right with a priority date of August 23, 1966. The water right is appurtenant to the SW ¼ of SW ¼ Sec. 11, T21N R7E, NE of the right-of-way and west of the Green River. This water right is for domestic supply and limited to Qi of 8 gpm and Qa of 1.0 afy. The authorized point of withdrawal (POW) is from a groundwater well. The well report included in Appendix N indicates the well depth is 187 feet although no geologic log is available.

<u>Water Right No. S1-*15475CWRIS</u>
Water right certificate S1-*15475CWRIS is a certificated surface water right with a priority date of May 25, 1959. The water right is appurtenant to the E ½ of NE ¼ Sec. 29, T21N R7E. This water right is for irrigation of 15 acres and fish propagation and limited to Qi of 0.15 CFS and Qa of 30.0 afy. The authorized POD for the water right is from Deep Creek.

<u>Water Right No. G1-*09584CWRIS</u>
Water right G1-*09584CWRIS is a certificated groundwater right with a priority date of July 10, 1968. The water right is appurtenant to a part of the E ½ of SE ¼ of Sec. 10 T21N R7E. This water right is for domestic supply and limited to Qi of 20 gpm and Qa of 2.0 afy. The POW for the water right is from a groundwater well. The well report included in Appendix N indicates the well depth is 80 feet although the geologic log is incomplete below 59 feet.

<u>Water Right No. S1-*21247CWRIS</u>
Water right S1-*21247CWRIS is a certificated surface water right with a priority date of September 25, 1968. The water right is appurtenant to the area served by Palmer Water Association (SE ¼ of SE ¼ Sec. 10 and NE ¼ of NE ¼ Sec. 15, T21N R7E). This water right is for domestic supply and limited to Qi of 0.07 CFS and Qa of 4.0 afy for 6 homes and 1.0 afy for a community hall. The authorized POD for the water right is from an unnamed spring located at E ½ of SE ¼ of SW ¼ of SE ¼ Sec. 10 T21N R7E.

<u>Water Right No. G1-*23912CWRIS</u>
Water right G1-*23912CWRIS is a certificated groundwater right with a priority date of November 4, 1981. The water right is appurtenant to King County parcels 1021079012, 1021079059, 1021079072, 1021079011, 1021079016, 1021079017, and 1521079002. This water right is for domestic supply and fire suppression and limited to Qi of 100 gpm

and Qa of 7.0 afy. The POW for the water right is from a groundwater well located on Kanaskat-Palmer State Park property.

Documents including the Certificates, Report of Examination (ROE), and associated maps are included in Appendix N. ROEs are prepared by permit writers to document findings and recommendations before a water right certificate is granted. The ROEs may contain additional information that is not included on the certificate forms.

Five surface water claims and one groundwater claim were identified in the vicinity of the site. A water right claim, filed under the Claims Registration Act of 1967 (Chapter 90.14 RCW), is a claim to protect a perfected water right which was established prior to the enactment of the Water Code by the Washington State Legislature (1917 for surface water and 1945 for groundwater). A water right claim is only a statement that a landowner claims to have a perfected water right. Ecology accepted claims on either short form (SFCL) or long form (LFCL). The short form was primarily intended for permit exempt uses allowed under RCW 90.44.050. Short forms contain very little information that can be used to evaluate the validity of the claim that a vested (pre-code) water right exists. The long form provides more information such as when the claimed water use began and how much water (Qi and Qa) was being claimed. A claim may be a valid water right only if water was used prior to the enactment of the Water Code, and water has been continuously used. Claims can only be confirmed through a general water right adjudication (legal proceeding) in Superior Court.

The three mapped claims correspond to Deep Creek (SFCL# S1-086418CL), Hyde Lake (SFCL# S1-086036CL), and a well in Cumberland (LFCL# G1-031090CL) (Table N-2). Three unmapped surface water claims (SFCL# S1-042884CL, SFCL# S1-161580CL, and LFCL# S1-161581CL) each correspond to an unnamed spring in the vicinity of the Green River Gorge Resort. The approximate unmapped claim locations are shown on Figure 31. Short form claim S1-042884CL has a Place of Use (POU) location that corresponds to another water right (S1-*06885CWRIS) filed under the same last name of Elder. A summary of the long form claims is included below.

Groundwater Water Claim No. G1-031090CL

This claim has a POW and POU location that corresponds to a well in Cumberland. The claim is for domestic uses (tavern and living quarters) with a claimed use of 28 gpm and annual quantity of 32 afy. The date of putting water to use is listed as March 1960. The well log was not located in Ecology records.

Surface Water Claim No. S1-161581CL

Based on review of water rights and DOH documents the POD for S1-161581CL is the Resort Spring. This claim is for domestic uses (resort and campground) and irrigation of 2 acres and claimed use 0.1 CFS and annual quantity of 12 afy. The form field stating date of first putting water to use is blank. S1-161580CL (SFCL) is a duplicate of S1-161581CL (LFCL) which are co-located, and both filed on the same date under the same name. S1-161581CL is the water right on file with the DOH for the GRGRWS.

Another type of water right are instream flows. Instream flows for the Green River are established at the Palmer and Auburn gauges by Chapter 173-509-030 WAC. They are considered equal to other certificated water rights and their seniority is based on when instream flows are established (June 6, 1980). The Palmer gauge is located upstream, and the Auburn gauge is located downstream of the Segale Property. Surface waters closed to further consumptive use appropriations are designated by Chapter 173-509-040 WAC instream resources protection program. All tributaries of the Green River, Deep Creek, Hyde Lake, and Deep Lake are surface waters closed to future appropriations to water rights with consumptive use. Deep Creek, Hyde Lake, and Deep Lake have an administrative closure date of April 17, 1953 and all tributaries of the Green River have an administrative closure date of August 19, 1953.

Segale is not pursuing a new water right or new permit exempt water well at this time. They anticipate completing a contract agreement with City of Tacoma water who has a pipeline along Cumberland-Kanaskat Road SE.

3.9 AQUIFER RECHARGE, DISCHARGE, AND GROUNDWATER FLOW

The primary sources of recharge and discharge to the regional aquifer are the following:

<u>Recharge:</u>

1. Infiltration of precipitation (Section 3.9.1 below).
2. Infiltration of runoff and interflow. A significant percentage of runoff sourced from the neighboring bedrock mountains (including Lizard Mountain) ultimately recharges groundwater in the regional aquifer.
3. Leakage from surface water bodies such as Deep Lake and Hyde Lake (Section 3.9.7 below). A significant source of lake water is provided by Deep Creek. Deep Creek also provides a seasonally variable amount of recharge to the perched groundwater zone which eventually recharges the regional aquifer.
4. Anthropogenic sources such as septic systems and irrigation located offsite.

<u>Discharge:</u>

1. Discharge to springs or surface waters such as the Green River (Section 3.9.7 below). This includes water supplies at the Resort Spring and Black Diamond Springs that collect this water for domestic supply, municipal use, or other uses.
2. Evapotranspiration (Section 3.9.2 below).
3. Withdrawal from domestic water wells located offsite.
4. Limited recharge into the very low-permeability Tertiary bedrock “aquifer”

Our assessment of the groundwater system at the site shows that groundwater primarily flows through the Vashon ice-contact and pre-Vashon deposits above the contact with the Puget Group bedrock. Flow is controlled by the bedrock topography and is largest where the saturated interval thickness and cross-sectional area is greatest. Recharge at Deep Lake can produce local radial groundwater mounding effects. Bedrock highs produce radial or divergent flow conditions. Groundwater beneath the Segale Property primarily discharges as either spring flow along the Green River Gorge, such as near the Resort, or as subsurface flow to the Green River.

3.9.1 Precipitation and Temperature

The precipitation gradient is relatively high across the site due to its close proximity to the Cascade Range. Based on annual precipitation contours produced by the USGS (2005) and depicted by King County (2011), the average annual rainfall is approximately 50 inches per year at Black Diamond, located about 5 miles to the west, and about 80 inches per year upstream of Palmer Junction, about ½ mile to the east. Based on these sources, the rainfall across the property area ranges from about 60 to 70 inches per year.

Nearby precipitation gauges were reviewed including those operated by NOAA, King County Hydrologic Information Center (KCHIC), and Washington State University (WSU). The gauges reviewed include Landsburg and Palmer 3 ESE (NOAA), 31z and BDIA (KCHIC), and Enumclaw N (WSU). These gauges were reviewed alongside data provided by PRISM Climate Group (PRISM, 2022). PRISM (Parameter-elevation Regressions on Independent Slopes Model) provides a regularly-spaced grid of monthly precipitation across the United States and is well suited to mountainous terrain (Daly et al., 1994).

TABLE 3: TEMPERATURE AND PRECIPITATION SUMMARY

Month	Landsburg, WA (NOAA)			PRISM
	Temperature (Fahrenheit / Celsius)	Precipitation (inches)	Snowfall* (inches)	Precipitation (inches)
January	39.3 / 4.1	8.0	3.9	8.5
February	40.9 / 4.9	5.4	1.5	6.1
March	44.0 / 6.7	6.2	1.0	7.1
April	48.5 / 9.2	5.6	0.1	6.0
May	54.9 / 12.7	3.9	0.0	4.4
June	59.2 / 15.1	3.2	0.0	3.9
July	64.2 / 17.9	1.3	0.0	1.5
August	64.4 / 18.0	1.6	0.0	1.8
September	58.8 / 14.9	2.8	0.0	3.1
October	50.3 / 10.2	5.8	0.0	6.3
November	42.8 / 6.0	8.5	1.3	9.1
December	38.4 / 3.0	7.5	2.4	8.1
Annual	50.5 / 10.3	59.0	10.2	65.9

Landsburg Precipitation and Temperature 30-year normal (1991-2020)
*Landsburg Snowfall based on period of record (1903 to 2011)
PRISM Precipitation 30-year normal (1991-2020)
PRISM = Parameter-elevation Regressions on Independent Slopes Model
NOAA = National Oceanic and Atmospheric Administration

Monthly breakdown of precipitation at the Landsburg (NOAA) gauge and by PRISM are summarized in Table 3. Snowfall from Landsburg is also included in Table 3 and is based on the entire period of record (1903 to 2011) because many years have a discontinuous snowfall record.

Precipitation values shown on the water level hydrographs (Appendix J) are based on the Landsburg gauge. Gaps in the precipitation record were filled using the 31z gauge due to its proximity to the Landsburg gauge.

3.9.2 Evapotranspiration

Evapotranspiration (ET) is the sum of evaporation from the land, canopy, and water surfaces and transpiration from plants. Earlier estimates of evapotranspiration near Palmer, Washington made by Richardson et al. (1968) are about 21 to 24 inches annually, based on the Landsburg and Palmer 3 ESE gauges. More recent estimates of evapotranspiration are made by OpenET (2022). OpenET provides monthly gridded satellite-based estimates of evapotranspiration for water management across the western United States. Annual evapotranspiration estimated by OpenET is around 30 inches in the approximate property area. Large, exposed surface waters such as lakes typically experience more evapotranspiration. OpenET analysis of Deep Lake indicates annual evapotranspiration is estimated around 36 inches. The monthly values are summarized in Table 4 below.

TABLE 4: EVAPOTRANSPIRATION (ET) SUMMARY

Month	ET inches Approximate Property Area	ET inches Deep Lake
January	0.3	0.4
February	0.7	0.9
March	1.8	2.4
April	2.9	3.6
May	4.2	5.2
June	4.8	5.6
July	5.8	6.6
August	5.1	5.6
September	2.9	3.3
October	1.3	1.5
November	0.5	0.7
December	0.1	0.3
Yearly	30.4	36.1

3.9.3 Groundwater Flow

Groundwater elevations and flow paths are shown on Figures 29 and 30. The groundwater contours depicted on Figure 29 represent average “wet season” levels. Groundwater contours depicted on Figure 30 represent "dry season" conditions. These figures are based on geologic reconnaissance of the site and adjacent areas and on-site groundwater well data collected in May 2022 (Figure 29) and November 2022 (Figure 30). These datasets were supplemented by off-site well data collected by CH2M Hill and HWA (1991) (Appendix K) and water levels reported on Ecology well logs at the time of construction (Appendix G).

The groundwater data indicates the primary flow directions at the site are to the west and northwest. This primary groundwater gradient transports groundwater that ultimately discharges as springs along the Green River Gorge. The Resort Spring area is located west of the Segale Property. Groundwater in the northern Segale Property flows to the north and north-east that discharges as subsurface flow to the Green River.

Subsurface bedrock ridges and knobs act as barriers to flow. The groundwater contour extent depicted on Figures 29 and 30 correlates to where groundwater intersects the bedrock surface (Figure 24). Bedrock mapped to the west and northwest of Deep Lake deflect westerly flowing groundwater north of Deep Lake to the north.

Flow is radially away from the bedrock knob in the western Segale Property. The bedrock surface at wells B-3 and EB-12W east of the bedrock knob (Figure 24) are higher in elevation than the water table elevation at either to the east (EB-7W) or south (EB-6W) (Figures 29 and 30), indicating that the aquifer at wells B-3 and EB 12W is in a localized groundwater high.

Groundwater flow is towards the river in the northern Segale Property and based on water level data observations is irrespective of the season. The seasonal low in EB-1W was 712.3 feet on November 9, 2022. The river surface elevation determined from LIDAR imagery along the Green River east of EB-1W is about 705 feet. Based on the Palmer Gauge (USGS gauge 12106700), the typical annual fluctuation of river stage is about 3 feet.

Based on the current dataset, the locations of the groundwater capture area limits do not appear to shift with respect to seasonal changes in water levels (Figures 29 and 30).

3.9.4 Unsaturated Zone

The unsaturated zone is the portion of the subsurface above the groundwater table. Sediments within the unsaturated zone contain air and water within their pore spaces. Water movement through the unsaturated zone, and therefore the rate of aquifer recharge, is highly sensitive to and non-linearly dependent on the amount of water within these pore spaces.

- The unsaturated zone is responsible for the delay, or lag time, between rainfall events and aquifer recharge. The lag time is typically highest during the start of the wet season when the antecedent water content of the unsaturated zone is low (driest). The lag time is typically shortest during the apex of the wet season when the antecedent water content of the unsaturated zone is high (wettest). The lag time is also dependent on the thickness of the unsaturated zone, which is variable across the existing site ranging from less than 10 feet (B-5) to over 120 feet (EB-7W and EB-8W) depending on the time of the year.

- The unsaturated zone thickness attenuates the timing of recharge water entering the groundwater system from precipitation events. Hydrograph attenuation is observed between the thinnest unsaturated zone well (B-5) to the thickest unsaturated zone wells (EB-7W and EB-8W). Water levels in B-5 follow precipitation events with little delay or attenuation. Thick unsaturated zones delay and attenuate such that multiple infiltration events may merge to form a much longer and dampened period of groundwater recharge.

3.9.5 Transmissivity

Transmissivity is a measurement used to quantitatively assess groundwater flow. It is defined as the amount of water that can be transmitted horizontally by the full saturated thickness of the aquifer under a hydraulic gradient (slope) of 1.

(A) Regional Aquifer

A previous study by Brown and Caldwell et al. (1989) assessed the aquifer transmissivity using well data reported on Ecology logs using methods described in Walton (1962). Some of the domestic wells completed in the regional aquifer are constructed with open-ended steel casing. In these cases, the transmissivity estimates based on the well yields reported on the logs are unreliable and likely underestimate the true aquifer transmissivity. The average transmissivity reported in Brown and Caldwell et al. (1989) is about 5,000 gallons per day per foot (gpd/ft).

Preliminary transmissivity estimates of the pre-Vashon sediments were calculated using short-term pumping data during well development of EB-4W, EB-7W, and EB-9W. Using the specific capacity approach described by the USGS in Lohman (1972) and equations and graphical methods in Theis et al. (1963), the range of transmissivities is roughly 8,500 to 49,000 gpd/ft (Table 5). The estimates are based on storage coefficients ranging from 0.001 to 0.1, which are representative of leaky confined and unconfined aquifers, respectively. These transmissivity estimates are higher than those presented in Brown and Caldwell et al. (1989). Full-scale aquifer testing (long-duration, high-flow) is planned for the site to assess aquifer properties.

TABLE 5: REGIONAL AQUIFER PRE-VASHON TRANSMISSIVITY ESTIMATES

Well	Pumping Rate (gpm)	Drawdown (feet)	Specific Capacity (gpm/ft)	Pumping Duration (hours)	T (gpd/ft) [S=0.1]	T (gpd/ft) [S=0.001]
EB-4W	7.5	0.96	7.8	3	8,500	14,000
EB-7W	9.3	0.36	26	3	34,000	49,000
EB-9W	5.4	0.34	16	3	20,000	39,000

gpm = gallons per minute; gpd = gallons per day;
gpm/ft = gallons per minute per foot; gpd/ft = gallons per day per foot;
T = Transmissivity; S = storage coefficient

(B) Green River Alluvial Aquifer

Preliminary transmissivity estimates of the alluvium were calculated using pumping data provided on the well log for W-26. Using the same approach described above, the transmissivity is approximately 84,500 gpd/ft (Table 6). The estimate is based on a storage coefficient of 0.1 which is representative of an unconfined aquifer. The calculated transmissivity is consistent with a high degree of hydraulic continuity with the Green River. The W-26 well (Well Tag AFJ213, Kanaskat-Palmer State Park) may have encountered the Green River recharge boundary resulting in a high T value because the assumptions of the specific capacity approach are no longer valid. This interpretation indicates groundwater withdrawal from the well is supplied directly by flow from the Green River during pumping.

TABLE 6: GREEN RIVER AQUIFER ALLUVIUM TRANSMISSIVITY ESTIMATES

Well	Pumping Rate (gpm)	Drawdown (feet)	Specific Capacity (gpm/ft)	Pumping Duration (hours)	T (gpd/ft) [S=0.1]
W-26 (AFJ213)	35	0.67	52.5	12	84,500

gpm = gallons per minute; gpd = gallons per day
gpm/ft = gallons per minute per foot; gpd/ft = gallons per day per foot
T = Transmissivity; S = storage coefficient

3.9.6 Groundwater and Deep Creek Discharge

In the broad vicinity offsite of the Segale Property, groundwater emanates from major spring systems along the Green River Gorge and include the Resort, Black Diamond, and Icy Creek Springs. Table 7 presents a compilation of flow data measured at the various spring locations and Deep Creek, including information presented in Luzier (1969), Brown and Caldwell et al. (1989), Mercer (2000), and water rights ROE documents. The Brown and Caldwell et al. (1989) report describes flows received from personal communication with Richard Bain (TCW Associates, Inc., 1989a). Due to lack of documentation and rounded discharges reported, it is AESI's interpretation that these reported flows are considered rough estimates with the exception of flow reported to the nearest tenth of a CFS in Deep Creek. Luzier (1969) reported flows for Icy Creek are based on a partial dataset from USGS gauge 12107300 and do not include low flows reported in the fall of 1968. These datasets are discussed in earlier Sections 3.8.1 and 3.8.2. These data and AESI measurements are summarized in Table 7.

TABLE 7: DEEP CREEK AND GREEN RIVER SPRINGS DISCHARGE

Spring Name	Discharge, cubic feet per second	Period of Observation	Reported by
Stream A	0.04 to 1.3	5/2021, 10/2021 to 3/2023	AESI
Stream B Resort Spring	0.5 to 5.9 0.5 and 1.5 (est.) 2 to 5	10/2021 to 3/2023 10/1946 and 5/1947 Not Reported	AESI S1-*07401CWRIS ROE Luzier (1969) Table 4
Stream B2	0 to 2 (est.)	10/2021 to 3/2023	AESI
Stream C	0 to 3.1	10/2021 to 3/2023	AESI
Deep Creek	0.03 to 19.1* 19.5	10/2021 to 3/2023 2/17/1989	AESI TCW Associates, Inc. (1989a)
Black Diamond Springs (#4)	4 to 25 10 (est.)	Not Reported 2/17/1989	Luzier (1969) Table 4 TCW Associates, Inc. (1989a)
Black Diamond Springs (#1, #2, #3)	6.4 to 11.9 5 to 40 20 (est.)	03/1988 to 01/1989 Not Reported 2/17/1989	Brown and Caldwell (1989) Luzier (1969) Table 4 TCW Associates, Inc. (1989a)
Icy Creek Spring	0.9 to 78 1.6 to 12.1 7 to 51 75 (est.)	09/1963 to 06/1968 Not Reported Not Reported 2/17/1989	USGS 12107300 monthly average Mercer (2000) Luzier (1969) Table 4 TCW Associates, Inc. (1989a)

Est. = Estimate, rounded.
ICE = Icicle Creek Engineers
ROE = Report of Examination, for water rights records refer to Section 3.8.7 and Appendix N.
*Deep Creek range of flows based on 3 monitoring stations (DC-328th, DC-KUZAK, and DC-NOLTE)

3.9.7 Surface Water-Groundwater Interaction

As described earlier in the report (Section 3.7.2), our observations indicate that:

- Deep Lake is connected to and provides recharge to the regional aquifer. Because Deep Lake is hydraulically connected to regional groundwater, there is exchange between the lake water and groundwater along the lakebed. Deep Creek flows into Deep Lake and high flow events in Deep Creek result in short-term elevated water levels in Deep Lake, followed by a rapid decline in the lake to background water levels. The rate of decline of water levels in Deep Lake following high flow events in Deep Creek is a result of surface water-groundwater interaction and the permeability of the adjacent stratigraphy.

- Based on subsurface data obtained in EB-10W, lacustrine (silt and clay) deposits underlie alluvium near Deep Creek. Surface water in Deep Creek flows above the shallow, perched groundwater zone formed on the fine-grained lacustrine deposits. A comparison of groundwater elevation in EB-11W and surface water elevation at the Deep Creek staff gauge SG-1 (Figure 28) is shown on Figure J-5. The elevations indicate that recharge provided by surface water in Deep Creek flows to the northwest towards the Segale Property.

- Overall, surface water flows in Deep Creek were observed to be relatively consistent between our three flow monitoring stations (Table J-1) and indicates that a significant percentage of the surface water in Deep Creek ultimately reaches Deep Lake, with two exceptions. One exception is following dry periods where a small amount, but relatively large percentage of Deep Creek flow, provides recharge to the perched groundwater zone. Recharge is interpreted from losing stream flow observed between DC-328th and downstream stations (DC-KUZAK and DC-NOLTE) and was greatest during the November 2022 flow measurement (Figure J-4) which corresponds with the seasonal low groundwater measured in onsite monitoring wells. The second exception is an unknown, but small amount of water that flows into Stream F and into Hyde Lake.

- Hyde Lake is hydraulically disconnected from the regional aquifer and provides a relatively smaller amount of recharge to the regional aquifer in comparison to Deep Lake. Hyde Lake in part is supported by surface flow in Stream F, which forks off from Deep Creek. Clay sediments described in the well logs south and east of the lake would support a perched groundwater zone and surface water in Hyde Lake. The clay sediments were not reported in wells situated north or northeast of the lake (W-5, W-17, W-23, or W-11 through W-13 wells), nor in on-site well EB-2W.

3.10 WATER QUALITY

3.10.1 Introduction

Water quality samples of groundwater wells and surface waters were obtained on a monthly basis to assess baseline constituent concentrations.

Water quality samples of surface water were collected at several on- and off-site locations starting in December 2021 (Figure 28). Surface water sites were selected based on areas that are (i) downstream of groundwater discharge points from the regional aquifer, including the Green River Gorge Resort Spring, or (ii) upstream of where surface waters recharge the regional aquifer. This includes Deep Creek which is an important surface water feature for Deep Lake.

Deep Creek is monitored at the downstream end of Segale-owned property across (southeast of) Cumberland-Kanaskat Road SE from the proposed pit area in the southern Segale Property; the Segale-owned parcel is not shown on figures because it is outside of the proposed development boundary.

Stream B (monitoring location S-B) water quality samples are collected downstream of the overflow from the Green River Gorge Resort Spring box, which is the closest access point to collect “ambient” groundwater discharge samples. Flow in Stream B is supported year-round by the overflow.

Water quality samples of groundwater were collected at several on-site well locations starting in April 2022 (Figure 28). Groundwater wells were selected to get an overall distribution of groundwater quality beneath the Segale Property. Dedicated groundwater sampling pumps were installed in the wells. Proactive Environmental Products LLC® Sample Champ XL pumps were installed in wells B-3, B-4, B-5, EB-1W, and EB-5W. A Grundfos Pumps Corporation 5-SQE-180 was installed in EB-7W.

3.10.2 Methods

Samples were submitted within method-specified hold times to Washington State Ecology-accredited laboratories and tested for pH, conductivity, total alkalinity, hardness (calcium and magnesium), color, total suspended and dissolved solids (TSS and TDS), nitrate and nitrite-nitrogen, sodium, chloride, sulfate, fluoride, coliforms, total phosphorus, total organic carbon, total petroleum hydrocarbons, total cyanide, surfactants, and total and dissolved metals including aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, mercury, manganese, nickel, selenium, silver, thallium, and zinc. Several locations were monitored for pesticides during initial sampling events in January and February 2022, but this was discontinued because the non-detect results did not warrant additional monitoring. Dissolved metals were monitored beginning in March 2022. Samples collected for testing of dissolved metals are field-filtered at the time of collection. The "dissolved" fraction is operationally defined as the solution that passes through a 0.45-µm (micron) filter. Total organic carbon monitoring began in August 2022. Testing results are summarized in Appendix O.

Field parameters were monitored by AESI at the time of sample collection and include temperature, pH, turbidity, dissolved oxygen (DO), conductivity, and oxidation-reduction potential (ORP). Groundwater temperature was measured by the submerged pressure transducers/data loggers and is reported as the ambient temperature prior to sample collection and warming from the pump. ORP was monitored beginning in August 2022. Conductivity and pH were also analyzed by a laboratory. AESI field monitoring data is indicated by the "(field)" tag in Appendix O.

Groundwater sampling through August 2022 consisted of purging at least 3 well volumes prior to collecting water quality samples. Groundwater sampling during September 2022 and onwards has consisted of low-flow sampling in general accordance with the EPA procedures (Puls and Barcela, 1996). EB-7W has a dedicated high-flow pump and therefore is still sampled under the original procedure.

Tables 8 to 11 in subsequent sections outline maximum contaminant levels (MCLs) and criteria for drinking water, groundwater, and surface water.

3.10.3 State Water Standards

(A) Drinking Water (Chapter 246-290-310 WAC)

Drinking water regulations are provided to ensure health quality standards are maintained for public drinking water supplies. Drinking water standards are established by the WDOH and comply with the Federal Safe Drinking Water Act of 1974 and subsequent amendments. Standards outline monitoring protocols and MCLs. The MCLs are divided into primary and secondary categories (Table 8). Primary standards are based on chronic, non-acute, or acute human health effects. The primary MCL for arsenic does not apply to TNC water systems per 246-290-310 WAC. Secondary standards are based on factors other than human health effects, such as aesthetics or taste.

TABLE 8: WASHINGTON DEPARTMENT OF HEALTH DRINKING WATER REGULATIONS

PRIMARY	
Substance	MCL
Antimony	0.006 mg/L
Arsenic[+]	0.010 mg/L*
Barium[+]	2.0 mg/L
Beryllium	0.004 mg/L
Cadmium[+]	0.005 mg/L
Chromium[+]	0.1 mg/L
Copper[+]	(1.3 mg/L)**
Cyanide	0.2 mg/L
Fluoride[+]	4.0 mg/L***
Lead[+]	(0.015 mg/L)**
Mercury[+]	0.002 mg/L
Nitrate-Nitrogen[+]	10.0 mg/L
Nitrite-Nitrogen	1.0 mg/L
Selenium[+]	0.01 mg/L
Sodium	(20 mg/L)**
Thallium	0.002 mg/L
Bacteriological[+]	E. coli or total coliform presence in a repeat sample

SECONDARY	
Substance	MCL
Chloride[+]	250 mg/L
Fluoride[+]	2.0 mg/L
Iron[+]	0.3 mg/L
Manganese[+]	0.05 mg/L
Silver[+]	0.1 mg/L
Sulfate[+]	250 mg/L
Zinc[+]	5.0 mg/L

PHYSICAL CHARACTERISTICS	
Substance	MCL
Color[+]	15 color units
Specific Conductivity	700 microsiemens/cm
Total Dissolved Solids[+]	500 mg/L

Notes:
MCL = Maximum Contaminant Level
mg/L = milligrams per liter (1 mg/L = 1000 µg/L)
* Does not apply to Transient Non-Community systems
** No established MCL but monitored. "Action level" or "recommended level" listed.
*** If fluoridated, see Chapter 246-290-460 WAC.
[+] Listed in groundwater standards (see Table 9)
Source: Chapter 246-290-310 WAC.

(B) Groundwater Standards (Chapter 173-200 WAC)

Washington State groundwater quality standards are designed to protect groundwater quality and existing and future beneficial uses through an antidegradation policy (173-200-030) and definition of MCL criteria (173-200-040) which are listed in Table 9. Groundwater standards and drinking water standards are similar but not identical. Regulations require that contaminants proposed for entry to groundwater shall be provided with All Known, Available, and Reasonable methods of prevention, control, and Treatment (AKART) prior to entry. AKART can be provided through source controls, accidental spill plan provision, and collection, treatment, and infiltration of all stormwater runoff.

TABLE 9: GROUNDWATER REGULATIONS

PRIMARY		SECONDARY	
Substance	MCL	Substance	MCL
Barium^{+}	1.0 mg/L	Chloride^{+}	250 mg/L
Cadmium^{+}	0.01 mg/L	Copper^{+}	1.0 mg/L
Chromium^{+}	0.05 mg/L	Iron^{+}	0.3 mg/L
Lead^{+}	0.05 mg/L	Manganese^{+}	0.05 mg/L
Mercury^{+}	0.002 mg/L	Sulfate^{+}	250 mg/L
Selenium^{+}	0.01 mg/L	Zinc^{+}	5.0 mg/L
Silver^{+}	0.05 mg/L	Total Dissolved Solids^{+}	500 mg/L
Fluoride^{+}	4 mg/L	Surfactants	0.5 mg/L
Nitrate-Nitrogen^{+}	10.0 mg/L	pH	6.5 to 8.5
Total Coliform Bacteria^{+}	1 CFU/100mL	Color^{+}	15 Color units
Pesticides / Herbicides	Varies	Odor	3 threshold odor units

CARCINOGENS	
Substance	MCL
Arsenic	0.05 µg/L
PAH	0.01 µg/L
Pesticides	Varies
Shortened list. See Chapter 173-200-040 WAC for list.	

Notes:
MCL = Maximum Contaminant Level
mg/L = milligrams per liter (1 mg/L = 1000 µg/L)
µg/L = micrograms per liter
CFU/100mL = Colony Forming Units per 100 milliliters
PAH = Polycyclic Aromatic Hydrocarbons
$^{+}$ Listed in drinking water regulations (see Table 8)
Source: Chapter 173-200-040 WAC.

3.10.4 Groundwater Quality Data

(A) AESI Resource Monitoring

Groundwater quality data for the regional aquifer was collected from seven on-site wells (B-3, B-4, B-5, EB-1W, EB-5W, EB-7W, and EB-12W). Samples that did not meet water quality standards or drinking water MCLs for pH, specific conductance, metals including arsenic, iron, manganese, cyanide, and color were identified in some of the wells. Arsenic, iron, manganese, pH, and specific conductance are common water quality issues in eastern King County (Turney et al., 1995). Observations regarding groundwater temperature, sodium, and odor are also discussed below.

(i) *Temperature*

The monthly temperature of groundwater wells where continuous water level data is collected has ranged from 8.1 to 9.9°C (46.6 to 49.8°F). The average water temperature is about 9.0°C (48.2°F).

(ii) *pH*

pH is a basic water quality parameter measured by the negative logarithm of hydrogen ion activity. In groundwater it changes as a result of geochemical reactions. The pH levels measured in multiple groundwater samples collected from monitoring well B-5 were found to be outside of the State groundwater quality limits of 6.5 to 8.5 pH specified in Chapter 173-200 WAC. During the monitoring period, the field pH measured in groundwater collected from B-5 has ranged from 5.33 to 6.56. Several pH samples reported by the laboratory did not meet water quality criteria in EB-5W, in these instances, field-collected pH from EB-5W was within State groundwater quality criteria. Due to the short method specified hold time the field pH is considered more representative than the lab-reported pH.

(iii) *Specific Conductance*

Specific conductance is a measure of the electrical conductance of water corrected for water temperature. It quantifies the amount of dissolved ions in water. The laboratory-measured conductance in groundwater samples collected from EB-12W has ranged from 681 to 861 µS/cm (microsiemens per centimeter). Field-measured conductance in groundwater from EB-12W has ranged from 658 to 833 µS/cm. The drinking water MCL of 700 µS/cm protects aesthetics such as taste.

(iv) *Metals*

AESI collected groundwater samples to be analyzed for total and dissolved metals. The samples to be tested for dissolved metals were field-filtered. In wells with high turbidity and suspended solids, the concentration of total metals may be skewed by the metals in the suspended sediment. In these cases, the dissolved metals are more representative of the natural aquifer concentration.

The change to low-flow sampling in September 2022 was in-part made to reduce overestimation of metals due to high levels of turbidity induced by the sampling process. The 0.45-µm filters retain particulate metal and allow both colloidal metal and dissolved metal to pass through.

In the case of groundwater wells a likely natural source of colloidal metal is clay (a hydrous aluminum phyllosilicate) within the aquifer framework. High concentrations of aluminum associated with high concentrations of metals (both total and dissolved) suggest colloidal metal influence. Metal colloids have been traced to overestimated metal concentrations, even those that have been run through 0.45-µm filters (Puls and Barcela, 1989; Puls et al, 1992). Metals correlated to aluminum concentrations include iron, manganese, copper, chromium, lead, nickel, and arsenic. This correlation has been observed at B-3, B-5, and EB-5W. Aluminum concentrations have dropped and stabilized under low-flow sampling.

Iron and manganese concentrations in eastern King County can also result from natural processes under reduced, low-oxygen geochemical conditions (Turney et al., 1995). Iron and manganese are more soluble under these conditions, favoring desorption from the aquifer material and resulting in higher concentrations. This can be reversed if the water is reoxygenated and iron and manganese can precipitate and adsorb to the aquifer material. Variations in manganese or iron concentration in low-oxygen wells (B-3, EB-7W, and EB-12W) may be a result of natural variations in the iron and manganese content and amount of clay in the aquifer framework material. Similar geochemical processes affect arsenic concentrations and are discussed in Section 3.10.6.

Iron: Total iron exceeded the drinking water and groundwater MCL of 0.3 milligrams per liter (mg/L) in groundwater samples collected from monitoring wells B-3 (4 of 9 samples), B-5 (3 of 9 samples), EB-5W (10 of 10 samples), and EB-12W (5 of 5 samples). Dissolved iron exceeded the MCL in all samples collected from EB-12W, one sample in B-3, and one sample in EB-5W. Since low-flow sampling began only EB-12W (total and dissolved iron) and EB-5W (total iron) have exceeded the MCL. The Washington State MCL for iron of 0.3 mg/L is a secondary MCL which is not based on health criteria. It is based on aesthetic effects such as taste.

Manganese: Total and dissolved manganese have exceeded the drinking water and groundwater MCL of 0.05 mg/L in all samples collected from B-3, EB-5W (one exception), EB-7W, and EB-12W. Total manganese exceeded the MCL in one sample in B-5. The Washington State MCL for manganese is a secondary MCL which is not based on health criteria.

Arsenic: Total and dissolved arsenic concentrations were elevated (>1 microgram per liter, or µg/L) in groundwater samples collected from wells B-3, EB-1W, EB-5W, and EB-7W, and exceeded the MCL for drinking water (10 µg/L) in all samples obtained from monitoring wells B-3 and EB-12W, and one sample obtained from EB-5W. The Washington State MCL for arsenic is a primary MCL based on health criteria.

The EB-5W sample that exceeded the MCL is likely an outlier due to high turbidity (322 NTU) during the sample event as the highest arsenic concentrations are associated with high turbidity samples and high aluminum concentrations. Subsequent analysis of groundwater samples collected under low-flow sampling from EB-5W show turbidity less than 30 NTU, total arsenic concentrations less than 5 µg/L, and dissolved arsenic concentrations less than 1 µg/L.

Arsenic concentrations in the northern Segale Property monitoring wells have ranged from 1.04 to 1.29 µg/L in EB-1W and 1.41 to 1.98 µg/L in EB-7W. Concentrations in EB-1W and EB-7W are similar to arsenic concentrations measured in surface water sampled from Stream A, described in Section 3.10.4.

Mercury and Antimony: Metals also associated with arseno-sulfides in the area include mercury and antimony. Mercury and antimony concentrations were well below both drinking water and groundwater MCLs.

(v) Total Cyanide

Total cyanide concentration exceeded the primary drinking water MCL of 0.2 mg/L in groundwater samples collected from EB-12W and B-3 during the February 2023 sample event, with respective concentrations of 0.576 mg/L and 0.241 mg/L. Cyanide concentrations in groundwater samples previously tested from these wells were below the MCL and the laboratory detection limit. Total cyanide was also detected in a groundwater sample collected from EB-5W during the February 2023 sample event with a concentration of 0.0823 mg/L. These wells are in close association with bedrock. Cyanide was not detected in B-3, EB-12W, or EB-5W in the March 2023 sample event.

(vi) Color

Apparent color levels exceeded the drinking water secondary MCL aesthetic objective of 15 PCU (platinum-cobalt units) in EB-1W (1 of 10 samples), EB-12W (4 of 5 samples), B-3 (6 of 10 samples), B-5 (4 of 9 samples), and EB-5W (9 of 10 samples).

(vii) Sodium

Sodium levels exceeded the recommended level of 20 mg/L sodium based on drinking water standards (Table 8) in groundwater samples collected from EB-12W, where sodium levels have ranged from 141 to 204 mg/L. High levels of sodium in groundwater at this location are known to be associated with volcanic bedrock (Turney et al., 1995), which could be associated with andesite intrusive sills within the Puget Group along the Lawson Anticline. Sodium does not have a state-established MCL.

(viii) *Oil and Grease*

Oil and grease was detected at a concentration of 70.7 mg/L in well B-4 during the December 2022 sampling event. Oil and grease has not been detected at B-4 in the two subsequent sampling events.

(ix) *Odor*

Odor is another aesthetic drinking water quality objective. Odor was not analyzed in the laboratory although presence of odor was noted at the time of field collection. An unpleasant odor was noted during purging of wells EB-7W and EB-12W. CH2M Hill and Hong West & Associates (1991) noted that bedrock wells in the area often produce water that has an unpleasant odor and considered a possible link to carbonaceous rock strata. A coal seam underlies the EB-12W well screen. Bedrock was not encountered at EB-7W.

(B) Brown and Caldwell et al. (1989) Monitoring

Brown and Caldwell et al. (1989) sampled groundwater from several wells in the vicinity of Cumberland and had the samples analyzed for major ions including calcium, magnesium, sodium, potassium, chloride, nitrate, sulfate, and alkalinity, pH, specific conductance, and TDS. The sampling locations include monitoring well B1 (TCW), W-17, W-22, W-25, and the Kanaskat-Palmer State Park well (Well Tag AFJ213, W-26). Iron and manganese were sampled at B1 (TCW) and wells W-22 and W-25. The report is included in Appendix K.

(i) *Metals*

Testing for total iron and manganese completed on groundwater samples collected from monitoring well B1 (TCW) indicated that concentrations of both of these analytes exceeded drinking water MCLs and groundwater quality standards with 2.2 mg/L iron and 0.13 mg/L manganese. The drinking water MCLs for iron (0.3 mg/L) and manganese (0.05 mg/L) are identical to the groundwater quality standards.

Laboratory analysis for dissolved iron and manganese was completed on groundwater samples collected from the W-22, W-17, and W-25 wells. Dissolved iron in groundwater from the W-22 well exceeded the drinking water MCL and groundwater quality standard with a concentration of 2.3 mg/L. Dissolved manganese in groundwater from the W-17 well exceeded the drinking water MCL and groundwater quality standard with a concentration of 0.06 mg/L.

Brown and Caldwell et al. (1989) reported iron and manganese concentrations are similar to AESI groundwater quality monitoring data.

(ii) *Nitrate*

The data shows elevated nitrates in groundwater samples collected from wells B1 (TCW), W-22, and W-25 wells. The nitrate concentrations in these wells ranged from 3 to 5.8 mg/L and are below the drinking water MCL. The elevated nitrates are generally consistent with on-site septic systems located around Cumberland.

3.10.5 Surface Water Quality Data

(A) AESI Resource Monitoring

Surface water quality data was collected from 10 springs/streams (S-A through S-E, S-B2, S-J through S-L, and S-3) and Deep Creek. Water quality exceedances of iron were identified in Deep Creek. Water quality exceedances for specific conductance and TDS were identified in coal mine drainage (S-J). These findings are consistent with observations by Packard et al. (1988) and Turney et al. (1995). pH, arsenic, sodium, and odor are also discussed below.

(i) *pH*

Surface water pH as measured in the field had values that were within the range of 6.5 to 8.5 pH units. Laboratory-analyzed pH was below 6.5 pH in Stream B (S-B) during the September, October, and November 2022 sampling events and in Deep Creek during the November 2022 sampling event. As discussed above, field-collected pH is considered to be more representative of actual water quality.

(ii) *Dissolved Oxygen (DO)*

DO concentration depends on a number of in-stream conditions, biological, and seasonal factors, the latter of which are discussed here. Stream flows decline during the dry season, when water tends to warm up and reduce its turbulent mixing with air, which reduces DO levels in the water column. DO concentrations tend to rise in most surface waters following precipitation events because rain saturates with oxygen as it falls. Colder water is saturated at higher DO levels than warmer water, so DO concentrations at a specific location are usually higher in winter than summer. Deep Creek DO was lowest during our sampling events in July and August 2022 (9.5 mg/L and 9.3 mg/L), which correspond with the highest recorded temperatures in Deep Creek (16.8 degrees Celsius and 16.9 degrees Celsius, respectively).

(iii) *Iron*

Iron exceeded the drinking water MCL of 0.3 mg/L in 7 of the 12 samples collected from Deep Creek. Dissolved iron in Deep Creek has ranged from 0.105 to 1.09 mg/L.

(iv) *Arsenic*

Arsenic concentrations remained below the drinking water MCL of 10 µg/L at springs and streams monitored for this study. Arsenic levels were around or below a reporting limit of 0.2 µg/L in most of the springs and streams (S-B, S-B2, S-C, S-D, S-E, S-J, S-K, S-L, and S-3). Dissolved arsenic concentrations in Deep Creek have ranged from 0.244 to 0.956 µg/L, with peak concentrations occurring in the late summer to early fall. Dissolved arsenic concentrations at S-A have ranged from 1.25 to 1.64 µg/L, consistent with levels observed in groundwater well EB-7W. Arsenic concentrations in S-3 are likely lower than S-A because spring flow at S-3 emanates from above Vashon till and therefore does not interact with the local bedrock.

(v) <u>*Odor*</u>

An unpleasant odor was observed at Stream C (S-C) and is similar to the odor noted in the groundwater wells EB-7W and EB-12W. Odor is an aesthetic drinking water objective and was not analyzed in the laboratory although its presence was noted at the time of field collection.

(vi) <u>*Coal Mine Drainage (Specific Conductance, TDS, and Sodium)*</u>

Streams J and L (S-J and S-L) originate from underground coal mine workings and were sampled in March and May 2022. The water quality data indicates water quality exceedances of specific conductance, TDS, and sodium. Stream J (S-J) exceeded the drinking water MCL for specific conductivity (700 µS/cm) in both sample events and TDS (500 mg/L) in the March 2022 sample. MCLs for specific conductivity and TDS are established for aesthetic drinking water quality objectives. Water samples collected from S-J also exceeded the recommended level of 20 mg/L sodium based on drinking water standards. Sodium does not have a state-established MCL. The concentration of sodium in S-J has ranged from 28 to 32 mg/L.

(B) Brown and Caldwell et al. (1989) Monitoring

Brown and Caldwell et al. also sampled major creeks, springs, and lakes in the vicinity of Cumberland. The sampling locations included the Black Diamond Springs (including Palmer Spring), Icy Creek (Fish Hatchery) Spring, the Green River, and Deep Creek and Deep Lake. Samples were taken to analyze major ions including calcium, magnesium, sodium, potassium, chloride, nitrate, sulfate, and alkalinity, hardness, pH, specific conductance, and TDS. Dissolved iron and manganese were sampled at all locations and the Black Diamond Springs were also sampled for total metals (iron, manganese, copper, zinc, arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) and fluoride. Springs were sampled by Richardson et al. (1968) in January of 1963 and the data is also presented in the Brown and Caldwell et al. (1989) report (Appendix K). No exceedances were identified.

(i) <u>*Sodium*</u>

Sodium at the Palmer Spring (Black Diamond Spring #4) exceeded the drinking water recommended level (of 20 mg/L) with a concentration of 31 mg/L. Sodium does not have a state-established MCL.

(ii) <u>*Arsenic*</u>

The reporting limit for arsenic in the Brown and Caldwell et al. (1989) study was 5 µg/L. Comparison of arsenic levels to the Brown and Caldwell et al. study is not possible because the reporting limit (5 µg/L) was above the surface water arsenic levels observed in this study.

(C) Washington Department of Health (DOH) Monitoring

Historical groundwater quality data is available for the Resort Spring (DOH ID 29487) and the Black Diamond Springs (DOH ID 07220) on the DOH Sentry database. The Resort Spring has reported no exceedances for any primary or secondary drinking water MCLs, other than a few instances of total coliform presence (in treated water in distribution) in February and December of 2000 and August 2005. Total coliform was also detected in water sampled from the spring box (raw water) in August 1989 and May 2002 (Appendix L). The Black Diamond Springs have reported no exceedances for any primary or secondary drinking water MCLs, other than a couple instances of total coliform presence in 2000 and 2007. Total coliform was also detected in spring water in September 1989 (Appendix L).

(D) Green River Water Quality

Ecology monitors the Green River (station I.D. 09A190) at Cumberland-Kanaskat Road SE in Palmer, Washington (Figure 28). The location of the station is described as 1.1 miles upstream of the Palmer Rearing Ponds and 4.5 miles downstream of the gauge near Bear Creek, or the Howard Hanson Dam (USGS gauge 12105900) at river mile 63.6, and therefore approximate river mile 59.1. Data from the period of record was obtained from the Ecology EIM (Environmental Information Management System) FIN (Freshwater Information Network) database.

The dataset is collected as part of Ecology’s Statewide River and Stream Ambient Water Quality Monitoring (Von Prause, 2021; Era-Miller et al., 2023) and currently (2023 water year) monitored analytes include: temperature, DO, pH, TSS, turbidity, specific conductivity, hardness, alkalinity, nitrogen (persulfate method), nitrite-nitrate nitrogen, chloride, total phosphorus, ortho-phosphate, potassium, ammonia, fecal coliforms and E. Coli, and metals such as arsenic, cadmium, calcium, chromium, copper, lead, magnesium, mercury, nickel, silver, sodium, and zinc. Results from the last 10 years were reviewed (2013 to 2023). With the exception of bacteriological levels (fecal coliforms and E. Coli), no MCL exceedances with respect to drinking water or groundwater WAC were reported. Dissolved arsenic has ranged from 0.23 to 0.84 µg/L. Arsenic concentrations are consistent with a previous study by Ecology (2002).

3.10.6 Arsenic

As discussed above, arsenic concentrations exceeded the Washington State drinking water MCL of 10 µg/L in B-3 and EB-12W located east of the old metal mine plant area. The arsenic concentration is anomalously high in comparison to levels observed in other monitoring wells or springs in the area. The arsenic concentrations are elevated in wells B-3 and EB-12W due to natural processes.

The local bedrock has concentrated arsenic in the form of realgar, orpiment, and possibly other unidentified miscellaneous forms. These wells are located along the bedrock structural feature known as the Lawson Anticline which is associated with arsenic-bearing ore deposits formerly mined at the Royal Reward Mine situated north of the wells. Mineralization follows the direction of the axis/hinge line of the fold and is concentrated along shale/coal beds and faults as well as disseminated in rock strata. Arsenic sulfide minerals have also been reported in the Puget Group bedrock at the Cardinal Reward Mine located roughly 1,500 to 1,800 feet west of monitoring wells B-3 and EB-12W.

Geochemical conditions observed at wells B-3 and EB-12W are favorable for arsenic release and mobilization in groundwater. Strongly reducing conditions at near neutral pH values causes release of arsenic in groundwater by arsenic desorption and reductive dissolution (Smedley and Kinniburgh, 2002). Groundwater in B-3 and EB-12W generally have high concentrations of iron and low concentrations of sulfate. Arsenic is also distinctive among heavy metals in being relatively mobile under reduced geochemical conditions at pH values typically found in groundwater, i.e., 6.5 to 8.5 pH (Smedley and Kinniburgh, 2002).

These conditions are consistent with the water quality results obtained from the wells:

a. B-3 and EB-12W wells were observed to have a negative Oxidation-Reduction Potential (ORP) (up to -199 and -177 millivolts, respectively), indicating strongly reduced conditions.
b. Both wells were observed to have near-neutral pH conditions: range of 7.39 to 8.29 (field) pH in B-3 and 7.53 to 7.81 (field) pH in EB-12W.
c. Both wells contain notable concentrations of iron, as described above.
d. Both wells contain very low concentrations of sulfate (<0.4 mg/L).

Two key factors are involved in formation of high concentrations of arsenic in groundwater: (1) geochemical conditions that release arsenic from solid phase into groundwater (described above) and (2) the released arsenic must not be flushed away. The observed hydrogeologic conditions limit the amount of flushing that can occur. The aquifer at B-3 and EB-12W is confined below low-permeability Vashon till, limiting the amount of flushing due to slow recharge through the till and lateral migration.

IV. CONCLUSIONS

4.1 SUMMARY

The geological and hydrogeological data, observations and analyses contained in this report provide documentation of the Affected Environment elements of Earth and Water resources to assist in the environmental review and planning for development of the subject property for sand and gravel extraction. Interpretations of subsurface conditions are based on the explorations completed for this study and a comprehensive literature review to incorporate into analysis of the regional hydrogeologic setting. Key bullet points below summarize our study and include the regional topographic setting, existing slopes, subsurface units encountered, formation interval thicknesses, historic coal mining, groundwater bearing zones, bedrock topography, water users, water rights, and existing water quality.

- The Segale Property is situated on a glaciated bedrock terrane north of the town of Cumberland, Washington and south and east of the Green River. The Green River has deeply incised into the bedrock and overlying unlithified deposits. The valley walls are steep sided along a section of the river known as the Green River Gorge, which stretches from Palmer Junction to Flaming Geyser State Park. Bedrock mountains border the eastern side of the site and form the headwaters of Deep Creek. Lizard Mountain is a bedrock ridge that extends into the southern Segale Property. A bedrock knob is exposed in the northern area of the western Segale Property. Hyde Lake and Deep Lake are located south of the subject property. Deep Creek flows adjacent to the southern Segale Property and into Hyde Lake and Deep Lake and terminates at Deep Lake.

- The topography of the Segale Property, DNR Property 16, and adjoining state-owned lands is mostly flat to moderately sloping but steepens to in excess of 40 percent in several areas. These areas include steep slopes along the Green River, the flanks of Lizard Mountain, the northern bedrock knob, the flanks of an alluvial terrace in the northern Segale Property, and two closed depressions located in the northern Segale Property and DNR Property 16. Scattered, smaller, localized areas of steep slopes are also found in a few other areas of the Segale and DNR 16 Properties. These smaller steep slope areas are generally less than 20 feet in height and either lie outside of the proposed pit limits or will be completely removed during mining.

- Several shallow landslides were observed during our reconnaissance and are located outside of the Segale Property boundaries along the Green River Gorge or on the flank of Lizard Mountain. No large deep-seated landslide areas were observed during our reconnaissance. Some of the shallow slides extended over heights of up to approximately

40 to 50 feet but all were limited to only a few feet in depth. The slides appeared to be fairly recent and either unvegetated or vegetated by young brushy growth. Three of the slides were co-located with groundwater seepage.

- Barneston Series are the predominant mapped soil unit on the Segale Property at about 78 percent by area. Barneston Series are Hydrologic Group A soils that compose the outwash terraces and terrace escarpments along the property. Arents (Group A) and Beausite (Group C) Series are less prevalent soil types at 2 percent and 10 percent by area, respectively, and are mapped in the southern Segale Property. Chuckanut (Group B) Series soils, covering about 10 percent of property area, are mapped on Lizard Mountain outside of the proposed pit area. Norma (Group B/D) Series are outside the proposed pit area and cover less than 0.1 percent of property area.

- Site stratigraphy generally includes Vashon recessional outwash (Qvr) and ice-contact deposits (Qvic), underlain by discontinuous Vashon lodgement till (Qvt) and Puget Group Bedrock (Tp). The Qvr/Qvic consisted of relatively clean sand and gravel with cobbles and interbeds of unsorted diamicton and boulders. The maximum Qvr/Qvic thickness observed in on-site borings was about 150 feet in EB-7W. The Qvt generally consists of a gray silty diamicton that drapes the irregular pre-glacial topography locally in erosional contact with the underlying sediments and bedrock. The maximum Qvt thickness observed in on-site borings was about 10 feet in EB-8W. The Tp is composed of sandstone, siltstone, shale, and coal which were later folded, faulted, and intruded by igneous andesitic sills and dikes (Ti).

- Site stratigraphy also includes older deposits associated with the pre-Vashon time (Qpv) which were generally observed in bedrock lows and include gray silt, sand, and gravel. The Qpv was identified from radiocarbon dating in EB-7W. The Qpv deposits underlie the Qvr/Qvic and Qvt. The maximum Qpv thickness observed in on-site borings is about 90 feet in EB-7W.

- The youngest naturally occurring deposits identified onsite are alluvium (sand) and underlying lacustrine deposits (silt and clay) localized near Deep Creek, which were observed to be up to about 40 feet thick in EB-10W.

- The youngest earth materials observed onsite are existing fill which was generally up to a few feet in thickness as encountered in explorations. Existing fill is up to several feet in thickness around Lizard Mountain and is associated with historical coal mining.

- Historical coal mining on and near the Segale Property has been documented at three mines and an unknown number of prospects at Lizard Mountain. Mapped underground workings of two mines on the south side of Lizard Mountain are primarily contained within the extent of the mountain. Mapped underground workings on the northern side of Lizard Mountain extend west and north of the mountain beneath flat areas of DNR Property 16 and the eastern Segale Property, respectively. The mapped workings correspond to the Occidental Mine and underlie the eastern Segale Property at depths of 80 to 380 feet below existing grade.

- Drift level coal mines are the primary source of stream flow on two of the seasonal streams flowing off Lizard Mountain, Streams J and L. All streams flowing off of Lizard Mountain infiltrate into the outwash adjacent to the mountain and recharge the groundwater system.

- One primary aquifer has been identified across the site and is termed the regional aquifer. The regional aquifer represents multiple water-bearing intervals between the Qvr/Qvic and the Qpv and is locally confined by Qvt. Groundwater flow is generally to the north and west. Groundwater elevations range from about 800 feet in the southern Segale Property to about 700 feet in the western Segale Property and about 710 feet in the northern Segale Property.

- A perched groundwater zone was encountered in the alluvium above the lacustrine deposits in EB-10W and EB-11W. Perched groundwater elevations in EB-11W have ranged from about 840 to 843 feet, about 45 to 50 feet above the regional aquifer in EB-10W. Perched groundwater elevations in EB-11W are lower than Deep Creek located to the southeast, resulting in northwest groundwater flow in the perched zone towards the Segale Property. Deep Creek provides a seasonally variable amount of recharge to the perched zone. The perched groundwater ultimately recharges the regional aquifer.

- Recharge to the regional aquifer is primarily from infiltration of precipitation either directly or from groundwater flowing downslope along the bedrock surface. Recharge is also sourced from Deep Lake which is in hydraulic connection with the regional aquifer. To a lesser extent, recharge through surface water leakage occurs at Hyde Lake which is situated above the regional aquifer.

- Exploration borings, geophysics, and site reconnaissance indicate significant relief on the underlying bedrock. Bedrock topographic lows were encountered in the northern Segale

Property and southern portion of the western Segale Property. Existing subsurface data indicates that these bedrock lows may be connected by an ancient, buried channel. Alternatively they may be disconnected isolated lows in the bedrock surface.

- Discharge from the regional aquifer occurs as springs along the Green River Gorge and subsurface flow to the Green River north of the Segale Property. Spring flow was monitored on a monthly basis at Streams A, B, and C. The regional aquifer provides spring water to Group A water systems at the Green River Gorge Resort.

- The site is not located within a SSA area or within an assigned TOT of WHPAs for any Group A water systems. The site is located outside of King County's groundwater management areas.

- Private wells withdraw groundwater south and east of the property. The largest cluster is south of the property and includes one Group B well about 1,800 feet from the property. All wells are over 1,000 feet from the proposed pit area. Three private wells are within ¼ mile of the proposed pit extent.

- Water rights were reviewed in the vicinity of the property, including 13 certificates and 6 claims. Segale is not pursuing a water right or a new permit exempt well for the proposed project.

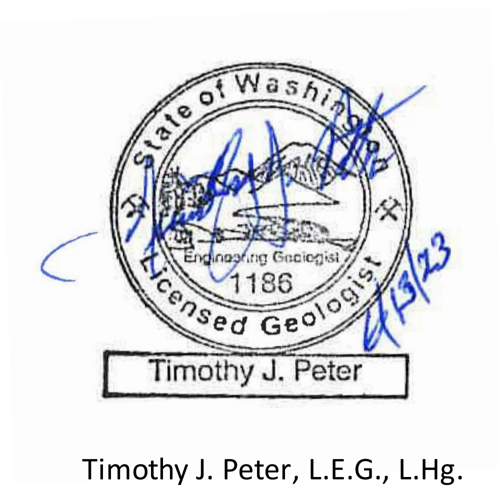
- Water quality data collected for this study indicates groundwater is generally high quality and meets the drinking water (246-290 WAC) and groundwater (173-200 WAC) standards, with a few exceptions. The exceptions are arsenic, iron, manganese, pH, color, conductivity, TDS, and cyanide. Iron, manganese, pH, color, conductivity, and TDS are secondary standards for aesthetic purposes. Detectable oil and grease was measured in groundwater from well B-4. Cyanide and oil and grease were observed in isolated sampling events and were not detected in repeat samples. Consistently high levels of arsenic observed in two of the wells are due to natural processes.

4.2 CLOSING

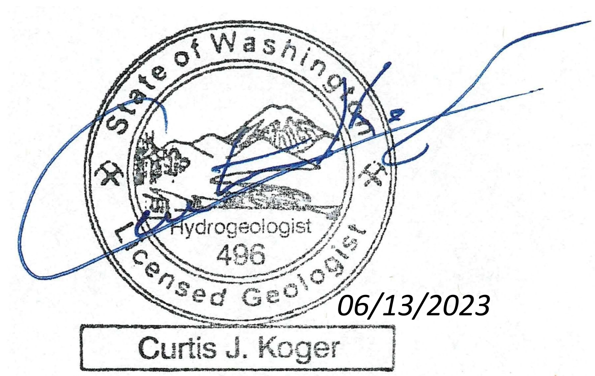
Thank you for the opportunity to work with you on your proposed mining project. We have obtained a significant amount of information necessary to characterize the Affected Environment. If you should have any questions, please do not hesitate to call. We look forward to continuing our hydrogeologic/geotechnical consulting services as the project progresses forward to environmental review.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Kirkland, Washington

Matthew J. Porter, L.G., L.Hg.
Senior Staff Geologist



Timothy J. Peter, L.E.G., L.Hg.
Senior Engineering Geologist



Curtis J. Koger, L.G., L.E.G., L.Hg.
Senior Principal Geologist/Hydrogeologist

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