

**GROUNDWATER HYDROLOGY AND WATER QUALITY ANALYSIS REPORT
FOR THE
IDAHO-MARYLAND MINE PROJECT
NEVADA COUNTY, CALIFORNIA**

March 2020

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TABLE OF CONTENTS

EXECUTIVE SUMMARY VI

1.0 INTRODUCTION 1

2.0 PROJECT DESCRIPTION 3

 2.1 BACKGROUND 3

 2.2 DEWATERING 3

 2.3 UNDERGROUND MINING 4

 2.4 ABOVEGROUND FACILITIES CONSTRUCTION AND OPERATIONS 5

 2.5 CENTENNIAL INDUSTRIAL SITE DEVELOPMENT 5

 2.6 POTABLE WATER PIPELINE 5

 2.7 WATER CONSUMPTION AND SUPPLY 6

 2.8 RECLAMATION & CLOSURE 6

3.0 ENVIRONMENTAL SETTING 8

 3.1 GEOLOGY 8

 3.2 SURFACE-WATER HYDROLOGY 13

 3.3 GROUNDWATER OCCURRENCE 19

 3.3.1 *Regional Groundwater Occurrence within Fractured Bedrock* 19

 3.3.2 *Groundwater Occurrence in Private Domestic Wells in the Project Area* 19

 3.3.2.1 Private Domestic Well Areas 20

 3.3.2.2 Water Level Monitoring in Private Domestic Wells 25

 3.3.3 *Groundwater Occurrence within Mine Workings* 27

 3.3.3.1 Mine Connections to Surface 27

 3.3.3.2 Mine Water Quantities 29

 3.3.3.3 Water Levels in the New Brunswick Shaft 29

 3.3.3.4 Water Levels in the Union Hill Mine 30

 3.3.4 *Groundwater Flow from Drains* 31

 3.3.4.1 ED-1 – Eureka Drain 32

 3.3.4.2 IMD-1 – East Eureka Shaft Drain 32

 3.3.4.3 IMD-2 – East Eureka Shaft 32

 3.3.4.4 D-1 – Unknown Origin 32

 3.3.5 *Bedrock Properties Related to Groundwater Flow* 32

 3.3.6 *Historic Ground Water Inflow in Underground Mine Workings* 35

 3.4 WATER QUALITY 36

 3.4.1 *General Water Chemistry Conditions* 38

 3.4.1.1 Water Chemistry in the New Brunswick Shaft and Drains 38

 3.4.1.2 Surface Water Chemistry 47

 3.4.2 *Water Chemistry Graphical Interpretation* 54

3.4.3	Conceptualization of Groundwater Movement	62
3.4.4	Groundwater Flow in Fractured Bedrock	62
3.4.5	Groundwater Movement in Mine Workings	64
4.0	PROJECT EFFECTS.....	70
4.1	SURFACE WATER RUNOFF	70
4.2	GROUNDWATER LEVELS DURING EXPLORATION AND MINING	71
4.2.1	Dewatering Effects in the East Bennett Area.....	75
4.2.2	Dewatering Effects in Perimeter Areas	78
4.2.2.1	Beaver Drive Area	79
4.2.2.2	Greenhorn Area	82
4.2.2.3	Other Outlying Areas	87
4.2.3	Future Exploration and Mining	90
4.3	POST-MINING GROUNDWATER CONDITIONS.....	91
4.4	MINED MATERIAL GEOCHEMISTRY	92
4.4.1	Barren Rock Used as Engineered Fill.....	93
4.4.2	Sand Tailings Used as Engineered Fill	95
4.4.3	Sand Tailings Used as Underground Cemented Paste Backfill.....	103
4.5	WATER QUALITY.....	103
4.6	DISCHARGE REQUIREMENTS	106
4.7	ADDITIONAL PERMITTING REQUIREMENTS RELATED TO WATER QUALITY	109
5.0	IMPACT ANALYSIS.....	111
5.1	THRESHOLD CRITERIA.....	111
5.2	PROJECT EVALUATION	111
5.3	CONCLUSIONS	121
6.0	REFERENCES	123
7.0	SHEETS	127
8.0	APPENDICES (UNDER SEPARATE COVER)	

LIST OF TABLES

Table 3-1	Existing and Project Peak Flows from Industrial Site Areas	18
Table 3-2	List of Idaho-Maryland Mine Connections to Ground Surface.....	28
Table 3-3	Water Volume Estimates in Stopes	29
Table 3-4	Mine Workings Water Volumes by Depth.....	29
Table 3-5	Water Quality Field Measurements, Drains and Shaft Samples, Idaho-Maryland Mine Project	39
Table 3-6	February Laboratory Analytical Results, Idaho-Maryland Mine Project	41
Table 3-7	December 2018 NPDES Laboratory Analytical Results, Idaho-Maryland Mine Project	44
Table 3-8	Water Quality Field Measurements, Surface Water Sites, Idaho-Maryland Mine Project	48
Table 3-9	April 2019 Laboratory Analytical Results, Idaho-Maryland Mine Project	52
Table 3-10	Streamflow and General Water Quality Parameters, South Fork Wolf Creek (Balance, 2020)	53
Table 4-1	Well Parameters and Potential Effects of Mine Dewatering, East Bennett Area	76
Table 4-2	Well Parameters and Potential Effects of Mine Dewatering, Beaver Drive Area	81
Table 4-3	Well Parameters and Potential Effects of Mine Dewatering, Greenhorn Area	84
Table 4-4	Well Parameters and Potential Effects of Mine Dewatering, Outlying Areas.....	88
Table 4-5	Estimated Daily Barren Rock Production.....	93
Table 4-6	Core Samples Collected by Benchmark Resources.....	93
Table 4-7	Tailings & Barren Rock Samples - Total Metals and DI-WET Results.....	97
Table 4-8	Tailings & Barren Rock Samples - ABA Results	100
Table 4-9	Barren Rock Crushed Core Samples – Total Metals Results.....	101
Table 4-10	Low Threat Discharge Permit Limits, Current Concentrations, and Treatment Goals	108

LIST OF FIGURES

Figure 3-1	Project Area Geologic Map	11
Figure 3-2	Southwest to Northeast Geologic Cross Section from Johnston (1940).....	12
Figure 3-3	Upper Wolf Creek and South Fork Wolf Creek Watershed Map	14
Figure 3-4	Annual Water Year Rainfall in Grass Valley.....	15
Figure 3-5	NID DS Canal Releases to Wolf Creek	16
Figure 3-6	Map of Domestic Supply Wells and Underground Mine Workings	21
Figure 3-7	Comparison of Shaft Water Levels with Rainfall.....	30
Figure 3-8	Pumping Rate (GPM) VS Depth.....	33
Figure 3-9	Transmissivity (Ft ² /day) VS Depth.....	34
Figure 3-10	Distribution of Hydraulic Conductivity with Depth (Todd Engineers, 2007).....	35
Figure 3-11	Changes in EC in Wolf Creek Over Time.....	50
Figure 3-12	Piper Diagram of Water Quality Data	55
Figure 3-13	Stiff Plots for New Brunswick Shaft Samples NBS-265, NBS-900, and NBS-1300.....	56
Figure 3-14	Stiff Plots for New Brunswick Shaft Samples NBS-1600, NBS-2300, and NBS-Pump	57

Figure 3-15	Stiff Plots for Drain Samples – ED-1 and IMD-2 February 2018.....	58
Figure 3-16	Stiff Plots for Drain Samples – IMD-1 February 2018 and April 2019.....	59
Figure 3-17	Stiff Plots for Wolf Creek Samples – WC-Up and WC-Mid December 2018	60
Figure 3-18	Stiff Plots for Wolf Creek Samples – WC-Down December 2018 and WC-Down April 2019	61
Figure 3-19	Stiff Plots for South Fork Wolf Creek Samples – SF Culvert and SF Pad, April 2019	62
Figure 3-20	Groundwater Movement in Mine Workings.....	67
Figure 3-21	Existing Drawdown Profile for New Brunswick Shaft	68
Figure 3-22	Simulated Drawdown of Groundwater Levels under Current Conditions Relative to Pre-Historical Mining Conditions	69
Figure 4-1	Simulated Drawdown of Groundwater Level at the End of Future Mining Relative to 2019 Water Level (Itasca, 2020b).....	74

LIST OF SHEETS

Sheet 1	Project Overview
Sheet 2	Brunswick Industrial Site
Sheet 3	Centennial Industrial Site
Sheet 4	Surface Geology
Sheet 5	Geology 1000 Level
Sheet 6	Geology 2000 Level
Sheet 7	Geology 3300 Level
Sheet 8	Underground Mine Workings
Sheet 9	Underground Mine Workings Within 600 ft bgs
Sheet 10	NCE Pre-Development Hydrology Map (H-3) - Brunswick Site
Sheet 11	NCE Pre-Development Hydrology Map (H-1)- Centennial Site
Sheet 12	Domestic Wells - Locations and Projected Drawdown
Sheet 13	Domestics Wells – Long Section
Sheet 14	Domestic Wells – Cross Section
Sheet 15	Planned Underground Mining – Base Case

LIST OF APPENDICES

Appendix A	Analytical Model Output
Appendix B	Idaho-Maryland Mining Corporation (IMMC) Hydrographs
Appendix C	Laboratory Analytical Reports – Water Sampling
Appendix D	Laboratory Analytical Reports - Geochemistry
Appendix E	Drill Core Photos: Rise Drillhole B-17-01
Appendix F	Drill Core Photos: Rise Drillhole B-18-04
Appendix G	Drill Core Photos: Rise Drillhole Z-18-09 (labelled Z-18-02)
Appendix H	McClelland Metallurgical Testing Report

GROUNDWATER HYDROLOGY AND WATER QUALITY ANALYSIS REPORT FOR THE IDAHO-MARYLAND MINE DEWATERING PROJECT NEVADA COUNTY, CALIFORNIA

EXECUTIVE SUMMARY

Rise Grass Valley, Inc. (Rise) proposes to reinitiate underground mining at the Idaho-Maryland gold mine, which has been closed since 1956 and is currently flooded with groundwater. This Groundwater Hydrology and Water Quality Analysis Report has been prepared by EMKO Environmental, Inc. (EMKO) to support Rise's application to Nevada County for approval of a Conditional Use Permit and Reclamation Plan to re-open, operate, and reclaim the mine (referred to as the "Project"). The Project would include the following primary actions:

- Dewatering of the existing underground mine workings, with treatment of the pumped water and discharge to South Fork Wolf Creek;
- Mining existing and new underground workings within the Mineral Lease Boundary;
- Processing gold mineralization and related rock;
- Placing engineered fill, consisting of barren rock and sand tailings, at the Brunswick and Centennial Industrial Sites; and
- Export of engineered fill from the Brunswick Industrial Site to support local construction projects.

The Conditional Use Permit and Reclamation Plan application proposes to allow:

- Operation of pumps and a water treatment facility to dewater the underground workings;
- Construction of a water pipeline to transport treated water to an outfall located in South Fork Wolf Creek;
- Construction of the necessary aboveground facilities at the Brunswick Industrial Site (e.g., headframes and hoists, surface structures, a mineral processing plant) to support underground mining and mineral processing;
- Construction of a new service shaft and ventilation shaft from the underground mine to surface at the Brunswick Industrial Site;
- Underground mining, including drilling, blasting, and ore removal;
- Ore and rock processing at the Brunswick Industrial Site and off-site transport of gold concentrate;
- Transport of engineered fill from the Brunswick Industrial Site and placement at the Centennial Industrial Site;
- Transport of engineered fill from the Brunswick Industrial Site to off-site customers;
- Placement of engineered fill at the Brunswick Industrial Site; and
- Construction of a potable water pipeline to residences along a portion of East Bennett Road.

The majority of aboveground facilities will be located on the 119-acre Brunswick Industrial Site. Ore processing would not involve the use of mercury or cyanide.

The Project site is located in the northern Sierra Nevada foothills, which have a lengthy and complex geologic history. There are several historic mines within the Project, including the Brunswick, Union Hill, Eureka, Idaho, and Maryland mines. The Brunswick and Union Hill mines occur within a metamorphosed andesitic volcanic unit known as the “Brunswick Porphyrite Block”. The other historic mines are located around the northern contact of the porphyrite block within mafic igneous and metamorphic rocks referred to as gabbro and serpentinite. The underlying rock types have some effect on existing water quality. The quality of the water that percolates through these different rock types in the engineered fill would also be potentially affected by the mineralogy of the rocks within the fill.

As part of the Project, water would be pumped from the existing underground workings at a rate up to 5.6 cubic feet per second (cfs), or about 2,500 gallons per minute (gpm) until the mine is dewatered. After initial dewatering, dry conditions in the mine would be maintained by pumping an average of 1.9 cfs, or about 850 gpm. The pumped water would be discharged to South Fork Wolf Creek. EMKO performed water quality testing of groundwater currently flooding the mine workings, water flowing from drains connected to the historic mines, and surface flows in Wolf Creek and South Fork Wolf Creek. Existing surface water meets applicable water quality criteria and is not adversely affected by the historic mining. Water within the underground workings already meets most water quality standards, with the primary exception of iron and manganese. A treatment plant will be constructed and operated to reduce the iron and manganese, and potential other trace constituents, to allowable levels prior to discharge. Treatment would occur under the requirements of the California Regional Water Quality Control Board (RWQCB) Low Threat Discharge Permit applicable to Tier 3 discharges from hard rock mines. Conventional water treatment processes, effective for the constituents of concern, are well understood and have been validated over years of application in facilities worldwide (Linkan, 2019).

EMKO and Itasca (2020b) evaluated the effects of mine dewatering on domestic water wells above the underground mine workings using analytical and numerical methods, respectively. The existing underground workings discharge water to Wolf Creek through several drains near Centennial Drive. The overall discharge rate is approximately 60 gpm to 125 gpm (0.13 cfs to 0.28 cfs), while the base flow in Wolf Creek may be 25 cfs to 30 cfs. The discharge from the drains is drawn from shafts that extend above the groundwater surface and act as wells that lower the groundwater surface over the area of the existing mine workings. Numerical modeling indicates that the current groundwater elevation in the area overlying the mine workings between East Bennett Drive and Idaho Maryland Road has been lowered up to 10 feet by the existing drainage through the mine workings (Itasca, 2020b).

EMKO evaluated aquifer properties within the fractured bedrock based on review of numerous well completion reports available from the California Department of Water Resources. The available data indicate that the hydraulic conductivity and transmissivity of the fractured bedrock decrease substantially with depth. The decreasing trend in aquifer properties with depth indicates that during dewatering, approximately 99 percent of the water will be pumped from the upper 550 feet of the mine workings, while most of the future mining will occur below a depth of 1,000 feet. Evaluations by EMKO and Itasca (2020b) indicate that in outlying areas, away from the current underground workings, drawdowns in existing wells will typically be less than a few feet, and appreciably less than the normal seasonal fluctuations in the water table of 20 feet to 50 feet per year. However, in the area overlying many of the

current underground workings, between East Bennett Road and Idaho Maryland Road, the additional drawdown could be up to 10 feet, in addition to the existing drawdown due to drainage through the existing shafts. To address any potential loss of well capacity in this area, Rise will install a pipeline under East Bennett Road that will be connected to the NID potable water system. Rise would connect any affected well owner to the potable system at no cost to that party.

Geomorphology evaluations of South Fork Wolf Creek (Balance, 2020) indicate that the base flow may be as low as 0.17 cfs. Dewatering of the mine could reduce the base flow by 0.1 cfs by decreasing the amount of groundwater that discharge to the creek (Itasca, 2020b). However, this reduction in base flow would be offset by discharge of 1.9 cfs to 5.6 cfs of treated water. Balance (2020) also determined that erosion and sedimentation within South Fork Wolf Creek would not occur at flows below 23 cfs. Thus, addition of up to 5.6 cfs during base flow conditions would not affect the streambed. During higher flows, the peak runoff in South Fork Wolf Creek would be reduced by appreciably more than 5.6 cfs by a storm water detention pond to be constructed on the Brunswick Industrial Site (see additional details in the next paragraph). Reduction in the base flow of Wolf Creek would be approximately 0.75 cfs (Itasca, 2020b), which is a very small fraction of the existing base flow.

As part of the Project, Rise proposes to construct storm water detention ponds to collect runoff from the engineered fill areas on both the Centennial and Brunswick Industrial Sites. The storm water detention facilities are designed to contain peak flows during storm events and allow the water to be released at a lower rate after peak flows in the creeks have passed. The detention pond at the Brunswick site is designed to reduce peak storm flows below those that currently leave the same site area by over 48 cfs for the 2-year storm, by over 60 cfs for the 10-year storm, by over 40 cfs for the 25-year storm, and by over 25 cfs for the 100-year storm. Therefore, the flow in South Fork Wolf Creek would not be increased during storm events despite the addition of treated mine discharge of up to 5.6 cfs to the creek flow. The detention pond at the Centennial Industrial Site would reduce peak storm discharges to Wolf Creek by 25 cfs to 60 cfs below existing flows. The reduction in peak storm flows would also enhance the capacity of existing storm drain facilities under the City of Grass Valley.

As part of the Project, Rise will need to comply with a wide range of regulatory requirements and obtain several regulatory permits, besides County approval of a Conditional Use Permit and Reclamation Plan. These requirements and permits include preparation of Storm Water Pollution Prevention Plans in accordance with the Construction and Industrial General Storm Water Permits, obtaining a Clean Water Act 404 permit for the treated water discharge, along with related Streambed Alteration Agreement, which would prevent the release of pollutants, including sediment, prevent erosion, and prevent flood flows from being impeded or redirected, within both Wolf Creek and South Fork Wolf Creek. A Clean Water Act Section 401 Water Quality Certification will also need to be obtained from RWQCB to verify that the project complies with applicable water quality standards. Preparation of a Report of Waste Discharge (RoWD) and issuance of a Waste Discharge Requirements permit (WDRs) by the RWQCB will ensure that water quality is protected, and applicable standards are met for the engineered fill areas. These additional permits and regulatory requirements are necessary for the Project to move forward after the Conditional Use Permit and Reclamation Plan are approved. Thus, they are part of the Project and not mitigation measures. As such, compliance with these permits and requirements will prevent or

mitigate potentially significant environmental impacts related to hydrology and water quality, based on California Environmental Quality Act (CEQA) Appendix G criteria.

1.0 INTRODUCTION

Rise Grass Valley Inc. (Rise) proposes to reinitiate underground mining and ore processing of the Idaho-Maryland Mine in unincorporated Nevada County (County). The proposed facilities and operations will be located on two properties owned by Rise referred to as the Centennial Industrial Site and the Brunswick Industrial Site. The project comprises four primary elements: (1) dewatering the existing underground mine workings, (2) mining existing and new underground mine workings, (3) processing ore and rock, and (4) placing engineered fill at the Centennial and Brunswick Industrial Sites. Rise is seeking approval of a new use permit and reclamation plan to build and operate the facilities for these project elements. This use permit and reclamation plan proposes to allow:

- operation of pumps and a water treatment facility to dewater the underground workings;
- construction of a water pipeline to transport treated water to an outfall located in South Fork Wolf Creek;
- construction of the necessary aboveground facilities at the Brunswick Industrial Site (e.g., headframes and hoists, surface structures, a mineral processing plant) to support underground mining and mineral processing;
- construction of a new service shaft and ventilation shaft from the underground mine to surface at the Brunswick Industrial Site;
- underground mining, including drilling, blasting, and ore removal;
- ore and rock processing at the Brunswick Industrial Site and off-site transport of gold concentrate;
- transport of engineered fill from the Brunswick Industrial Site and placement at the Centennial Industrial Site;
- transport of engineered fill from the Brunswick Industrial Site to off-site customers;
- placement of engineered fill at the Brunswick Industrial Site; and
- construction of a potable water pipeline to residences along a portion of East Bennett Road.

The majority of aboveground facilities, including the treated water outfall structure and engineered fill placement, will be located on the 119-acre Brunswick Industrial Site. Engineered-fill placement will also occur on the 56-acre Centennial Industrial Site. Of the total 175 acres in surface land holdings, approximately 104 acres will be disturbed as a result of construction of the facilities proposed to support dewatering, mining, and processing at the Idaho-Maryland Mine. However, most of this acreage has already been disturbed by prior mining and other industrial activities, with paved surfaces and compacted soils present in many areas. In addition, Rise owns approximately 2,585 acres of subsurface rights that encompass the historic Idaho-Maryland Mine workings. Once the aboveground facilities are constructed, Rise will begin dewatering the mine, performing advanced exploration, and mining the underground workings.

The purpose of this report is to provide an analysis of hydrology and water quality conditions for the proposed project. This technical report provides a description of existing environmental setting, or baseline conditions, as well as a discussion of conditions that would occur as a result of the project, relative to hydrology and water quality. This report has been prepared to provide the appropriate

technical data and evaluations to support the environmental review of the proposed project under the California Environmental Quality Act (CEQA).

Section 2.0 of this report provides a summary of the proposed project. Section 3.0 describes the environmental setting. Section 4.0 includes a discussion of conditions that would occur as a result of the proposed project. Section 5.0 provides an analysis of potential environmental impacts based on Appendix G of the CEQA Guidelines, as amended in December 2018.

2.0 PROJECT DESCRIPTION

2.1 Background

The Idaho-Maryland Mine is a historic, past-producing, underground gold mine. The mine produced 2,414,000 ounces of gold between 1866 and 1956. The mine has been inactive since its closure in 1956 and was inactive for several periods during its production period. In 1901 the mine was allowed to flood with water, and then the mine was dewatered in 1904. In 1914 it was again allowed to flood, and then it was dewatered in 1919. The mine was allowed to flood again after its final closure in 1956.

During its operation, the Idaho-Maryland Mine was one of California's and the United States' most important mines. In 1941, the mine employed approximately 1,000 workers and was California's largest lode gold mine and the United States' second-largest lode gold mine by annual production. The Idaho-Maryland Mine encompasses an extensive system of 73 miles of underground tunnels, many raises, four inclined shafts, and two vertical shafts. The historic mining operation had extensive surface infrastructure adjacent to the Centennial Industrial Site and at the Brunswick Industrial Site, most of which has been dismantled and removed.

The Idaho-Maryland Mine has three distinct sections (Idaho #1, Idaho #3, and Brunswick Mines), which are connected by underground workings. The Union Hill mine is a smaller mine that was closed in 1918 and has been flooded with groundwater since then. The Union Hill mine is not connected to the Idaho-Maryland Mine, but is near the Brunswick Mine. The ore veins of the Union Hill Mine are believed to be part of the Brunswick vein system. Rise Gold is proposing to dewater the Idaho-Maryland Mine, but not the Union Hill Mine.

In 1995, in an effort to reopen the Idaho-Maryland Mine, Emgold Mining Corporation acquired a use permit from Nevada County to dewater the mine. This permit was allowed to expire and no work was completed on the dewatering project. In 2005, Emgold submitted an application to the City of Grass Valley to dewater the Idaho-Maryland Mine and restart mining and processing operations. Between 2005 and 2011, the City of Grass Valley implemented environmental review of the application consistent with the California Environmental Quality Act. Emgold subsequently abandoned the use permit application because it could not pay the fees required for continued processing. Rise has no affiliation with Emgold.

2.2 Dewatering

Activities necessary to dewater the Idaho-Maryland Mine would take place using access provided by the New Brunswick shaft to the underground workings. Currently, groundwater has filled the underground workings to approximately 260 feet below ground surface at the location of the New Brunswick shaft. The groundwater must be removed to access the underground workings for mining. The Idaho-Maryland Mine encompasses a system of underground tunnels, many raises, numerous winzes, four inclined shafts, and two vertical shafts. An estimated equivalent of 72.8 miles (117km) of underground tunnel occur at the I-M Mine, assuming typical drift dimensions of 7.5ft x 8.5ft (W x H). (AMEC 2017)

Initial dewatering of the underground workings would be accomplished using a submersible pump. The pumping rate to dewater the existing underground workings is anticipated to be approximately 5.6 cubic feet per second (cfs), or about 2,500 gallons per minute (gpm). Approximately 2,500 acre-feet¹ (approximately 815 million gallons) of water would be pumped from the underground workings over an approximately 6-month period. The water would be pumped via a pipeline to an existing 40 acre-foot clay-lined settling pond (Vector, 1989) on the project site for treatment prior to discharge.

After treatment, the water would be pumped from the site water treatment area across land owned by Rise to a discharge point located along South Fork Wolf Creek. The discharge location is identified on Sheets 1 and 2. Discharge would occur in compliance with the conditions of a National Pollutant Discharge Elimination System (NPDES) permit, which would be obtained from the California Regional Water Quality Control Board, Central Valley Region (RWQCB). Sheets 1 and 2 shows the treated water pipeline route and approximate location of the outfall structure.

2.3 *Underground Mining*

Exploration and mining of the underground workings would begin once dewatering is complete.

To provide access to the gold ore, an extensive network of tunnels and raises will be constructed throughout the life of the mine. These tunnels are constructed in the nonmineralized rock, which, at the mine, is typically meta-andesite volcanic rock. Mine development in nonmineralized “barren” rock (i.e. nongold bearing) is expected to result in the production of approximately 500 tons per day (182,500 tons per year) of barren rock. The barren rock will be transported from the tunnel face to the mine shaft (using electric or diesel-powered load/haul/dump vehicles, rail cars, and/or conveyors) to underground rock bins located adjacent to the shaft. The rock will then be loaded into the shaft skips, hoisted to the surface, and dropped into one of the compartments of the concrete silo located on the surface. The barren rock will then be transported by trucks on the surface for use as engineered fill.

Ore production through tunneling and long-hole blasting produces 1,000 tons per a day (365,000 tons per year) of ore. Approximately 50 percent of the ore will be returned to the underground mine as backfill after processing and the remainder will be used for engineered fill on the Centennial and Brunswick Industrial Sites.

Blasting would occur using ammonium nitrate fuel oil (ANFO) and/or bulk emulsion explosives. Small capacity explosives magazines would be located underground to store explosives consistent with federal, state, and local requirements.

Groundwater is anticipated to continue to seep into the underground workings at a rate averaging approximately 1.9 cfs, or 850 gpm, once initial dewatering is complete. Operational dewatering during exploration and mining would require the use of centrifugal pumps and sumps at various elevations during the production life of the mine. Similar to the initial dewatering effort, groundwater would be pumped

¹ An acre-foot is the volume of water that would cover an area of one acre to a depth of one foot. It is equivalent to 43,560 cubic feet or approximately 326,000 gallons.

to the clay-lined settling pond for treatment, prior to discharge to South Fork Wolf Creek in compliance with the NPDES permit.

Mining of ore creates voids that must be filled as mining progresses to ensure the stability of the underground workings. Sand tailings produced by mineral processing on the surface will be blended with cement and water and pumped back into the mine to backfill mined voids. Approximately 50 percent of the sand tailings (500 tons per day) will be placed underground as cemented paste fill.

2.4 Aboveground Facilities Construction and Operations

To support dewatering and underground mining, aboveground structures and processing facilities will need to be constructed and installed. As shown on Sheet 2, approximately 15 acres of previously disturbed land on the northeast side of the Brunswick Industrial Site will be graded to construct the ventilation system, headframe and hoist, water treatment plant, collar replacement, mineral processing plant, and service shaft. Site grading will create a flat pad with a 1- to 2-percent grading towards a storm drain system and detention pond to collect sheet flow. Areas will be covered with asphalt or concrete as necessary to support facilities construction.

2.5 Centennial Industrial Site Development

The 56-acre Centennial Industrial Site was historically used by the Idaho-Maryland Mine to deposit mine tailings. These mine tailings were never compacted. Some of the materials used to build the tailings berm and small quantities of gold ore brought in from other mines in the region by the historic operator for processing contains elevated metals. As a result, under existing conditions, the majority of the property cannot be developed because of unstable soils and/or contamination. Rise is working with the California Department of Toxic Substances Control (DTSC) to develop a plan that consolidates and caps the contaminated soils in a manner consistent with current federal and state regulations.

Rise will use the engineered fill generated as waste by-product of the gold mining process described above to fill and grade the Centennial Industrial Site. The fill and grading activities will disturb approximately 44 of the 56-acre Centennial Industrial Site. The remaining 12 acres will be avoided, which includes Wolf Creek, a minimum approximately 100-foot setback, and special-status plant species.

2.6 Potable Water Pipeline

A buried potable water pipeline will be added to provide water to residences along a portion of East Bennett Road. The existing NID potable water pipeline will be extended on East Bennet Road to provide potable water service to residences currently on wells that may be affected by the project.

The pipeline will be installed within the County right-of-way and stubbed at the property owner's property boundary in a location designated by the County. If the property owner decides to connect to the potable water line, Rise will fund the permitting and construction costs.

2.7 Water Consumption and Supply

The Idaho-Maryland Mine will have a surplus of water from the natural groundwater flow into the underground workings. Once dewatering is completed, approximately 1.9 cfs, or 850 gpm (approximately 1,224,000 gallons per a day), are estimated to be pumped to the surface and settling pond. This water will support non-potable project-related water demand (i.e., mining and processing activities). The ore processing plant will run on a closed circuit.

Groundwater consumed during operations is estimated to be 123,000 gallons per day. Water consumption includes water vapor in ventilation air, cemented paste backfill, concentrates and engineered fill, and dust control and compaction of engineered fill. The following list provides a description of project elements consuming groundwater:

- **Underground mining service water:** This includes water use for dust suppression in rock drills and blasted rock piles, which is piped into the mine workings. No net consumption of water will result from these activities because water in underground workings is pumped to the surface for reuse.
- **Water Vapor in Ventilation:** Ventilation air flow through the mine working will become saturated with water vapor, consuming approximately 40,000 gallons per day of water.
- **Cemented Paste Backfill:** Water is needed to transport and bind the cemented paste backfill underground. This water is permanently retained in the backfill or used in the hydration of cement. Backfilling will consume approximately 20,000 gallons of water per day, assuming a 15 percent water content by mass and 500 tons per day of backfill placed.
- **Gold Concentrates and Engineered Fill:** Concentrates and engineered fill shipped off-site will contain approximately 24,000 gallons of water per day.
- **Dust Control and Compaction:** Active fill areas and unpaved surfaces require water to control fugitive dust and engineered fill placed at the Brunswick Industrial Site must be compacted to meet design standards. These activities are estimated to consume up to 42,000 gallons per day of water.

An average of approximately 5,700 gallons per day of potable water will be purchased from NID through already-existing connections for sinks, toilets, and showers installed in buildings at the Brunswick Industrial Site.

Water needed for compaction and dust suppression during activity at the Centennial Industrial Site will be purchased from NID. Approximately 42,000 gallons of water per day may be required for dust suppression and compaction. Compacting 8 hours per day and 5 days per week requires water service of up to 125 gallons per minute.

2.8 Reclamation & Closure

Upon completion of underground mining, access to underground workings will be closed consistent with federal and state regulations. Upon completion of aboveground ore processing and off-site sale of engineered fill, the Brunswick Industrial Site will be reclaimed. A majority of the aboveground facilities and structures will remain to support the site's postmining industrial land use. All paved surfaces,

including access roads, parking areas, and driveways, will remain to facilitate access to the site and buildings. The Brunswick and Centennial Industrial Sites fill slopes will be revegetated with an erosion-control seed mix to reduce erosion and maintain fill slope stability. The fill pads will be maintained until they are used or sold for future industrial purposes.

Dewatering would cease and the underground workings would be allowed to fill back up with groundwater.

3.0 ENVIRONMENTAL SETTING

The existing environmental setting is described in this section. The environmental setting provides the information to identify baseline conditions for comparison with Project effects (Section 4.0) in the impact analysis (Section 5.0).

3.1 Geology

The project site is located in the northern Sierra Nevada foothills, which have a lengthy and complex geologic history, much of which has been described by Johnston (1940) and Clark (1976). Additional information regarding geologic conditions in the Project area is provided by Kulla (2017). The information described below has been summarized from these references.

The northern Sierra Nevada foothills are part of a belt of metamorphic rocks that extends approximately 180 miles from the area of Yosemite Valley to north of Nevada County. The metamorphic belt is approximately 20 to 40 miles wide, being bounded on the east by granitic intrusive rocks of the Sierra Nevada batholith and plunging beneath younger sedimentary rocks of the Central Valley on the west. (Clark, 1976)

The rocks within the metamorphic belt were initially deposited as sedimentary and volcanic rocks in the Paleozoic and Mesozoic eras. The sedimentary and volcanic rocks were deposited in a subsiding sea adjacent to an island arc terrain that formed due to subduction of the Pacific tectonic plate beneath the North American tectonic plate. Tectonic activity, including compression, the intrusion of granodiorite as part of the Sierra Nevada batholith, and faulting, caused the sedimentary and volcanic rocks to undergo regional and contact metamorphism. In the project area, the rocks are part of an unnamed metamorphic complex located to the west of the more well-known Calaveras Complex (or Formation) and Shoo Fly Formation. Following uplift and erosion of the Sierra Nevada, Tertiary volcanic and volcanoclastic deposits were deposited over the eroded surface of the metamorphic belt. Subsequent erosion has removed areas of the Tertiary volcanic and volcanoclastic deposits, exposing the underlying older metamorphic and intrusive rocks. (Clark, 1976).

The general near-surface stratigraphy in the project area is summarized as follows:

At or near surface – Quaternary – Soils, sand, sand, and gravel deposits formed during recent, post glacial weathering and erosion.

At or near surface – Tertiary – In areas where erosion has not exposed the older bedrock, tertiary deposits remain. The principal rock types of the Tertiary formation are rhyolite, rhyolite tuff and breccia, andesite, andesite tuff, breccia, and mud flows; and interbedded stream sands and gravels. In places, the tertiary rocks cover older deposits of sand, gravel, and weathered bedrock. (Johnston, 1940)

Near surface – Weathered Rock – A zone of weathered bedrock extends to depths of approximately 100 – 120 feet below surface. The weathered bedrock is highly broken and oxidized. The contact between weathered and unweathered bedrock is distinct and typically grades from oxidized rubble into highly fractured rocks and into solid and competent bedrock. Photos of Rise drillholes in the Brunswick and Union

Hill areas illustrating the weathered rock zones are displayed in Appendix E-G. Rise compiled geology from mapping presented by Johnston (1940), historic geological mapping of the underground mine workings, and recent core drilling. Figure 3.1 shows generalized geological units in relation to the mineral claims. More detailed geological plans prepared by Rise are provided in Sheets 4-7.

The Brunswick and Union Hill mining areas occur within meta-andesite rocks, which is a metamorphosed andesitic volcanic unit. The degree of metamorphism may vary in this unit, such that parts of it have been referred to as amphibolite schist, porphyrite, diabase, and quartz porphyrite (Johnston, 1940, Plate 1). This metamorphic unit is referred to as the “Brunswick Porphyrite Block” for the purposes of this study.

The Eureka, Idaho, and Maryland mine areas are mostly located on the contact of the Brunswick block and within mafic intrusive and metamorphic rocks, including gabbro and serpentinite. The gabbro and serpentinite tend to form a band around the northwest end of the Brunswick Porphyrite Block, as shown on Figure 3.1.

To the east of the Brunswick Porphyrite Block are fine-grained metasediments (slates, argillites) of the Mariposa Formation. Younger, tertiary andesite volcanic rocks are present to the east and southwest of the Brunswick Porphyrite Block. Based on geological mapping and well log information (see Section 3.3.2), the tertiary andesite deposits are typically less than a few hundred feet thick, forming a relatively thin mantle that obscures the underlying bedrock geology and faulting.

In mineralized areas quartz fills faults, fractures, and fracture zones. The gold-bearing quartz veins strike in all directions and range from horizontal to vertical. Gold is hosted in discrete veins and in stockworks consisting primarily of massive to banded, sheared, and brecciated milky white quartz \pm carbonate. Gold occurs as native gold, ranging from very fine grains to large nuggets within the quartz. Sulfide minerals from 1% to 4% are commonly associated with gold mineralization. Sulfides are primarily pyrite with lesser galena and chalcopyrite. Pyrite is the dominant accessory mineral and constitutes up to 2% of the vein mineralization. Sphalerite and arsenopyrite are rarely observed. Scheelite is common in the Union Hill area of the Brunswick veins. Gangue minerals include quartz, carbonate (ankerite, calcite, dolomite, and ferrodolomite), sericite, chlorite, mariposite, and albite. Ankerite is a common alteration mineral and may occur in the mafic and ultra-mafic rocks and the meta-volcanic rocks. The mineralized wallrock is strongly carbonate altered (AMEC, 2017).

Important ore controls at the Idaho-Maryland and Brunswick deposits bound the Brunswick Block on the East, North, and West side of the Brunswick Block. The information discussed below is summarized from AMEC (2017).

Idaho Fault Zone

The Idaho Fault Zone lies along the northern boundary of the Brunswick Block as a continuous fault system and is a major control of the Idaho-Maryland gold mineralization. The fault zone is poorly exposed on surface but is intersected in much of the underground workings. The zone strikes 275° to 290° and dips 60° to 70° south, possibly shallowing with depth, and is interpreted to have reverse movement. The Idaho fault zone is traceable underground for 3 km along strike and is shown on mine level plans down to I2700

level, a vertical depth of 3,000ft (914m). At the western end it is a single fault on the footwall of a diabase dike separating the Brunswick Block from gabbro and serpentinite to the north. In the eastern area of the mine the Fault splits into several main, and minor branches. The fault in the eastern area is also associated with a diabase dike on the outside margin of the Brunswick Block and is comprised of both linear and non-linear fault members. The non-linear faults are sigmoidal link faults that trend north-easterly, dipping 20° to 40° SE.

The Idaho fault zone is generally associated with the diabase dikes within the serpentinite, but fault splays are known to intersect the Brunswick Block. Post-mineral reactivation of the faults reportedly shows 15 m of normal displacement in some cases.

6-3 Fault Zone

The 6-3 Fault forms the eastern termination of the Brunswick Block and is a major control on the gold mineralization hosted within the Brunswick Block. The 6-3 Fault is poorly exposed on surface but is intersected in many underground workings and drill holes. The fault strikes 330° to 350°, dipping 70° NE and is interpreted as a reverse fault. No significant gold mineralization is noted within or east of the 6-3 Fault.

The Morehouse Fault

The Morehouse Fault lies on the southwestern margin of the Brunswick Block and is a control on mineralization. It has been intersected in underground workings and drilling but is not well exposed on surface. Underground it is represented by several fault intersections and veins, such as the Morehouse, 16, and 52 Veins, that suggest it strikes northwesterly and dips around 40 degrees NE. Slickensides and mullions suggest reverse movement. The relationship between the Morehouse and Idaho fault systems is unclear. The Morehouse fault may splay into to the Idaho Fault in a northwesterly direction or may follow the westerly nose of the Brunswick Block in an arc to merge into the E-W trending Idaho fault. The easterly trend and orientation of the Morehouse fault is not well known due to limited drilling and underground development on the southern side of the Brunswick Block, and due to the poor surface expression of these faults. Bateman has suggested the Morehouse structure may continue easterly to the 6-3 Fault and to depth until it intersects the Idaho fault.

Figure 3-1 Project Area Geologic Map

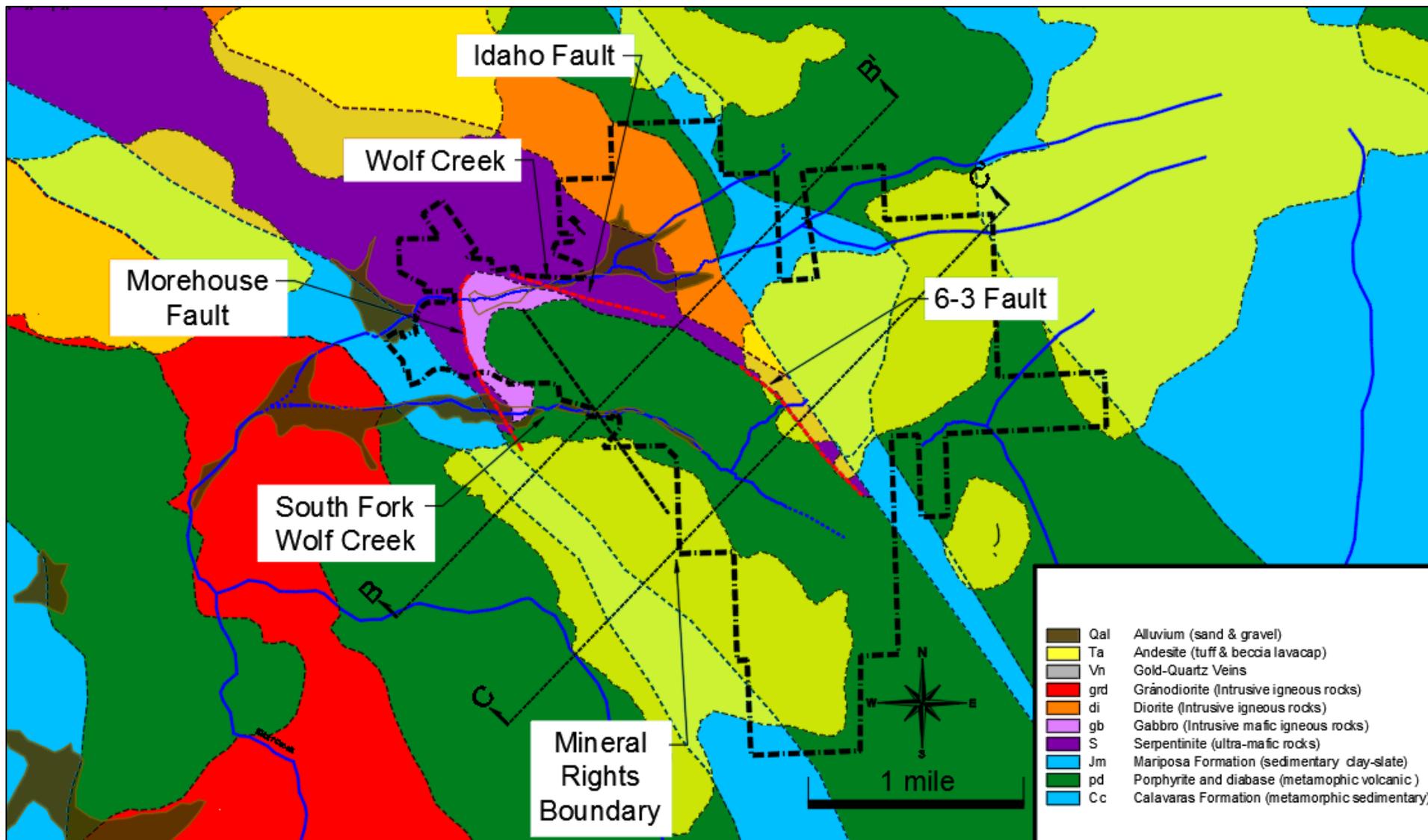


Figure 3-2 Southwest to Northeast Geologic Cross Section from Johnston (1940)

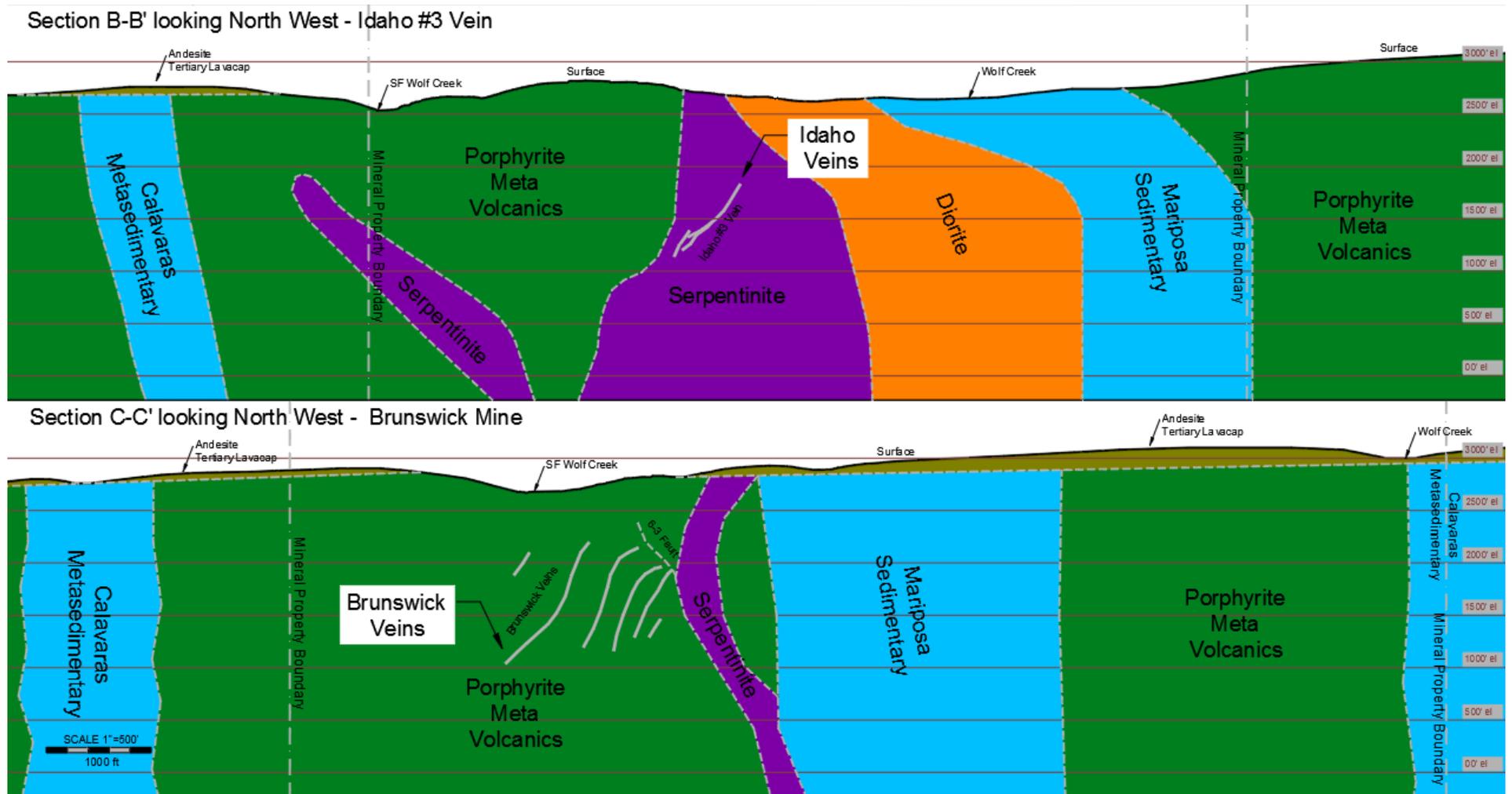


Figure 3.2 presents a series of geologic cross sections compiled by Rise based on mapping and cross sections presented by Johnston (1940) and field data obtained as part of subsurface investigation for this Project. The section lines are shown on Figure 3.1. The Brunswick Porphyrite Block is shown in green to the northeast of the Calaveras metasedimentary deposits. The cross sections illustrate the relationship between the porphyritic metavolcanics that are the primary lithology hosting the Brunswick veins with the serpentinite unit, which is the primary lithology hosting the veins of the Idaho #1 and Idaho #3 Mines. The Tertiary andesite deposits are also depicted as a thin, horizontal mantle capping the underlying near-vertical metamorphic rocks.

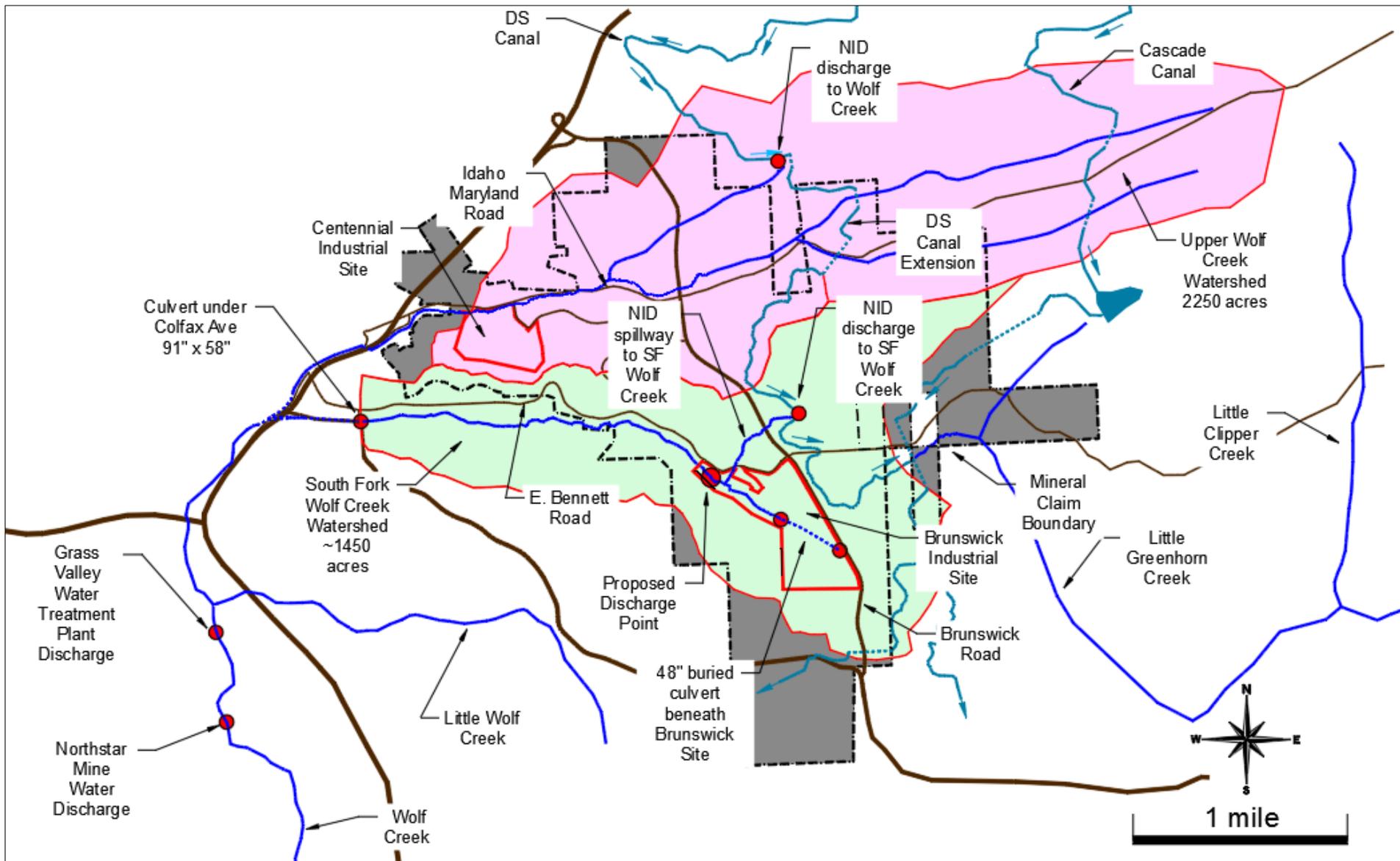
As discussed further in Section 3.4, the different mineral content of the varying metamorphic rock types in the project area can influence the chemical signature of the dissolved solids in groundwater and surface water. For example, minerals that may occur in mafic rocks such as serpentinite and gabbro, such as certain minerals in the olivine, pyroxene, and serpentine groups, may contain high proportions of magnesium (Heinrich, 1965). On the other hand, minerals that may occur in more intermediate meta-volcanic rocks, such as the meta-andesite porphyry, may contain higher proportions of calcium, including some pyroxene and feldspar minerals (Heinrich, 1965). Rise also reports the occurrence of many calcite veinlets throughout the Brunswick Porphyrite Block (personal communication, electronic mail message from Ben Mossman to Andy Kopania, February 27, 2019). Calcite consists of calcium and carbonate. Recent test work on core samples from the meta-andesite rocks confirm high carbonate content with net neutralization potentials of approximately 200 tons CaCO₃ per 1000 tons of solids (see discussion in Section 4.5). Thus, variations in the calcium, magnesium, and carbonate content from different sample locations can provide an indication of the host rock through which groundwater has passed.

3.2 Surface-Water Hydrology

The project site is located within two watershed areas. The Upper Wolf Creek watershed is the larger of the two, encompassing approximately 2,250 acres upstream from the western end of the Centennial Industrial Site. The southeast part of the project area is within approximately 1,450 acres of the South Fork Wolf Creek watershed upstream of a culvert where the creek passes underneath part of the City of Grass Valley. Figure 3.3 and Sheet 1 shows an overview of the Upper Wolf Creek and South Fork Wolf Creek watersheds.

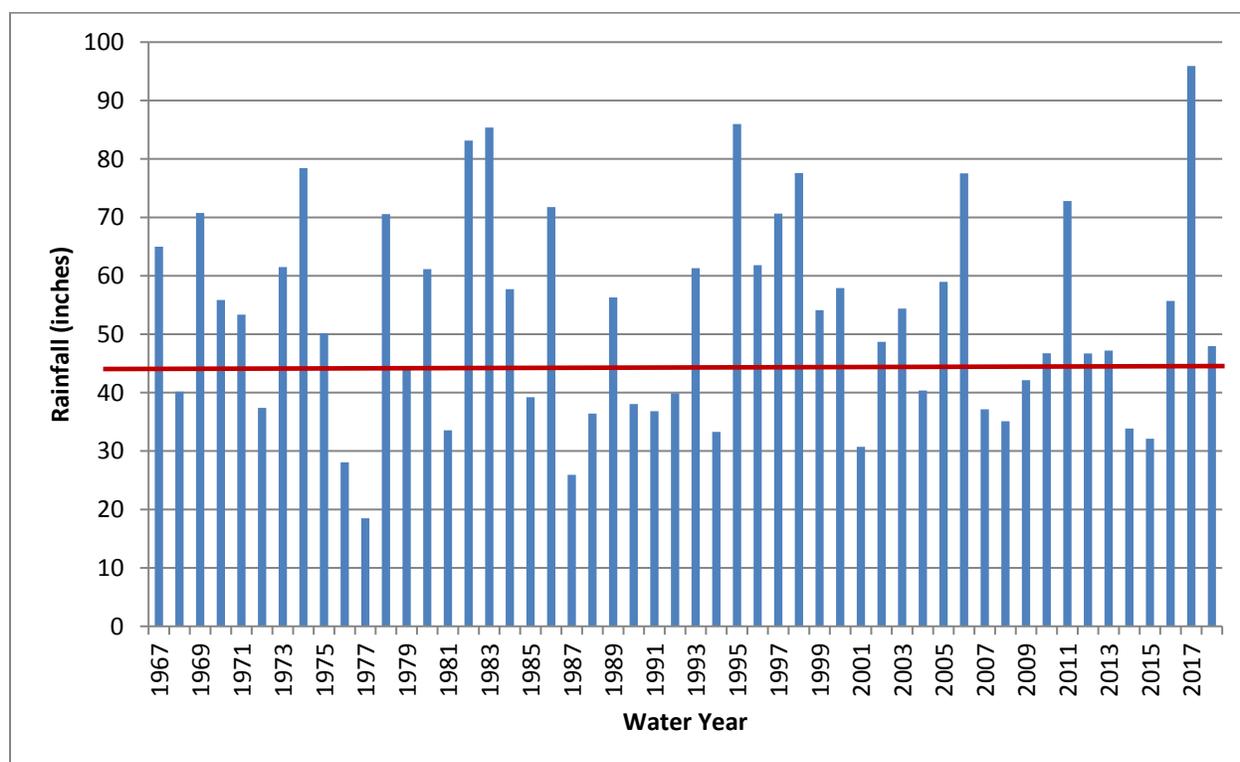
Approximately 4,500 feet west of the Idaho-Maryland Mine underground workings, both Wolf Creek and South Fork Wolf Creek flow under the City of Grass Valley within culverts. South Fork Wolf Creek merges with the main channel of Wolf Creek within these culverts. Wolf Creek is tributary to the Bear River. On the downstream side of the City of Grass Valley, outflows from the City of Grass Valley wastewater treatment plant and from the Northstar Mine water treatment system flow into Wolf Creek. Both of these discharges occur under permits from the RWQCB.

Figure 3-3 Upper Wolf Creek and South Fork Wolf Creek Watershed Map



Precipitation data are available from the Western Region Climate Center (WRCC, 2019) for the Grass Valley 2 station from 1967 through 2018. Rainfall data were evaluated for a water year, not a calendar year. A water year begins on October 1 and extends to September 30 of the next calendar year. This time period better-represents the seasonal rainfall patterns in California than does a calendar year. In this report, a water year is designated by the year in which it ends. For example, the period from October 1, 1976 through September 30, 1977 is designated as the 1977 water year. The annual water-year rainfall from 1967 to 2018 for Grass Valley is shown on Figure 3.4. The average water-year rainfall for this period is 52.81 inches. The maximum water year rainfall was 95.93 inches in 2017, while the minimum water year rainfall was 18.48 inches in 1977. The average annual rainfall amount is plotted as the red line on Figure 3.4.

Figure 3-4 Annual Water Year Rainfall in Grass Valley



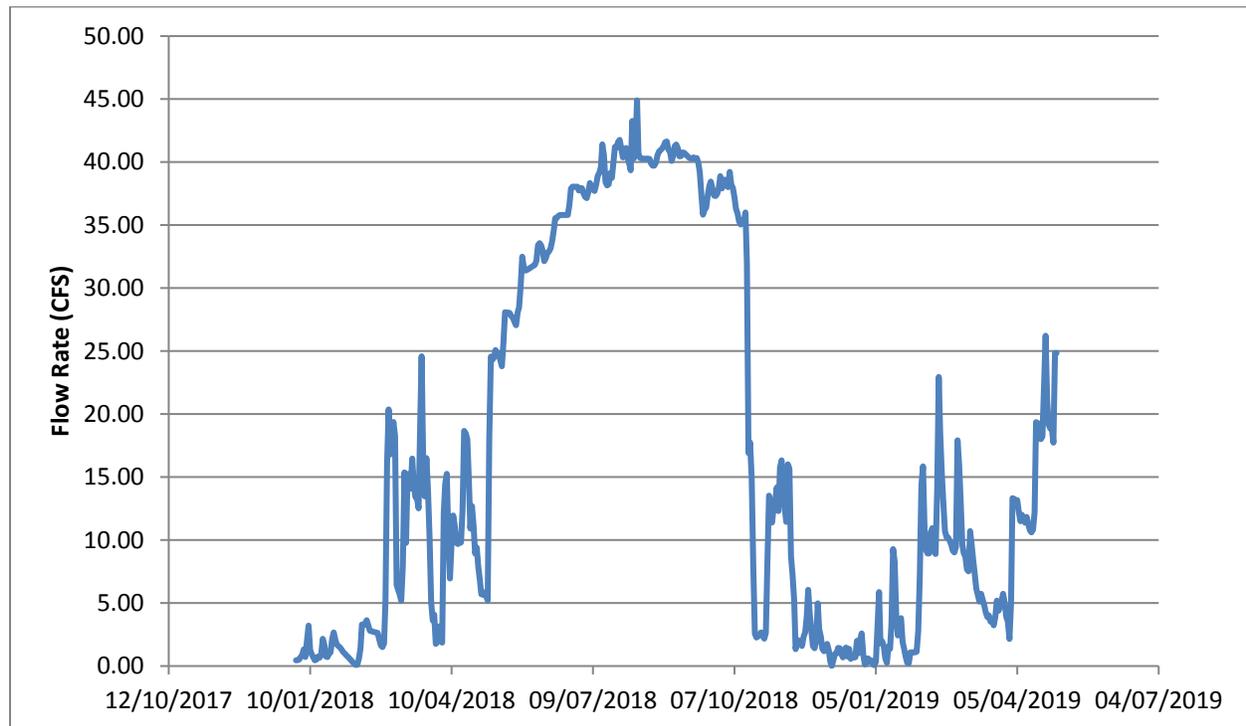
Much of the flow within Wolf Creek is due to releases of water by Nevada Irrigation District (NID) from the DS Canal at the DS Canal Wolf Creek Release, located near the southwest end of Success Cross Road (NID, 2013). The NID Phase II Raw Water Master Plan (RWMP; NID, 2013) indicates that the average annual release of water from the DS Canal into Wolf Creek in 2007 was about 35 cubic feet per second (cfs) and is projected to increase to over 50 cfs by 2032. The DS Canal becomes the DS Canal Extension downstream of the Wolf Creek Release. NID reports that there is no consistent flow of water maintained within the DS Canal Extension (NID, 2013), so almost all of the flow from the DS Canal is discharged to Wolf Creek at the release location. The water from the DS Canal is NID “Upper Division” water sourced from higher elevations of the Deer Creek watershed above Scotts Flat Reservoir (NID, 2013). Water

released by NID to Wolf Creek is eventually diverted to the Tarr Canal downstream of the City of Grass Valley.

Flow data from NID gauge DC 146 were obtained from NID. Gauge DC 146 is located along the DS Canal upstream of the Wolf Creek Release. Daily releases from the DS Canal into Wolf Creek from January 2018 through April 2019 are shown on Figure 3.5. In 2018, the releases to Wolf Creek averaged approximately 36 cfs. On April 17, 2019, EMKO measured the flow in Wolf Creek at the Centennial Drive bridge (at the intersection with Idaho-Maryland Road) at approximately 50 cfs. On that date, NID reports that the flow at DC 146 was 19.36 cfs. Thus, at the time of the measurements, almost 40 percent of the flow in Wolf Creek at Centennial Drive was due to NID releases from the DS Canal and the rest was due to natural runoff and groundwater discharge.

EMKO also measured the flow in Wolf Creek at the Centennial Drive bridge on August 8, 2019. At that time, the flow was estimated to be approximately 75 cfs.

Figure 3-5 *NID DS Canal Releases to Wolf Creek*



Although ND does not maintain flows within the DS Canal Extension, water is occasionally diverted through that canal section for maintenance purposes. According to NID, water used to flush a segment of the DS Extension in 2018 was released through the DS Canal Extension Spill II into a natural creek that flows under Brunswick Road and East Bennett Road before entering South Fork Wolf Creek (Matt Halvorson, NID, personal communication, November 15 and 19, 2018). Data provided by NID indicates that in 2018, NID made the following releases of water to South Fork Wolf Creek through the DS Canal Extension:

- March 6 to 10, 2018 – 8.78 cfs to 10.63 cfs;
- March 26 to April 4, 2018 – 6.15 cfs to 8.17 cfs; and
- April 24 to May 4, 2018 – 3.58 cfs to 13.64 cfs.

During the last period listed above, flows of 13.64 cfs were maintained for six consecutive days, while flows above nine cfs were maintained for 11 consecutive days.

On April 17, 2019, EMKO measured the flow in South Fork Wolf Creek upstream of the natural creek discussed above at approximately 3.7 cfs, and downstream of the natural creek discussed above at approximately 6.5 cfs. Thus, the flow from the natural creek was approximately 2.8 cfs at that time. The DS Canal Extension was dry on April 17, 2019 so the flow consisted entirely of natural runoff and groundwater discharge.

On August 8, 2019, EMKO again measured the flow in South Fork Wolf Creek downstream of the natural creek. The flow on that date was less than one cfs. There was no flow in the natural creek at that time. Due to the lack of any measurable rainfall during the summer in the region, the flow in South Fork Wolf Creek at the time of the August 8, 2019 measurement is anticipated to consist entirely of groundwater discharge.

Additional evaluation of runoff from the South Fork Wolf Creek watershed has been conducted for the Project by Balance Hydrologics, Inc (Balance, 2020). In September 2019, Balance (2020) measured the flows just downstream of the natural creek described above and at Ophir Street, where the creek enters a box culvert, at 0.17 cfs and 0.40 cfs, respectively. In January 2020, Balance (2020) measured the flows at the same two locations at 1.5 cfs and 2.5 cfs, respectively.

Peak flow rates for a 10-year, 24-hour storm event and a 100-year, 24-hour storm event have been reported by Cranmer Engineering, Inc. (Cranmer, 1986) as part of the development of the Storm Drainage Master Plan for the City of Grass Valley. For South Fork Wolf Creek at Hennessy School (i.e. the 2.75 square mile area of the watershed upstream of Highway 49), Cranmer (1986) calculated a peak flow rates of 658 cfs for the 10-year, 24-hour storm and 1,087 cfs for the 100-year, 24-hour storm. Thus, peak flow rates during significant storm events may be as much as two to three orders of magnitude (100 times to 1,000 times) greater than the base flow in or the NID discharges to South Fork Wolf Creek.

Nevada City Engineering, Inc. (NCE, 2019) has conducted an evaluation of the runoff from the Brunswick and Centennial Industrial Sites using the unit-hydrograph method for estimating peak runoff and volumes, consistent with the Nevada County Land Use and Development Codes, Chapter XVII Road Standards. The Brunswick Industrial Site includes two catchment areas with a combined area of approximately 124 acres. The catchment areas at the Brunswick Industrial Site are shown on Sheet 10. The peak flow rate, in cfs, and total runoff volume, in acre-feet, from the combined catchment areas were evaluated by NCE (2019) for storms with recurrence intervals of two years, 10 years, 25 years, and 100 years. The results of the unit-hydrograph evaluation for the point where the combined runoff from the two catchment areas discharge to South Fork Wolf Creek are provided in Table 3-1. The peak runoff from the two catchments

that include the Brunswick Industrial Site under existing conditions ranges from approximately 80 cfs for a two-year, 24-hour storm up to almost 230 cfs for a 100-year, 24-hour storm (NCE, 2020).

The Centennial Industrial Site has a single catchment area that encompasses approximately 70 acres (NCE, 2019), as shown on Sheet 11. The results of the unit-hydrograph evaluation from the Centennial Industrial Site to Wolf Creek for storms with recurrence intervals of 10 years and 100 years are provided in Table 3-1. The peak runoff from the Centennial Industrial Site under existing conditions ranges from approximately 70 cfs for a 10-year, 24-hour storm up to slightly more than 120 cfs for a 100-year, 24-hour storm (NCE, 2019).

Upper Division water from higher-elevation watersheds is conveyed through both Upper Wolf Creek and South Fork Wolf Creek watersheds by NID through irrigation canals, including the DS Canal, Cascade Canal, and Rattlesnake Canal. NID estimates that leakage from its canals is approximately 15 percent of the water conveyed through the system (NID, 2013). Total water demand over NID's 287,000-acre service area is approximately 165,000 acre-feet per year (afy) (NID, 2013). Fifteen percent of this demand is about 24,750 afy, or 0.086 acre-feet per acre across the service area. Based on these figures, the average rate of seepage from the NID canal system into the subsurface across the entire service area is about 0.7 inches. This value is very small compared to the average annual rainfall of 52.81 inches.

Previous evaluations conducted in the region (EMKO, 2011) and estimates conducted for this study (see Section 3.5.1) suggest that the rate of groundwater recharge overall in the Grass Valley area is approximately 10 to 12 inches per year, or about 20 percent of the total rainfall amount. Thus, the total recharge over the 287,000-acre NID service area is approximately 240,000 to 290,000 AF/yr. Comparing the amount of leakage from the NID canal system with the estimated amount of rainfall that recharges groundwater indicates that the leakage from the canals contributes only about 10 percent of the total groundwater recharge in the area.

Table 3-1 Existing and Project Peak Flows from Industrial Site Areas

Brunswick Industrial Site Storm Water Flows to South Fork Wolf Creek			
Return Period (years)	Existing Peak Runoff (cfs)	Project Peak Runoff (cfs)	Reduction Due to Project (cfs)
2	79	31	48
10	140	79	61
25	195	153	42
100	227	201	26
Centennial Industrial Site Storm Water Flows to South Fork Wolf Creek			
Return Period (years)	Existing Peak Runoff (cfs)	Project Peak Runoff (cfs)	Reduction Due to Project (cfs)
10	72	45	27
100	121	76	45

3.3 Groundwater Occurrence

Groundwater occurs within the near surface Quaternary and Tertiary deposits and in fractured bedrock at and near the project site. According to the California Department of Water Resources (DWR) Sustainable Groundwater Management Act (SGMA) Basin Prioritization Dashboard (DWR, 2019), there are no alluvial groundwater basins in the vicinity of the Project site. The nearest groundwater basin is the South Yuba portion of the Sacramento Valley groundwater basin (DWR Basin No. 5-21.61), located more than 15 miles west of Grass Valley.

3.3.1 Regional Groundwater Occurrence within Fractured Bedrock

Based on a review of driller logs in the area (see Section 3.3.2), groundwater within the fractured bedrock occurs under both unconfined and confined conditions within the Project area. The groundwater surface generally mimics the topography, but with the depth to water being somewhat greater along ridges and near drainage divides and somewhat shallower at lower elevations and near drainages. Thus, groundwater tends to flow from the ridge areas down toward the main drainages, such that the surface topography of the watersheds also defines individual groundwater flow zones within the fractured bedrock aquifer system. The primary source of recharge is percolation of local rainfall, as discussed in Section 3.2 and evidenced by seasonal fluctuations in groundwater levels. As described in Section 3.3.2, the amount of recharge each year also appears to be relatively constant since almost all of the wells maintain a consistent magnitude of seasonal fluctuation from year to year and there are no long-term trends observed in most of the wells that can be correlated to variations in annual water-year rainfall.

Several studies of groundwater conditions within fractured bedrock have been conducted in the area of the project. The U.S. Geological Survey (Page et al., 1984) conducted a study covering a 148 square mile area of southwestern Nevada County, including the segment of the Wolf Creek watershed from Grass Valley to the Bear River. The underlying bedrock consisted of similar rock types to those encountered at the project site (see Section 3.1), including hard, dense metavolcanic and igneous rocks of pre-Tertiary age. The study results found that the degree of fracturing in the bedrock, and thus the well yield, decreases with depth, with most of the available groundwater occurring above a depth of 215 ft bgs. At depths shallower than 215 ft bgs, 70 percent of the wells evaluated produced more than five gpm. However, at depths deeper than 215 ft bgs, 75 percent of the wells produced five gpm or less.

EMKO (2011) conducted a study for NID in the Banner Mountain area between the DS Canal and the Lower Cascade Canal. The study area extended from Red Dog Road on the north to Idaho-Maryland Road on the south. Wells included in the study ranged from 30 feet to 560 feet deep. Wells shallower than 100 feet deep produced groundwater at up to 17 gpm. In wells deeper than 100 feet, the rate of groundwater production did not exceed 3.5 gpm.

3.3.2 Groundwater Occurrence in Private Domestic Wells in the Project Area

Over 1,200 Water Well Driller Reports (also known as Well Completion Reports) available from DWR's online database (DWR, 2020) for private domestic wells located within approximately one to two miles of the project site. Domestic water wells are relatively sparse over the mineral rights and increase in number

and density past the eastern border of the mineral rights. EMKO located 38 well reports which included well draw down in pumping tests in a 1 to 2-mile vicinity of the project and compiled well report data for wells located in the project watersheds. Sheet 12 displays the location of the domestic wells and highlights those that are closest to the underground mine workings within the Wolf Creek and South Fork Wolf Creek watersheds. Section views of well locations and well depths relative to the mine workings are included in Sheets 13-14.

3.3.2.1 Private Domestic Well Areas

As discussed in Section 3.3.1, groundwater within the fractured bedrock tends to flow from the ridge areas down toward the main drainages. Due to this flow pattern, the surface topography of the watersheds also tend to define the groundwater flow zones, or local fractured bedrock groundwater “basins”. The private domestic wells that occur in the Wolf Creek and South Fork Wolf Creek watersheds are primarily located in four distinct areas, as shown on Figure 3.6 and described below.

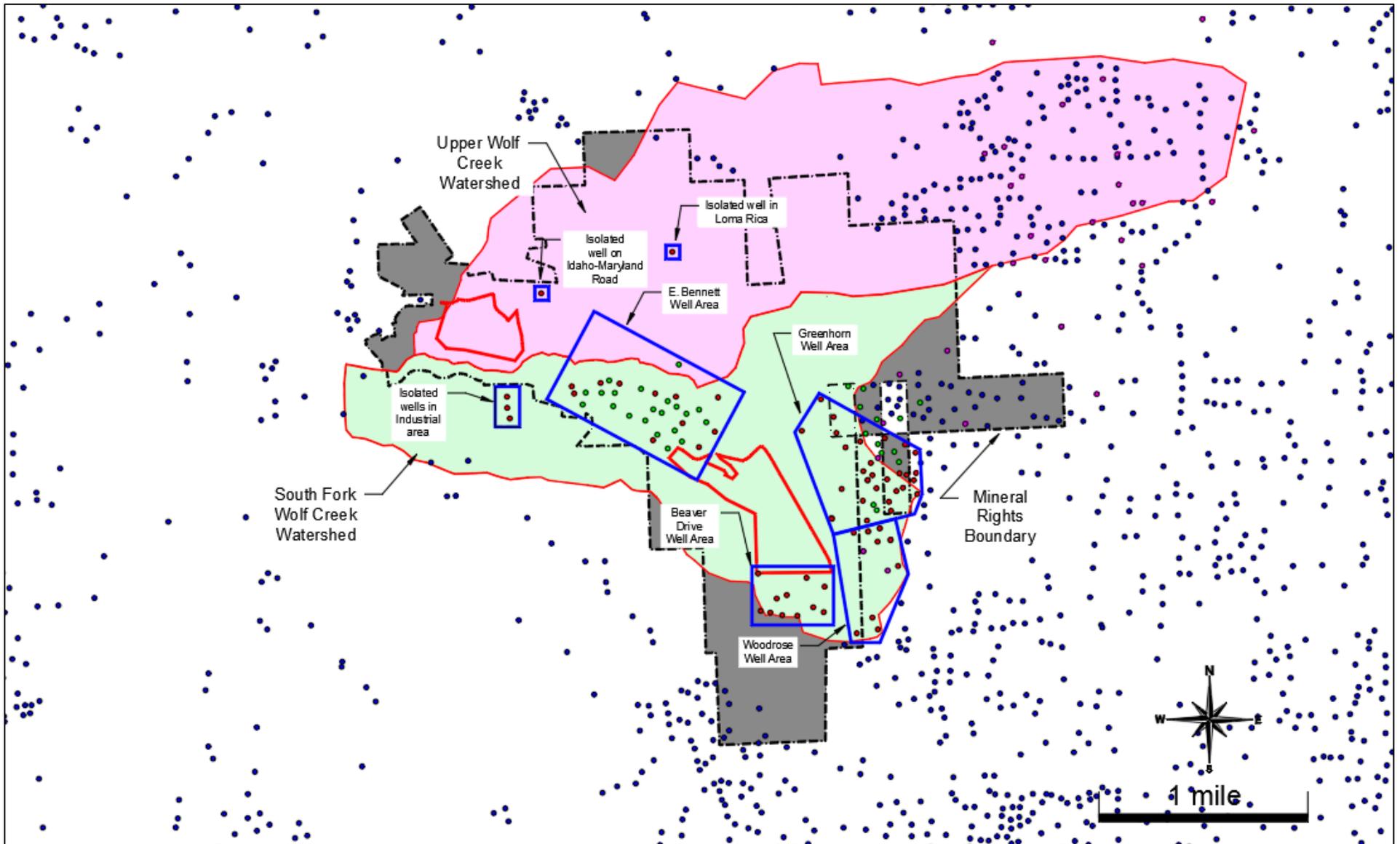
- 1) East Bennett Area – A residential area located west of the Brunswick site and adjacent to East Bennett Road. The properties in this area are currently not connected to NID’s potable water supply system.
- 2) Beaver Drive Area – A residential area south of the Brunswick site. This small residential area is not served by NID’s potable water supply system. However, the residential areas to the west and south of Beaver Drive are connected to the NID potable water supply system.
- 3) Greenhorn Area – A residential and agricultural area east of the Brunswick site on the east side of Brunswick Road. This area is zoned for residential-agricultural uses (RA-3) and most properties with wells in this area are not served by the NID potable water supply system.
- 4) Woodrose Area – A residential area east of the Brunswick site on the east side of Brunswick Road. This area is zoned for residential-agricultural uses (RA-3) and most properties with wells in this area are not served by the NID potable water supply system.

In addition to the three main areas listed above, there are a few additional areas inside or close to the boundaries of the mineral rights where groundwater supply wells are present:

- 1) There are several wells located on industrial-zoned land south of the Centennial Industrial Site. This area is not served by NID’s potable water supply system.
- 2) There is one well on industrial-zoned land east of the Centennial Industrial Site. This area is in the city limits of Grass Valley and is served with potable water.
- 3) There is one well in the Loma Rica ranch area which lies above the Mitchell Crosscut on the Idaho-1000 level. This area is within the city limits of Grass Valley but is largely vacant land currently.

The locations of the wells within these three areas are shown on Figure 3.6.

Figure 3-6 Map of Domestic Supply Wells and Underground Mine Workings



EAST BENNETT AREA

The wells along East Bennett Road are primarily within the South Fork Wolf Creek watershed, although a few of them in the northeast part of this area are within the Wolf Creek watershed. This area generally overlies the main area of underground mine workings in the project vicinity. These wells are completed in the meta-andesite that forms the Brunswick Porphyrite Block.

Well drilling reports are available for 11 wells which include lithology, water levels, and well yields. An additional 21 wells are noted by previous studies by Emgold and provide additional data for static water levels, limited production rate data, and no lithology data.

The primary characteristics of this area include:

- The majority of wells draw water from the fractured bedrock and the remaining wells draw water from the weathered bedrock.
- The lowest producing well, W1, which notes quartz veining present and a production rate of 0.5 gpm, is drilled to 420 feet and within 200 feet of the Brunswick mine. Well W15, drilled to 400 feet and within 200 feet of the Brunswick mine workings was reported to have no water or water production.
- Static water levels in wells WS201, WS44, W19, WS235 indicate a drawdown cone at the Old Brunswick shaft.
- Well WS201, drilled 425 feet deep, passes within feet of the Old Brunswick Shaft. The static water level is approximately 270 ft bgs or about 2,590 ft msl, which is approximately 90 feet above the water level in the flooded mine. WS201 produces approximately 3.5 gpm.
- Well WS29 passes within feet of the B300L of the Old Brunswick mine and is reported to produce 10 gpm. No information is available for static water for this well.
- The highest producing wells, W19, W16, W7 with productions rates from 30-40 gpm and depths from 100-220 feet are located close to the Brunswick mine workings. Well W7 is located directly above the main mine working of the Brunswick Mine. W16 draws water from weathered rock and the other wells draw from fractured rock.
- Ground surface elevations at the well locations generally range from approximately 2,700 feet above mean sea level² (ft msl) to 2,850 ft msl.
- Total depth of the wells in this area ranges from 100 ft bgs to 700 ft bgs.

² Any reference to mean sea level (ft msl) used in this report is intended to be in reference to the survey datum used, not necessarily to sea level at or near the project location. For example, the datum point for the North American Vertical Datum of 1988 (NAVD88) is located in Quebec, Canada (<https://www.ngs.noaa.gov/datums/vertical/index.shtml>), whereas the datum for the National Geodetic Vertical Datum of 1929 (NGVD29) is based on 26 separate tide gauges in the US and Canada (<https://www.ngs.noaa.gov/datums/vertical/national-geodetic-vertical-datum-1929.shtml>). Due to the wide range of data sources used for this report, the vertical datum used is not always known, but most likely would be NAVD88 or NGVD29. In the project area, NAVD88 elevations are 2.54 feet higher than NGVD29 elevations (<https://www.ngs.noaa.gov/datums/vertical/index.shtml>). Given the large elevation ranges related to this project, on both the ground surface and in the subsurface, the difference between NAVD88 and NGVD29 elevations is inconsequential for the purposes of this report.

- The depth to first water at the time a well was drilled ranges from 80 feet below ground surface to 370 ft bgs, and elevations ranging from approximately 2,377 ft msl to 2,717 ft msl.
- Static water elevations range from a few feet to 130 ft bgs and approximately 2,546 ft msl to 2,766 ft msl..
- Initial production rates reported at the time a well was drilled range from 0.5 gpm to 40 gpm, with a median rate of 6.5 gpm.

BEAVER DRIVE AREA

The Beaver Drive area is located within the South Fork Wolf Creek watershed. The wells in this area are located over 1,700 feet laterally southeast of the main underground mine workings. However, there is one lateral drift that extends under the northwest corner of the Beaver Drive domestic well area. This drift is at the B1300 level at an elevation of approximately 1,480 ft msl and approximately 1,380 to 1,470 feet below the ground surface in the Beaver Drive area. Many of the wells in this area encountered the Tertiary andesite at ground surface, they all extend below this unit and are completed in the meta-andesite porphyry.

Well drilling reports are available for 11 wells which include lithology, water levels, and well yields.

The primary characteristics of the Beaver Drive area include:

- Eight of the eleven wells draw water from the weathered rock aquifer, one well draws water from the Tertiary aquifer and one from the Quaternary.
- The lowest producing well is W38. This well was initially drilled in 1984 to 350 feet and has production of 2 gpm from the weathered rock aquifer. In 1992 it was deepened to 700 feet in the greenstone bedrock and yielded no (0 gpm) water production.
- The highest producing well, W35, with a production rate of 30 gpm and depth of 125 feet bgs draws water from weathered bedrock.
- Well W35 is located approximately 280 feet east of well W38; thus, the highest producing well and the lowest producing well in the Beaver Drive area are adjacent to each other.
- Ground surface elevations at the well locations range from approximately 2,865 ft msl to 2,950 ft msl.
- Total depth of the wells in the Beaver Drive area ranges from 125 ft bgs to 700 ft bgs.
- The depth to first water at the time a well was drilled ranges from 45 ft bgs to 190 ft bgs, and elevations ranging from approximately 2,709 ft msl to 2,900 ft msl.
- The depth to static water at the time a well is only recorded in two of the well logs at 45-78 ft bgs or approximately 2,821 – 2,900 ft msl.
- Initial production rates reported at the time a well was drilled range from 0 gpm to 30 gpm, with a median rate of 4 gpm.

GREENHORN AREA

The wells in the Greenhorn area are located east of Brunswick Road. They extend from the eastern edge of the South Fork Wolf Creek watershed into the Greenhorn Creek watershed. The wells in this area are located over 1000 feet laterally from the main underground mine workings. However, there is one lateral drift that extends into the northern part of the Greenhorn area. This drift is at the B1100 level at an elevation of approximately 1,700 ft msl and approximately 1,100 to 1,300 feet below the ground surface east of Brunswick Road. Although some of the wells in this area encountered the Tertiary andesite at ground surface, they all extend below this unit into the underlying bedrock units.

Well drilling reports are available for 32 wells which include lithology, water levels, and well yields.

The primary characteristics of the Greenhorn area include:

- The lowest producing wells (W61, W65, W68, W72, W73, W75) have production rates of 2-4 gpm and depths from 125-500 feet.
- The highest producing wells (W43, W45, W51, W62, W67) have production rates of 100-150 gpm and depths from 105-175 feet.
- Deeper wells producing water from fractured bedrock (W56, W70) produce 7-25 gpm and are 300-380 feet deep.
- Ground surface elevations at the well locations range from approximately 2,800 ft msl to 2,995 ft msl.
- Total depth of the wells ranges from 75 ft bgs to 780 ft bgs.
- The depth to first water at the time a well was drilled ranges from 17 ft bgs to 435 ft bgs, and elevations ranging from approximately 2,532 ft msl to 2,952 ft msl.
- The depth to static water at the time a well was drilled ranges from 10 ft bgs to 255 ft bgs, or elevations ranging from approximately 2,532 ft msl to approximately 2,884 ft msl.
- Initial production rates reported at the time a well was drilled range from 2 gpm to 150 gpm, with a median rate of 25 gpm.

WOODROSE AREA

The wells in the Woodrose area are located east of Brunswick Road and near the southeastern edge of the South Fork Wolf Creek watershed. The wells in this area are located over 3000 feet laterally from the main underground mine workings. Although some of the wells in this area encountered the Tertiary andesite at ground surface, they all extend below this unit and are typically completed in the underlying bedrock.

Well drilling reports are available for 12 wells which include lithology, water levels, and well yields.

The primary characteristics of the Woodrose area include:

- Five of the 12 wells are completed in the fractured bedrock, five are completed in the weathered bedrock, and two are completed within the Tertiary units.

- The lowest producing wells (W90, W83, W82) draw water from fractured bedrock and have production rates of 0.5-1.5 gpm and depths from 560-720 feet bgs.
- The highest producing wells (W78, W79, W80, W81, W91) produce 20-40 gpm at depths from 100-300 feet bgs in weathered bedrock and fractured bedrock.
- Ground surface elevations at the well locations range from approximately 2,809 ft msl to 2,980 ft msl.
- Total depth of the wells ranges from 100 ft bgs to 720 ft bgs.
- The depth to first water at the time a well was drilled ranges from 10 ft bgs to 410 ft bgs, and elevations ranging from approximately 2,597 ft msl to 2,887 ft msl.
- The depth to static water at the time a well was drilled ranges from 10 ft bgs to 150 ft bgs, or elevations ranging from approximately 2,777 ft msl to approximately 2,910 ft msl..
- Initial production rates reported at the time a well was drilled range from 0.5 gpm to 40 gpm, with a median rate of 10 gpm.

ISOLATED AREAS

Well completion reports are available for three wells in the E. Bennett Industrial Area, south of the Centennial Industrial Site. This area is located over 2500 feet latterly from the main underground mine workings. Two wells draw water from fractured rock and one from weathered rock, have well depths from 100-200 feet, and production from 6-50 gpm.

Well drilling reports are available for 1 well on industrial zoned land within the City of Grass Valley on Idaho-Maryland road. This well is located close to the original Idaho #1 mine and is logged as greenstone with quartz veining. Production is reported at 3 gpm and well depth at 560 feet.

One well completion report is available for the Loma Rica Ranch area, which lies above the Mitchell Crosscut on the Idaho-1000 level. This area is within the city limits of Grass Valley but is largely vacant land. This well reportedly is 100 feet deep, completed within the weathered bedrock, and is reported to produce 40 gpm.

3.3.2.2 Water Level Monitoring in Private Domestic Wells

The Idaho-Maryland Mining Corporation (IMMC) and its predecessors monitored water levels in up to 79 private domestic wells from 1995-2001 and again from 2003-2007 in accordance with conditions included in Use Permit U84-107 based on mitigation program requirements identified in a 1995 Environmental Impact Report (EIR) (IMMC, 2007). Groundwater quality data were not collected as part of the mitigation monitoring program as these data were considered to be confidential to each well owner. The IMMC hydrographs are included in Appendix B. Review of the water-level hydrographs from the mitigation monitoring program indicates the following:

EAST BENNETT AREA

The groundwater levels generally follow the topography but are somewhat muted, with the depth to water being greater along ridges and near drainage divides and shallow at lower elevations and near

drainages. The water levels in most wells follow a seasonal pattern, with annual fluctuations typically ranging from 5 feet to 25 feet in different wells between dry months and wet months. Within individual wells, the magnitude of the seasonal fluctuation remains consistent throughout the monitoring period. No long-term increasing or decreasing trends are observed and there are no apparent annual variations due to drought or above-normal rainfall years.

BEAVER DRIVE AREA

There is not as much apparent topographic influence on the groundwater levels in this area, potentially because there is less variation in topography between well locations, in comparison to the East Bennett Area and the wells east of Brunswick Road. The seasonal fluctuations in the Beaver Drive area are larger than those in the other areas, ranging from 20 feet to 50 feet per year. While there are no long-term trends observed in the hydrographs, some of the wells may show annual differences due to variations in water-year rainfall totals. Wells along the southwest drainage divide for the South Fork Wolf Creek watershed tend to have more variable and irregular data and do not exhibit the consistent seasonal variations that are observed in other wells in this area.

GREENHORN AREA

Groundwater levels in the wells in the Greenhorn area east of Brunswick Road tend to vary with the topography, as in the East Bennett Area. The hydrographs show seasonal variations, with annual water level fluctuations ranging from 10 feet to 30 feet but remaining very consistent within individual wells. No long-term trends and no variations with changes in annual water-year rainfall are observed. Several NID canals traverse the area east of Brunswick Road. Comparison of the hydrographs for wells adjacent to canals and wells more distant from the canals does not indicate any direct influence of the canals on groundwater elevations or on seasonal fluctuations.

Wells in the Woodrose and isolated areas were not monitored by IMMC.

Due to the nature of groundwater within fractured bedrock, in some areas there may be a zone of unfractured (i.e. non-water bearing) bedrock above a zone with water-producing fractures. Under these conditions, the static water level in a well will be higher than the elevation of the water-bearing fractures (for example, as demonstrated by a difference between the depth of first-encountered groundwater and the depth of the static water surface in the well after drilling is completed), which is consistent with the behavior of confined aquifer conditions. However, the static groundwater surface generally mimics the topography, but with the depth to water being somewhat greater along ridges and near drainage divides and somewhat shallower at lower elevations and near drainages.

The primary source of recharge is percolation of local rainfall, as evidenced both by the seasonal fluctuations in the groundwater levels and by the fact that groundwater levels in the wells monitored are typically higher than the elevation of the nearest creek within the same watershed. Thus, the areas along ridges and near drainage divides, in addition to the slopes above the creeks, act as recharge areas while groundwater discharge may occur through fractures that are present at or near the elevation of the creeks. Groundwater recharge through fractures that are present at the ground surface in the higher

parts of a watershed can produce the hydrostatic pressures that may be observed when those same fractures are encountered at depth in a well, creating the apparent confined aquifer conditions.

The hydrographs demonstrate that a consistent magnitude of seasonal fluctuation is maintained from year to year in almost all areas evaluated. In addition, there are no long-term trends observed in most of the wells that can be correlated to variations in annual water-year rainfall. Thus, the amount of recharge appears to be consistent from year to year and is not affected substantially by drought or wet cycles. The consistent annual recharge may be due to the limitations of recharge in fractured bedrock, where the annual rainfall amount may be greater than the capacity of the fractures to accept additional flow. In this situation, increases or decreases in the annual rainfall due to climatic cycles does not have an appreciable effect on the amount of water that can be recharged because the capacity of the fractures to transmit water to the subsurface is already at its maximum.

3.3.3 Groundwater Occurrence within Mine Workings

As discussed in Section 2.0, there are two separate systems of underground mine workings in the project site, the Union Hill mine and the Idaho-Maryland mine workings. Both sets of mine workings are currently flooded with water.

3.3.3.1 Mine Connections to Surface

There are fourteen shafts or tunnels which connect the underground workings of the Idaho-Maryland mine to the ground surface, as listed in Table 3.2. Only the New Brunswick shaft is on Rise property. The majority of the historic mine workings have been covered by road pavement or structures.

Table 3-2 *List of Idaho-Maryland Mine Connections to Ground Surface*

	IM Mine Workings to Surface	Location – APN	Status and Comments	Known Water Discharge	Estimated Surface Elevation (ft msl)
1	Eureka Shaft	009-201-022 or 009-201-035	Covered by Building - Eagle Automotive	NO	2532
2	Eureka Vertical Shaft	Nevada County - Spring Hill Drive	Covered by street pavement - Spring Hill Drive	NO	2514
3	Eureka Drain	009-201-023 & 009-201-022	Unknown drain drift or culvert from Eureka Shaft. Covered in earth	YES	2502
4	East Eureka Shaft	009-550-041	Open - Under Building - Navo & Sons	YES	2501
5	East Eureka Drain	009-550-041	24-inch culvert from E. Eureka shaft to Wolf Creek	YES	2497
6	Idaho Drain Tunnel	009-680-021	Covered by earth grading - Grass Valley Recycle	NO	2516
7	Idaho Pump Shaft	009-680-021	Covered by earth grading - Grass Valley Recycle	NO	2524
8	Idaho Shaft	009-680-021	Covered by earth grading - Grass Valley Recycle	NO	2526
9	Old Air Raise	Nevada County - Centennial Drive	Covered by street pavement - Centennial Drive	NO	2572
10	Roundhole Shaft	009-690-037	Remains in place. Covered by concrete cap. Likely caved	NO	2670
11	Old Brunswick Incline Shaft	009-581-019	In close proximity to residential house. Previously created sinkhole due to residential use. Unknown mitigation	NO	2854
12	Old Brunswick Shaft #2	009-581-053	In vacant wooded area. Buried under old rock dump	NO	2816
13	Old Brunswick drain tunnel	009-581-053	In vacant wooded area. Unknown if tunnel has been sealed	NO	2742
14	New Brunswick Shaft	009-630-039	Steel Cover - To be re-used by Rise	NO	2756

It should be noted that only the surface connections at an elevation of 2,502 ft msl or lower discharge water to the surface.

3.3.3.2 Mine Water Quantities

The total amount of water currently present within the Idaho-Maryland mine underground workings is estimated at 1,183 acre-feet. The amount of water was estimated by Rise based on the calculated volumes of mine workings. Mine tunnels or drifts were assumed to be 100% open voids. Mine stopes were estimated to have 75% of their volumes backfilled. The backfill itself is assumed to have a porosity of 40%. Tables 3.3 and 3.4 show the calculated water volumes for the Idaho-Maryland mine based on area and elevation.

Table 3-3 Water Volume Estimates in Stopes

	Idaho 1 Stopes	Idaho 3 Stopes	Brunswick Stopes
Longsection Area of ore mining (ft ²)	2,292,473	1,267,966	2,825,806
Total Volume of stoping (ft ³)	11,736,000	14,580,000	34,440,000
Development ore mined	9%	30%	30%
Stoping volume (ft ³)	10,631,435	10,206,000	24,108,000
Voids in fill	0.40	0.40	0.40
Percentage of stopes backfilled	0.75	0.75	0.75
Water in stopes (ft ³)	5,847,289	5,613,300	13,259,400

Table 3-4 Mine Workings Water Volumes by Depth

	Water Contained in Stopes (ft ³)			Water in Drifts (ft ³)	Total Water		
	Idaho 1	Idaho 3	Brunswick		ft ³	acre-ft	gallons
Surface to 580 Level	544,000	0	587,000	1,259,000	2,390,000	55	17,878,000
580-900 Level	1,687,000	390,000	3,888,000	4,206,000	10,171,000	233	76,084,000
900-1300 Level	1,297,000	1,427,000	4,470,000	7,091,000	14,285,000	328	106,859,000
1300-1600 Level	1,244,000	1,487,000	4,319,000	3,277,000	10,327,000	237	77,251,000
1600-1880 level	1,075,000	1,065,000	583,000	3,241,000	5,964,000	137	44,614,000
1880-2300 Level	0	1,244,000	0	3,474,000	4,718,000	108	35,293,000
2300-3280 Level	0	0	0	3,661,000	3,661,000	84	27,386,000
	5,847,000	5,613,000	13,847,000	26,209,000	51,516,000	1,183	385,365,000

3.3.3.3 Water Levels in the New Brunswick Shaft

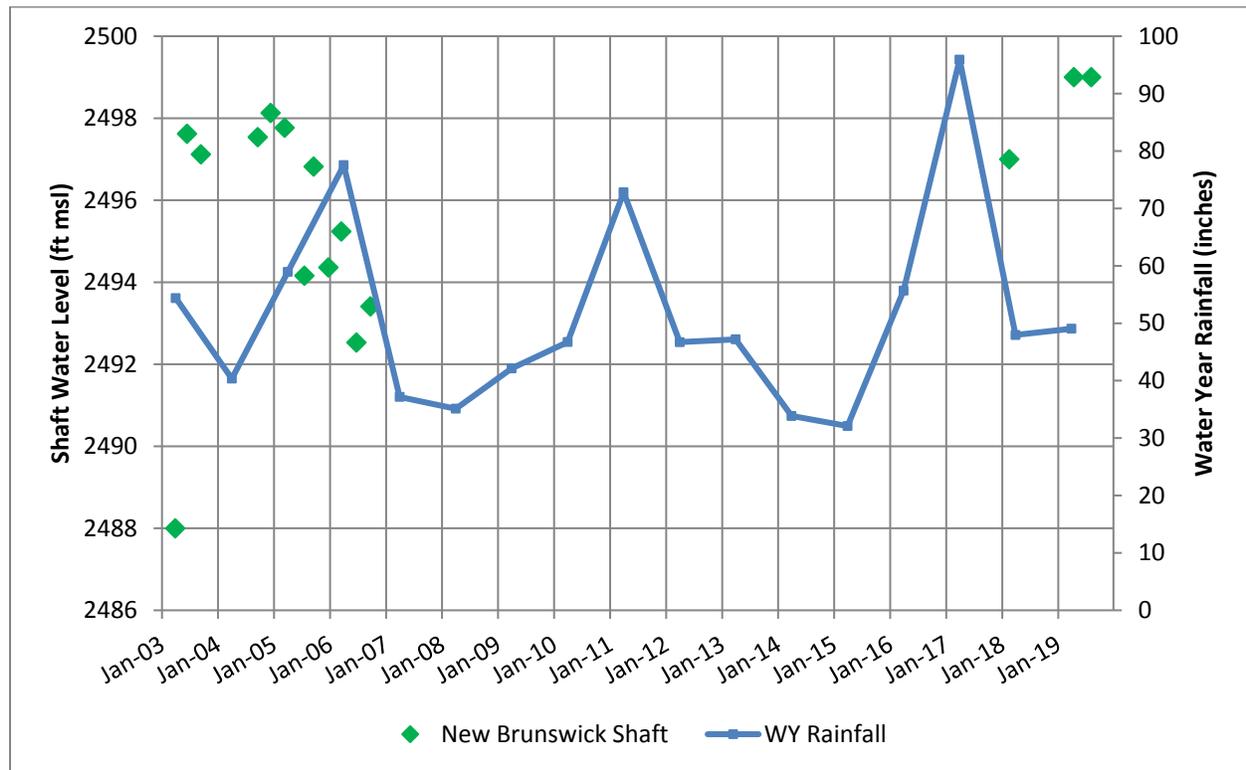
EMKO measured the depth to water in the New Brunswick shaft in February 2018, April 2019, and August 2019. In February 2018, the water in the shaft was 259 feet below the top of the collar (i.e. ground surface). In April 2019 and August 2019, the water in the shaft was 257 feet below the top of the collar. The collar is at an elevation of 2,756 ft msl. Thus, the water surface in the shaft was at 2,497 ft msl in February 2018 and at 2,499 ft msl in April 2019 and August 2019.

IMMC measured water levels in the New Brunswick shaft at least 13 times between March 2003 and September 2006 (IMMC, 2007). The water level generally varied from 2,488 ft msl to 2,498 ft msl, with a

median value of approximately 2,497 ft msl^{3,4}. Thus, over a 16-year period, the water level in the New Brunswick shaft has varied by approximately 11 feet, from 2,488 ft msl to 2,499 ft msl. These elevations are lower than the groundwater levels reported for wells along East Bennett Road, which are reported to range from 2,525 ft msl to 2,765 ft msl, as discussed in Section 3.3.2.

Figure 3.7 compares the water levels in the New Brunswick Shaft with annual water-year rainfall from 2003 through 2019. The data presented on Figure 3.7 demonstrate that the variations in the water level in the shaft do not occur on a seasonal basis and that there is not a consistent correlation between water levels in the shaft and rainfall.

Figure 3-7 Comparison of Shaft Water Levels with Rainfall



3.3.3.4 Water Levels in the Union Hill Mine

The Union Hill mine is a smaller mine than the others in the project area. It was closed in 1918 and has been flooded with water since that time. The Union Hill mine is not connected to any of the other

³ IMMC used an estimated collar elevation of 2,750 ft msl. Since the collar elevation has been confirmed at 2,756 ft msl, the water elevations reported by IMMC (2007) have been increased by six feet in this report.

⁴ One measurement, from June 2004, had a reported elevation of 2,581 ft msl, or about 100 feet higher than the other 12 measurements made by IMMC (2007). Review of the data presented by IMMC (2007) suggests that the anomalous June 2004 elevation may be due to a data recording or reporting error. Thus, it is not considered further in this report.

underground mine workings in the area but is in close proximity to the workings of the Brunswick Mine. The Union Hill mine workings are completely within the South Fork Wolf Creek Watershed.

At the Union Hill mine, the water level has been observed to fluctuate seasonally, from approximately one to 10 feet below the collar of the Union Hill shaft (Tessa Brinkman, personal communication, March 14, 2019). On April 17, 2019, EMKO observed the water level in the Union Hill shaft to be approximately 18 inches below the top of the shaft, while on August 8, 2019 it was approximately four feet below the top of the shaft. The top of the Union Hill shaft is at approximately 2666 ft msl so the water level in the Union Hill Mine ranges from approximately 2,665 ft msl to 2,656 ft msl. On April 17, 2019, the water level in the Union Hill shaft was 165 feet higher than the water level in the New Brunswick shaft.

The water levels in the Union Hill Mine are within the range of the water levels observed in the wells in the East Bennett Area, which range from 2,525 ft msl to 2,765 ft msl, as discussed in Section 3.3.2. However, the water levels in the Union Hill Mine are lower than the water levels in the wells in the Beaver Drive Area and in the area east of Brunswick Road, which are all greater than 2,700 ft msl.

The elevation of the bank of South Fork Wolf Creek at a location closest to the Union Hill shaft is approximately 2,658 ft msl. The bottom of the channel is a few feet below the bank. During the rainy season, the water level in the Union Hill Mine tends to be slightly higher than the elevation of South Fork Wolf Creek adjacent to the Union Hill shaft, whereas during the dry season, the water level in the Union Hill shaft may be comparable to the water level in South Fork Wolf Creek. Thus, the groundwater in the fractures that intersect the Union Hill Mine may provide flow to South Fork Wolf Creek at certain times of the year.

The Union Hill mine workings are within 95 feet to 180 feet of workings of the Brunswick Mine at three to four different levels (Sheet 14). During the post WWII period, the combined Idaho-Maryland Mine workings were completely dewatered. In 1956, the water level at the Union Hill Mine was reported to be within 20 feet of the top of the shaft⁵ (Clark, 2005), suggesting that the complete dewatering of the adjacent mine workings resulted in no more than 10 to 20 feet of water level decline in the Union Hill Mine.

3.3.4 Groundwater Flow from Drains

Several drains have been observed along Wolf Creek in the area of the East Eureka and Idaho shafts (Condor, 1994). In February 2018, EMKO verified that the same drains are still present and that groundwater is continuing to discharge from these drains. For this report, the historic naming of these drains that was used in previous studies has been retained. Drain locations are shown on Sheet 3.

The drains present along Wolf Creek include:

⁵ It is unclear if the reference to water level is on a vertical or inclined basis as the Union Hill is an inclined shaft at approximately 63 degrees.

3.3.4.1 ED-1 – Eureka Drain

Located at the northwest corner of Idaho-Maryland Road and Spring Hill Road. Although the flow from this drain has been reported to be in the range of 100 gpm (Condor, 1994), field observations made by EMKO in February 2018 and December 2018 indicate that the drain was flowing at a rate of only a few gallons per minute at the time of those observations. On April 17, 2019, EMKO observed flows in the range of 20 to 25 gpm from this drain. The flow enters a culvert that passes under Idaho-Maryland Road and discharges to Wolf Creek. It is assumed that this seep is occurring from the original Eureka shaft.

3.3.4.2 IMD-1 – East Eureka Shaft Drain

A 24-inch galvanized culvert drains water into Wolf Creek from the East Eureka shaft, which is located under the Roto-Rooter plumbing shop at 815 Idaho-Maryland Road, to the east of Centennial Drive. Todd Engineers (2007) reports the flow from this drain to be about 60 gpm. EMKO observed this drain to be flowing at a rate that was consistent with that reported by Todd Engineers (2007) on several occasions between February 2018 and December 2018. On April 17, 2019, EMKO measured the flow from this drain at approximately 100 gpm.

3.3.4.3 IMD-2 – East Eureka Shaft

A small steel pipe originates at a sump adjacent to the East Eureka shaft under the east end of the Roto-Rooter plumbing shop. EMKO observed water in the shaft at a depth of less than two feet below the top of the shaft in February 2018. Flow from this drain was minimal, in the range of 1-2 gpm, in February 2018.

3.3.4.4 D-1 – Unknown Origin

Located along the north side of Idaho-Maryland Road across the street from the Roto-Rooter plumbing shop. A small box culvert allows water to discharge into the gutter from beneath the business park area up the hill from the drain. The water flows down the gutter to a drop inlet just east of Spring Hill Road, where it flows through a culvert under the road and into Wolf Creek. Field observations made in February 2018, December 2018, and April 2019 indicate that this drain flows consistently at a rate of only a few gallons per minute. As discussed further in Section 3.4, water quality data indicate that the discharge from D-1 may not be related to the underground mine workings in the area. No workings with connection to the Idaho-Maryland mine are noted in this area on the historic mine maps (Sheet 8).

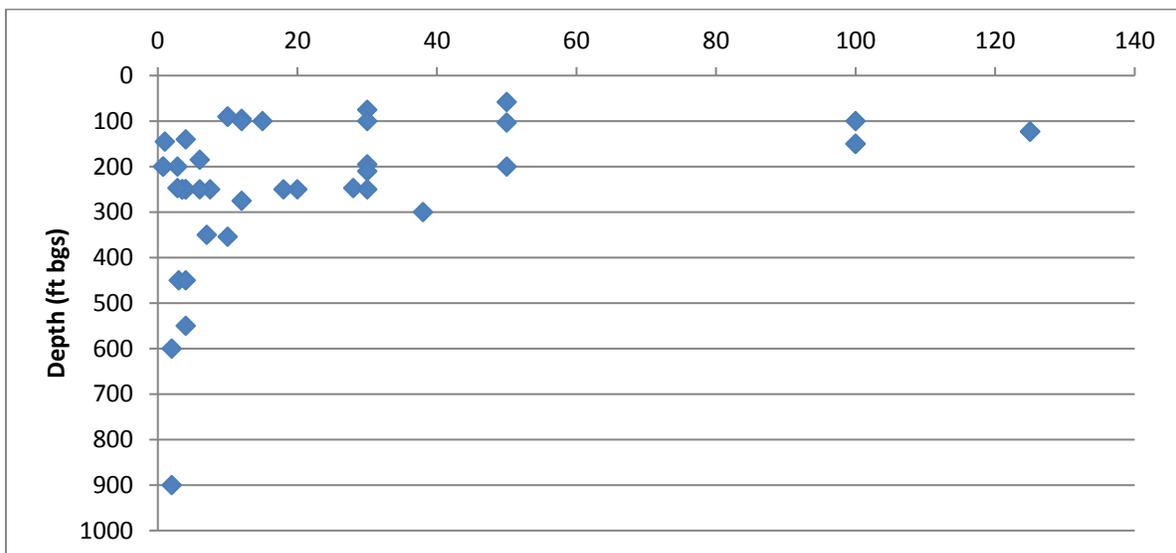
3.3.5 Bedrock Properties Related to Groundwater Flow

The primary physical properties that define groundwater flow include the transmissivity and hydraulic conductivity. The transmissivity is a parameter that measures how much groundwater an aquifer may transmit for a given decrease in water level, for example when a well is pumped. The hydraulic conductivity is related to the permeability of the overall aquifer zone. The derivation of these properties primarily relates to porous media, such as sand and gravel-type aquifers (Domenico and Schwartz, 1990), but they are often applied to fractured bedrock aquifers when there is a sufficient degree of fracturing and interconnection between fractures.

Aquifer properties are typically estimated by measuring the rate and total amount of decline in the groundwater surface elevation that occurs when a well is pumped. This decline in the groundwater surface as a result of pumping is commonly referred to as drawdown. As discussed in Section 3.3.2, EMKO reviewed 38 well completion reports which contained information regarding the total drawdown that occurred and the pumping rate achieved during initial testing of the wells immediately after they were drilled.

Figure 3.8 shows the pumping rate versus total depth drilled for these 38 wells. There is a clear correlation between pumping rate and depth. The maximum pumping rate achieved was 125 gpm in a well with a total depth of 123 ft bgs. In contrast, at depths of 200 feet or deeper, the maximum reported pumping rate is 50 gpm. Below a depth of 300 feet, the maximum pumping rate reported was 10 gpm, and below a depth of 450 feet, the maximum pumping rate reported was only four gpm.

Figure 3-8 Pumping Rate (GPM) VS Depth



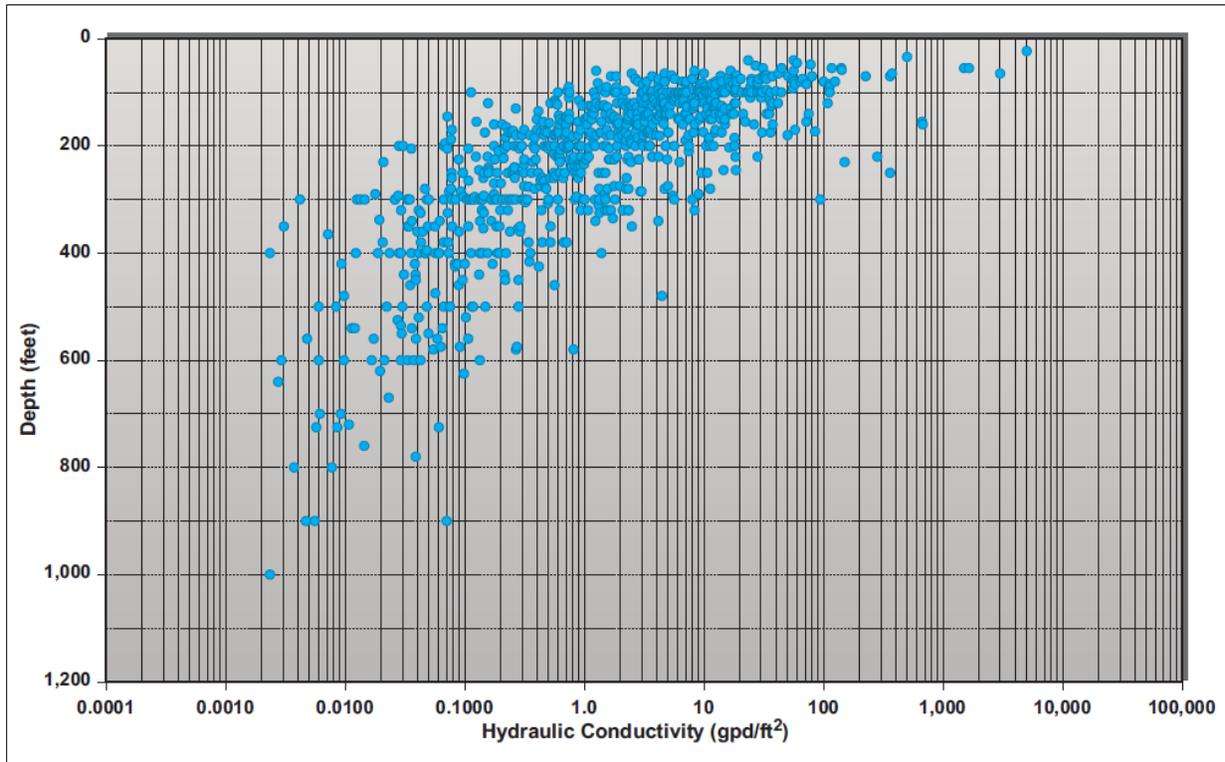
The information from the well completion reports can also be used to estimate the transmissivity in the fractured bedrock. Dividing the pumping rate, in gpm, by the drawdown that occurred as a result of the pumping, in feet, yields a value referred to as the Specific Capacity of the well. Several empirical relationships have been developed between the specific capacity and transmissivity (Thomasson, et al., 1960; Driscoll, 1986). Figure 3.9 shows the transmissivity values, calculated from the specific capacity values based on the 38 driller's logs referred to above, versus the total depth of the well. The transmissivity values in Figure 3.9 have been converted to units of feet squared per day (ft^2/day) to be consistent with the values used for the calculations described in Section 4.

As expected from the pumping rates, there is also a clear correlation between the transmissivity and depth. The two highest transmissivity values are approximately $8,780 \text{ ft}^2/\text{day}$ and $6,930 \text{ ft}^2/\text{day}$, from wells that are 300 feet and 100 feet deep, respectively. The average transmissivity for wells shallower

of 2.5×10^6 , or 2.5 million, which is very significant since groundwater flow rates and well production rates are directly proportional to the hydraulic conductivity. Overall, the transmissivity values shown on Figure 3.10 and the hydraulic conductivity values shown on Figure 3.10 indicate that 99 percent of the groundwater flow in the project area occurs above a depth of 550 ft bgs.

The range of aquifer properties with depth in the fractured bedrock are part of the existing environmental setting, but can be used to estimate the effect of dewatering of the mine workings as part of the proposed project on groundwater levels in wells adjacent to and above the underground mine workings, as discussed in Sections 4.0 and 5.0.

Figure 3-10 *Distribution of Hydraulic Conductivity with Depth (Todd Engineers, 2007)*



3.3.6 Historic Ground Water Inflow in Underground Mine Workings

The Idaho-Maryland Mine encompasses a system of underground tunnels, many raises, numerous winzes, four inclined shafts, and two vertical shafts. An estimated equivalent of 72.8 miles (117km) of underground tunnel occur at the I-M Mine, assuming typical drift dimensions of 7.5ft x 8.5ft (W x H). (AMEC, 2017)

The estimated groundwater inflow rate during the final years of the mines operation (i.e. the overall Idaho-Maryland Mine including the Brunswick underground workings) prior to mine closure around 1955

is reported to have ranged from 500 gpm to 1,200 gpm seasonally, with an average of approximately 850 gpm (JAA, 1991).

It has been reported by previous manager of the historic mine, who worked at the mine during the period until the closure in 1955, that there were no specific areas in the mine working which produced large quantities of water. (Wildan, 1995).

Before exploration and mining can proceed, the volume of water contained in existing workings must be removed from the underground workings. Removal of the static water within the flooded mine workings is referred to as the “initial dewatering”. As the water level in the mine is lowered during the initial dewatering, groundwater will flow into the mine workings through fractures and contribute to the volume of water that must be pumped during the initial period. Thus, the initial dewatering rate, typically reported in gallons per minute (gpm), is a combination of removal of the static water and removal of groundwater that flows into the newly dewatered mine workings. Once the initial dewatering is completed, continued pumping is necessary to remove the groundwater that will constantly flow into the mine through fractures within the bedrock. For the purposes of this report, this is referred to as “maintenance dewatering”.

There are several records of past dewatering from the Idaho-Maryland portion of the mine complex and from the Brunswick mine.

In the early part of the 1900s, mine workings at the Idaho-Maryland mine extended to a depth of approximately 1,900 feet and was not connected to the Brunswick Mine. Maintenance dewatering is reported to have ranged from approximately 250 gpm for 10 months of the year to approximately 500 gpm for the remaining two months of the year, for an annual average pumping rate of approximately 300 gpm (Mine and Mineral Resources of Nevada County, California, 1918).

The mine was subsequently allowed to flood and again dewatered in 1919-1920. At this time the initial dewatering of the upper 1,000 feet of the mine occurred from September 24th 1919 to March 31st 1920, a period of approximately 190 days, where 89,500,000 gallons of water was handled at a dewatering rate averaging approximately 330 gpm over the period. (Idaho Maryland Mines Company, 1920).

Initial dewatering of the Brunswick mine in 1933, before it was connected to the Idaho-Maryland Mine, to a depth of approximately 950 feet bgs occurred at a rate of between 720-800 gpm over approximately 90 days (Clark, 2005).

3.4 Water Quality

EMKO has conducted water sampling on three separate occasions for this project. Sample locations are shown on Sheets 2 and 3. In February 2018 water sampling was conducted to identify overall water quality parameters, including general mineral and metal concentrations. EMKO collected water samples from the drains and directed collection of water samples from various depths in the New Brunswick shaft at that time. Samples were labeled based on their level below ground surfaces (samples NBS-265 through NBS-2300). Field parameters were also measured in Wolf Creek, South Fork Wolf Creek, and from a pond

on the Brunswick Industrial Site. The February 2018 sampling in the shaft was conducted by Advanced Marine Services Corporation of Carson City, Nevada, using a Niskin bottle to obtain depth-discrete samples. The Niskin bottle is shown in Plate 1, below.

Plate 1 – Niskin bottle set up to sample at the New Brunswick Shaft.



In December 2018 EMKO conducted water sampling to obtain data to support a National Pollutant Discharge Elimination System (NPDES) discharge permit application for the dewatering program. Additional water samples were obtained from and field parameters measured in the New Brunswick Shaft and Wolf Creek.

Sample locations are shown on Sheets 2 and 3.

In April 2019 EMKO measured field parameters and conducted water sampling on South Fork Wolf Creek, the East Eureka Drain (IMD-1), and on Wolf Creek.

In August 2019 EMKO measured field parameters at the Centennial Drive bridge on Wolf Creek and at two locations on South Fork Wolf Creek.

In September 2019, December 2019, and January 2020, Balance (2020) measured water temperature, conductance, pH and turbidity in two reaches of South Fork Wolf Creek. The upstream measurements were made at the location of the proposed discharge point of the treated water from the mine. The

downstream measurements were made at the location where the creek enters a box culvert at Ophir Street in the City of Grass Valley.

Water samples were submitted to California Laboratory Services (CLS) in Rancho Cordova, California. CLS is certified with the California State Water Resources Control Board through the Environmental Laboratory Accreditation Program (ELAP). Laboratory Analytical Reports are included in Appendix C.

Table 3.5 shows the field parameters measured in the drains and for the water samples from the New Brunswick shaft. Tables 3.6 and 3.7 present the laboratory analytical results from the samples collected in February 2018 and December 2018, respectively. Table 3.8 provides the field parameters measured at surface water locations, while Table 3.9 presents the laboratory analytical results from the samples collected in April 2019. Table 3.10 summarizes the field measurements made by Balance (2020) along South Fork Wolf Creek.

3.4.1 General Water Chemistry Conditions

The evaluation of water chemistry conditions presented below addresses two specific sets of observations. Water chemistry data from the New Brunswick shaft and from the drains provides an indication of existing conditions in groundwater related to these features. Surface water chemistry data provides insight into seasonal variations in water quality related to different water sources, including local stormwater runoff, releases from the DS Canal system, discharge from the drains, and discharge of groundwater through fractures in the bedrock.

3.4.1.1 Water Chemistry in the New Brunswick Shaft and Drains

The water within the New Brunswick shaft and flowing from the drains is groundwater that has entered the mine workings through the fractures in the subsurface. Field measurements indicate that the pH values measured from water samples from the New Brunswick shaft are relatively consistent at 6.83 to 7.20 (Table 3.5). The pH values at the drains range between 6.97 and 7.67 (Table 3.5).

Oxidation-reduction potential (ORP) measurements from the New Brunswick shaft and the ED-1, IMD-1 and IMD-2 drains are all strongly reducing (i.e. negative), with ORP values ranging from -47 millivolts (mV) to -120 mV (Table 3.5). The ORP for the D-1 drain indicates oxidizing conditions at +53.2 mV (Table 3.5). The appreciably different ORP value at D-1 suggests that the water seeping from that drain is not related to the groundwater within the underground mine workings.

Table 3-5 Water Quality Field Measurements, Drains and Shaft Samples, Idaho-Maryland Mine Project

Field Parameters	Units	IMD-1		IMD-2	D-1	ED-1	NBS-300	NBS-1300	NBS-Pump
		15/02/2018	17/04/2019	15/02/2018	13/02/2018	13/02/2018	16/02/2018	15/02/2018	18/12/2018
Temperature	Degrees C	15.5	15.6	15.3	15.8	15.8	14.6	14.3	14.52
Specific Conductance (EC)	umhos/cm	452	268	457	320	475	410	408	338
Dissolved Oxygen	Percent Saturation	33.8	20.7	29.6	78.3	22	24.3	48	NM
Dissolved Oxygen	mg/L	3.37	1.88	2.95	7.74	2.18	2.44	4.84	NM
pH	std units	7.17	7.11	7.16	7.67	6.97	7.12	7.2	6.83
Oxidation-Reduction Potential	mV	-116.6	-47	-90.4	53.2	-120.4	-111.2	-114.6	-64

Locations:

IMD-1: Corrugated steel culvert in Wolf Creek just west of Roto-Rooter building

IMD-2: East Eureka Shaft under Roto-Rooter building

D-1: Unnamed drain on north side of Idaho-Maryland Rd across from Roto-Rooter building

ED-1: Eureka Drain at northwest corner of Idaho-Maryland Rd and Spring Hill Dr

NBS-XXXX: New Brunswick Shaft (XXXX = sample depth below collar)

NBS-Pump: New Brunswick Shaft from pump (approx. 260 ft below collar)

The total dissolved solids (TDS) level within all of the samples from the New Brunswick shaft and from the drains is within a relatively narrow range of 200 milligrams per liter (mg/L) to 230 mg/L (Tables 3.6 and 3.7). These TDS concentrations are not substantially elevated, especially for groundwater within mineralized bedrock formations. The lack of elevated TDS concentrations in the water in the shaft and from the drains could be due to the relatively young age of the groundwater (see discussion of stable isotope findings in Section 3.5) and the resulting short contact time of the water with the bedrock.

Acute toxicity tests measure the rate of survival of specified fish species, such as rainbow trout or fathead minnows, within a sufficiently large water sample. The tests are intended to assess whether the water contains any salts, minerals, or contaminants that could be acutely harmful to aquatic organisms. Rainbow trout are generally more sensitive than other species used for acute toxicity tests and, thus, provide a conservative or protective assessment of overall water quality relative to aquatic life. Discharge permits that may apply to this project (see Section 4.6) typically require that the acute toxicity tests have a survival rate of at least 70 percent for a single test and a median of 90 percent for three consecutive tests. Acute toxicity tests conducted on the December 2018 sample from the New Brunswick shaft had a 100 percent survival rate for rainbow trout (Table 3.7).

Table 3-6 February Laboratory Analytical Results, Idaho-Maryland Mine Project

Laboratory Parameters	Units	D-1	ED-1	IMD-1	IMD-2	NBS-265	NBS-900	NBS-1300	NBS-1600	NBS-2300	Regulatory Standards
		2/13/2018	2/13/2018	2/15/2018	2/15/2018	2/15/2018	2/15/2018	2/15/2018	2/15/2018	2/15/2018	
General Chemistry											
Ammonia as N	ug/L	<100	50	<100	240	<100	NA	NA	NA	66	25
Bicarbonate as Ca CO ₃	mg/L	210	220	220	220	190	200	190	200	180	
Biochemical Oxygen Demand	mg/L	<3.0	8	15	2	6.6	NA	NA	NA	8.3	
Calcium	mg/L	12	47	47	48	53	53	54	52	55	
Carbonate as CaCO ₃	mg/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
Chloride	mg/L	2.9	2.4	2.3	2.5	2.2	2.2	2.2	2.2	2.2	
Cyanide (amenable)	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	
Cyanide (total)	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0052
Fluoride	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	2
Hardness as CaCO ₃	mg/L	220	210	200	210	190	190	190	190	200	
Hydroxide as CaCO ₃	mg/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	
Magnesium	mg/L	46	22	20	21	14	14	14	14	14	
MBAS	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	
Nitrate as N	mg/L	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	10
Nitrite as N	mg/L	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	1
pH (lab)	std units	7.70	7.09	7.25	7.09	7.22	7.25	7.27	7.27	7.22	6.5 - 8.5
Potassium	mg/L	<1.0	2.4	2.3	2.5	1.7	1.6	1.7	1.6	1.7	
Sodium	mg/L	2.7	13	13	13	7.7	7.5	7.7	7.4	7.9	
Specific Conductance (lab)	umhos / cm	420	420	410	410	360	360	370	360	360	900
Sulfate as SO ₄	mg/L	13	<0.50	0.55	0.83	0.62	<0.50	<0.50	<0.50	<0.50	
Total Alkalinity	mg/L	210	220	220	220	190	200	190	200	180	
Total Dissolved Solids	mg/L	210	230	220	230	210	200	220	200	200	
Total Suspended Solids	mg/L	<5.0	11	<5.0	180	<5.0	NA	NA	NA	<5.0	10
Petroleum Hydrocarbons											

Laboratory Parameters	Units	D-1	ED-1	IMD-1	IMD-2	NBS-265	NBS-900	NBS-1300	NBS-1600	NBS-2300	Regulatory Standards
		2/13/2018	2/13/2018	2/15/2018	2/15/2018	2/15/2018	2/15/2018	2/15/2018	2/15/2018	2/15/2018	
TPH as Diesel	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	
TPH as Motor Oil	mg/L	<0.050	<0.050	<0.050	<0.050	0.83	<0.050	<0.050	<0.050	<0.050	
TPH as Gasoline	ug/L	<50	<50	<50	<50	<50	<50	<50	<50	NA	
Metals											
Aluminum	ug/L	<50	290	<50	<50	<50	<50	<50	<50	<50	200
Antimony	ug/L	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	6
Arsenic	ug/L	6.6	59	41	37	<2.0	<2.0	<2.0	<2.0	<2.0	10
Barium	ug/L	<100	130	130	130	<100	<100	<100	<100	<100	1000
Beryllium	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	4
Boron	ug/L	<100	140	140	140	<100	<100	<100	<100	<100	
Cadmium	ug/L	<1.0	<1.0	<1.0	<1.0	1.7	<1.0	<1.0	<1.0	<1.0	1.8 (HD)
Chromium	ug/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	150 (HD)
Copper	ug/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	6.5 (HD)
Iron	ug/L	<100	4800	2200	1600	1600	1600	1600	1600	1600	300
Lead	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1.8 (HD)
Manganese	ug/L	<20	310	200	210	270	230	230	230	240	50
Mercury	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.05
Molybdenum	ug/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	
Nickel	ug/L	24	<10	<10	<10	<10	<10	<10	<10	<10	36 (HD)
Selenium	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	5
Silver	ug/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	1.9 (HD)
Thallium	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.7
Vanadium	ug/L	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	
Zinc	ug/L	<50	94	<50	<50	66	<50	<50	<50	<50	83 (HD)
Bacteriological											
E. Coli	MPN / 100 mL	<1.8	<1.8	<1.8	2	<1.8	NA	NA	NA	<1.8	Present
Fecal Coliform	MPN / 100 mL	<1.8	<1.8	<1.8	2	<1.8	NA	NA	NA	<1.8	Present
Total Coliform	MPN / 100 mL	>1600	140	2	17	2	NA	NA	NA	<1.8	>1X

Laboratory Parameters	Units	D-1	ED-1	IMD-1	IMD-2	NBS-265	NBS-900	NBS-1300	NBS-1600	NBS-2300	Regulatory Standards
		2/13/2018	2/13/2018	2/15/2018	2/15/2018	2/15/2018	2/15/2018	2/15/2018	2/15/2018	2/15/2018	
Organic Priority Pollutants											
PCBs	ug/L	All <0.50	All <0.50	All <0.50	All <0.50	All <0.50					
SVOCs	ug/L	All ND	All ND	All ND	All ND	NA					
cis-1,2-Dichloroethylene	ug/L	<0.50	<0.50	<0.50	<0.50	2.4	1.8	2.4	3.1	NA	6/ND
Toluene	ug/L	<0.50	<0.50	<0.50	1.1	<0.50	<0.50	<0.50	<0.50	NA	150
All other VOCs	ug/L	All ND	All ND	All ND	All ND	NA					
Radiological											
Gross Alpha	pCi/L	0.057+/-0.936	0.784+/-1.20	0.980+/-1.27	1.78+/-0.810	1.02+/-1.24	NA	NA	NA	0.986+/-1.25	15/5
Radium 226	pCi/L	0.000+/-0.047	0.096+/-0.115	0.000+/-0.046	0.094+/-0.113	0.047+/-0.092	NA	NA	NA	0.117+/-0.122	3
Uranium	pCi/L	0.229+/-0.450	0.000+/-0.329	0.459+/-0.551	0.000+/-0.329	0.229+/-0.450	NA	NA	NA	0.229+/-0.450	20
Radium 228	pCi/L	0.000+/-0.584	0.143+/-0.654	0.000+/-0.588	0.113+/-0.645	0.000+/-0.546	NA	NA	NA	0.001+/-0.672	2

See Sheets 2 & 3 for sample locations.

Yellow highlighted cells are results that exceed MCLs or anticipated NPDES discharge standards.

ND = Not detected above laboratory reporting limit

NA = Not analyzed

Table 3-7 December 2018 NPDES Laboratory Analytical Results, Idaho-Maryland Mine Project

Laboratory Parameters	Units	NBS-Pump	WC-Up	WC-Mid	WC-Down	NPDES Limits
		12/18/2018	12/18/2018	12/18/2018	12/18/2018	
General Chemistry						
Ammonia as N	ug/L	NA	NA	NA	NA	25
Bicarbonate as Ca CO ₃	mg/L	190	87	50	67	
Biochemical Oxygen Demand	mg/L	NA	NA	NA	NA	
Calcium	mg/L	51	16	11	12	
Carbonate as CaCO ₃	mg/L	<5.0	<5.0	<5.0	<5.0	
Chloride	mg/L	2.2	4.5	3	3.2	
Cyanide (amenable)	mg/L	NA	NA	NA	NA	
Cyanide (total)	mg/L	0.0022 (J)	0.0026 (J)	0.0018 (J)	<0.0050	0.0052
Fluoride	mg/L	NA	NA	NA	NA	
Hardness as CaCO ₃	mg/L	180	100	64	69	
Hydroxide as CaCO ₃	mg/L	<5.0	<5.0	<5.0	<5.0	
Magnesium	mg/L	14	15	9.2	9.5	
MBAS	mg/L	NA	NA	NA	NA	
Nitrate as N	mg/L	NA	NA	NA	NA	10
Nitrite as N	mg/L	NA	NA	NA	NA	10
pH (lab)	std units	NA	NA	NA	NA	6.5 - 8.5
Potassium	mg/L	1.4	1.5	1.3	1.1	
Sodium	mg/L	7.7	5.5	4.2	4.3	
Specific Conductance (lab)	umhos/cm	400	200	140	170	900
Sulfate as SO ₄	mg/L	NA	NA	NA	NA	
Total Alkalinity	mg/L	190	87	50	67	
Total Dissolved Solids	mg/L	210	140	91	82	
Total Phosphorus, as P	mg/L	<0.050	<0.050	<0.050	<0.050	
Turbidity	NTU	4.7	2.5	2.4	1.9	5
Total Anions	meq/L	3.9	2	1.6	1.6	
Total Cations	meq/L	4.1	2.1	1.5	1.6	
Ion Balance RPD	%	6	4	9.8	3	
Total Suspended Solids	mg/L	NA	NA	NA	NA	10
Metals						
Aluminum	ug/L	16 (J)	110	130	100	200
Antimony	ug/L	<5.0	<5.0	<5.0	<5.0	6
Arsenic	ug/L	2.1	1.3	1.8	4.0	10
Barium	ug/L	NA	NA	NA	NA	
Beryllium	ug/L	<1.0	<1.0	<1.0	<1.0	4
Boron	ug/L	26 (J)	10 (J)	10 (J)	18 (J)	
Cadmium	ug/L	<0.25	<0.25	<0.25	<0.25	1.8 (HD)

Laboratory Parameters	Units	NBS-Pump	WC-Up	WC-Mid	WC-Down	NPDES Limits
		12/18/2018	12/18/2018	12/18/2018	12/18/2018	
Hexavalent Chromium	ug/L	<1.0	<1.0	<1.0	<1.0	10
Chromium	ug/L	0.32 (J)	0.77 (J)	0.67 (J)	0.76 (J)	150 (HD)
Copper	ug/L	0.40 (J)	2	1.3	1.4	6.5 (HD)
Iron	ug/L	1400	240	250	310	300
Lead	ug/L	<0.50	<0.50	<0.50	<0.50	1.8 (HD)
Manganese	ug/L	230	15 (J)	16 (J)	35	50
Mercury	ug/L	<0.050	<0.050	<0.050	<0.050	0.05
Molybdenum	ug/L	NA	NA	NA	NA	
Nickel	ug/L	<5.0	4.5 (J)	3.2 (J)	3.4 (J)	36 (HD)
Selenium	ug/L	<5.0	<5.0	<5.0	<5.0	5
Silver	ug/L	<1.0	<1.0	<1.0	<1.0	1.9 (HD)
Thallium	ug/L	0.12 (J)	<1.0	<1.0	<1.0	1.7
Vanadium	ug/L	NA	NA	NA	NA	
Zinc	ug/L	5.5 (J)	7.2 (J)	3.2 (J)	4.7 (J)	83 (HD)
Acute Toxicity (96-hr bioassay with Rainbow Trout)						
Percent Survival	%	100	100	100	100	
Organic Priority Pollutants						
PCBs & Pesticides (EPA 608)	ug/L	All ND	All ND	All ND	All ND	
BEP	ug/L	5.3	<1.5	<1.5	<1.5	
All Other SVOCs (EPA 625)	ug/L	All ND	All ND	All ND	All ND	
PAHs (EPA 610)	ug/L	All ND	All ND	All ND	All ND	
2,3,7,8-TCDD (EPA 1613)	pg/L	<0.233	<0.233	<0.233	<0.233	0.013
cis-1,2-Dichloroethylene	ug/L	4.2	<0.50	<0.50	<0.50	10 (T)
All other VOCs (EPA 624)	ug/L	All ND	All ND	All ND	All ND	

See Sheets 2 & 3 for sample locations.

Yellow highlighted cells are results that exceed anticipated NPDES discharge standards.

ND = Not detected above laboratory reporting limit

NA = Not analyzed

BEP = bis(2-ethylhexyl) phthalate

meq/L = milliequivalents per liter

RPD = Relative Percent Difference

ug/L = micrograms per liter

mg/L = milligrams per liter

pCi/L = picocuries per liter

umhos/cm = micromhos per centimeter

MPN/100 mL = Most Probable Number per 100 milliliters

(J) = Analyte detected below the laboratory reporting limit

NTU = Nephelometric Turbidity Units

2,3,7,8-TCDD = 2,3,7,8-tetrachloro-dibenzo(p)dioxin

pg/L = picograms per liter

HD = Hardness-dependent metal limits (based on hardness of WC-Mid sample)

The primary constituents of interest in the water samples from the New Brunswick shaft and the drains are iron and manganese. Within the New Brunswick shaft, the iron concentration ranges from 1,400 micrograms per liter ($\mu\text{g/L}$) to 1,600 $\mu\text{g/L}$ (Tables 3.6 and 3.7). While iron is not present in drain D-1, in

the other three drains, the iron concentration ranges from 1,600 µg/L up to 4,800 µg/L (Table 3.6). The secondary drinking water maximum contaminant level (MCL) and the NPDES effluent limit for iron are both 300 µg/L.

Within the New Brunswick shaft, the manganese concentration ranges from 230 µg/L to 270 µg/L (Tables 3.6 and 3.7). Similar to iron, manganese is not present in drain D-1, while in the other three drains, the manganese concentration ranges from 200 µg/L up to 310 µg/L (Table 3.6). The MCL and the NPDES effluent limit for manganese are both 50 mg/L.

Arsenic has been detected above its MCL and NPDES effluent limit of 10 µg/L in three of the drain samples, ranging from 37 µg/L in IMD-2 to 41 µg/L in IMD-1 to 59 µg/L in ED-1 (Table 3.6). The arsenic concentration at D-1 is 6.6 µg/L. The arsenic concentration does not exceed the MCL or NPDES effluent limit in any of the samples from the New Brunswick shaft or from Wolf Creek (Tables 3.6, 3.7, and 3.9).

The compound cis-1,2-dichloroethylene (cis-1,2-DCE) is detected in all samples from the New Brunswick shaft at concentrations ranging from 1.8 µg/L to 4.2 µg/L (Tables 3.6 and 3.7). This compound generally occurs as a breakdown product of the industrial solvent trichloroethylene (TCE) or the dry-cleaning solvent tetrachloroethylene (PCE). Neither of these parent compounds were detected in any of the water samples. The presence of cis-1,2-DCE in the water samples from the New Brunswick shaft could be due to two potential sources. One potential source is historic solvent use within the New Brunswick mine for equipment repair or maintenance. Any residual solvent could have broken down into cis-1,2-DCE within the reducing conditions that occur within the water in the mine. The second potential source is seepage of shallow groundwater into the New Brunswick shaft from the adjacent former SPI Mill site, located to the southeast. The Mill site was known to have industrial solvent impacts, including cis-1,2-DCE, in shallow groundwater in the past (SPI, 1999). The shaft has a general downward flow path to allow water seeping into the shaft from shallow depths to flow toward the other mines through tunnels at greater depths (see discussion in Section 3.5). The consistent presence and relatively uniform concentration of the cis-1,2-DCE indicates that if the source was due to historic solvent use in the New Brunswick mine, then the solvent use would have had to occur primarily within the shaft above the shallowest mine workings connected to the shaft, at the 580FT level of the mine, or occurred relatively uniformly throughout the entire mine, both of which seem unlikely. Thus, the most likely source for the cis-1,2-DCE in the New Brunswick shaft is seepage of shallow groundwater from the Mill site into the upper part of the shaft and downward movement of this seepage within the shaft.

Previous water quality sampling was conducted in 1991 from the drains and the New Brunswick shaft (Condor, 1994). In 2006, IMMC conducted groundwater sampling at several depths from the New Brunswick shaft, as reported by Walker and Associates, Inc. (2008). The reported water quality from 1991 and 2006 is consistent with the findings presented in this report. Thus, there does not appear to be any significant change in the water quality in the shaft, drains, or creeks over the last two to three decades.

3.4.1.2 Surface Water Chemistry

Surface water within Wolf Creek and South Fork Wolf Creek may come from three distinct sources. These sources are stormwater runoff from within the respective watersheds, discharge of groundwater through fractures and drains, and transfer of water from other watersheds through the NID canal system. Each of these water sources is expected to have a different water chemistry. As a result, the water chemistry measured in the creeks may vary seasonally or over time, depending primarily on the amount of local rainfall and the magnitude and duration of NID canal releases.

During February 2018, NID releases to Wolf Creek from the DS Canal were low, in the range of 2.5 cfs (see Figure 3.5). Rainfall in February 2018 was 0.75 inches. During December 2018, NID releases to Wolf Creek from the DS Canal were very low, typically 1.5 cfs or less (see Figure 3.5). Rainfall in December 2018 was 4.72 inches. During April 2019, NID was increasing the rate of water releases to Wolf Creek from the DS Canal, with flows increasing from 5 cfs to over 19 cfs from April 1, 2019 to April 17, 2019 (see Figure 3.5). Rainfall in April 2019 was 2.89 inches.

Based on the NID releases to Wolf Creek and rainfall amounts, the flows in Wolf Creek in February 2018 were most likely a combination of groundwater discharge and local stormwater runoff. The flows in Wolf Creek in December 2018 were also most likely a combination of groundwater discharge and local stormwater runoff. In contrast, the discharges from the DS Canal in April 2019 indicate that almost 40 percent of the total 50 cfs flow at the Centennial Drive bridge was canal water from NID Upper Division sources at higher elevations, as described in Section 3.2.

Field measurements indicate the pH in Wolf Creek ranges from 6.8 to 7.53 (Table 3.8). However, looking at individual sampling events on Wolf Creek, in February 2018 the pH ranged from 7.06 to 7.33, in December 2018 the pH ranged from 7.45 to 7.53, and in April 2019 the pH ranged from 7.19 to 7.50. In addition, the pH in Wolf Creek tends to decrease slightly from upstream to downstream during individual sampling events. As reported in Section 3.4.1.1, above, the pH levels in the groundwater in the New Brunswick shaft and flowing from the drains are generally lower than the pH at the upstream sample location on Wolf Creek. Thus, the decreasing pH trend in the downstream direction is consistent with groundwater discharge mixing with the upstream flow in Wolf Creek.

Table 3-8 Water Quality Field Measurements, Surface Water Sites, Idaho-Maryland Mine Project

Field Parameters	Units	WC-Up	Wolf Creek at IMD-1		Wolf Creek at Centennial Drive Bridge			Wolf Creek where D-1 discharge enters creek	WC-Down
		18/12/2018	15/02/2018	17/04/2019	18/12/2018	17/04/2019	08/08/2019	13/02/2018	18/12/2018
Temperature	Degrees C	9.73	5.6	9.64	8.53	9.07	13.05	7.3	9.42
Specific Conductance (EC)	umhos/cm	180	69	76	115	53	35	92	126
Dissolved Oxygen	Percent Saturation	105.7	83.9	88.8	111.9	88.4	110.8	91.6	101.3
Dissolved Oxygen	mg/L	11.99	10.57	9.4	13.07	9.26	10.54	11.05	11.58
pH	std units	7.53	7.33	7.5	7.49	7.27	6.8	7.06	7.45
Oxidation-Reduction Potential	mV	103.6	-7.3	32	-13.5	155.5	148	-13.3	59.7

Field Parameters	Units	Wolf Creek at Vet Hospital below DiMartini	South Fork Wolf Creek along Brunswick Rd prior to entering SPI culvert	Clay-Lined Pond at SPI	Culvert discharge to South Fork Wolf Creek (SPI discharge)			South Fork Wolf Creek below SPI Site	South Fork Wolf Creek at Drill Pad	
		17/04/2019	15/02/2018	15/02/2018	15/02/2018	17/04/2019	08/08/2019	15/02/2018	17/04/2019	08/08/2019
Temperature	Degrees C	12.17	8.4	8.1	8.8	12.24	14.75	8.7	12.22	15.21
Specific Conductance (EC)	umhos/cm	65	46	209	68	54	85	68	79	93
Dissolved Oxygen	Percent Saturation	95.8	95	90.3	99.9	93.3	86.7	109	95.7	98.9
Dissolved Oxygen	mg/L	9.4	11.1	10.67	11.6	9.03	7.87	12.6	9.29	9.1
pH	std units	7.19	5.78	7.1	6.68	6.55	6.79	6.78	7.17	7.00
Oxidation-Reduction Potential	mV	79.9	60.8	22.9	-28.3	98.7	12	-22.4	88	108.4

Locations:

- IMD-1: Corrugated steel culvert in Wolf Creek just west of Roto-Rooter building
- D-1: Unnamed drain on north side of Idaho-Maryland Rd across from Roto-Rooter building
- SPI Site: Former Sierra Pacific Industries sawmill
- WC-Up: Wolf Creek east of intersection of Idaho-Maryland Rd and Sutton Way
- WC-Down: Wolf Creek east of driveway to RV sales lot

In the South Fork Wolf Creek, field pH values tend to be slightly more acidic than they are in Wolf Creek, ranging from 5.78 to 7.17 (Table 3.8). Within individual sampling events, the pH in South Fork Wolf Creek ranged from 5.78 to 6.78 in February 2018, from 6.55 to 7.17 in April 2019, and from 6.79 to 7.00 in August 2019. However, due to limited overlap in the sampling locations and only two repeat sample locations along South Fork Wolf Creek between the February 2018 and August 2019 measurements, there is currently insufficient data to make definitive conclusions about the variability of pH over time. For both sampling events, though, the pH level increased from upstream to downstream. As reported in Section 3.4.1.1, above, the pH levels in the groundwater in the New Brunswick shaft are consistently higher than the pH at the upstream sample location on South Fork Wolf Creek. Thus, the increasing pH trend in the downstream direction is consistent with groundwater discharge mixing with the upstream flow in South Fork Wolf Creek.

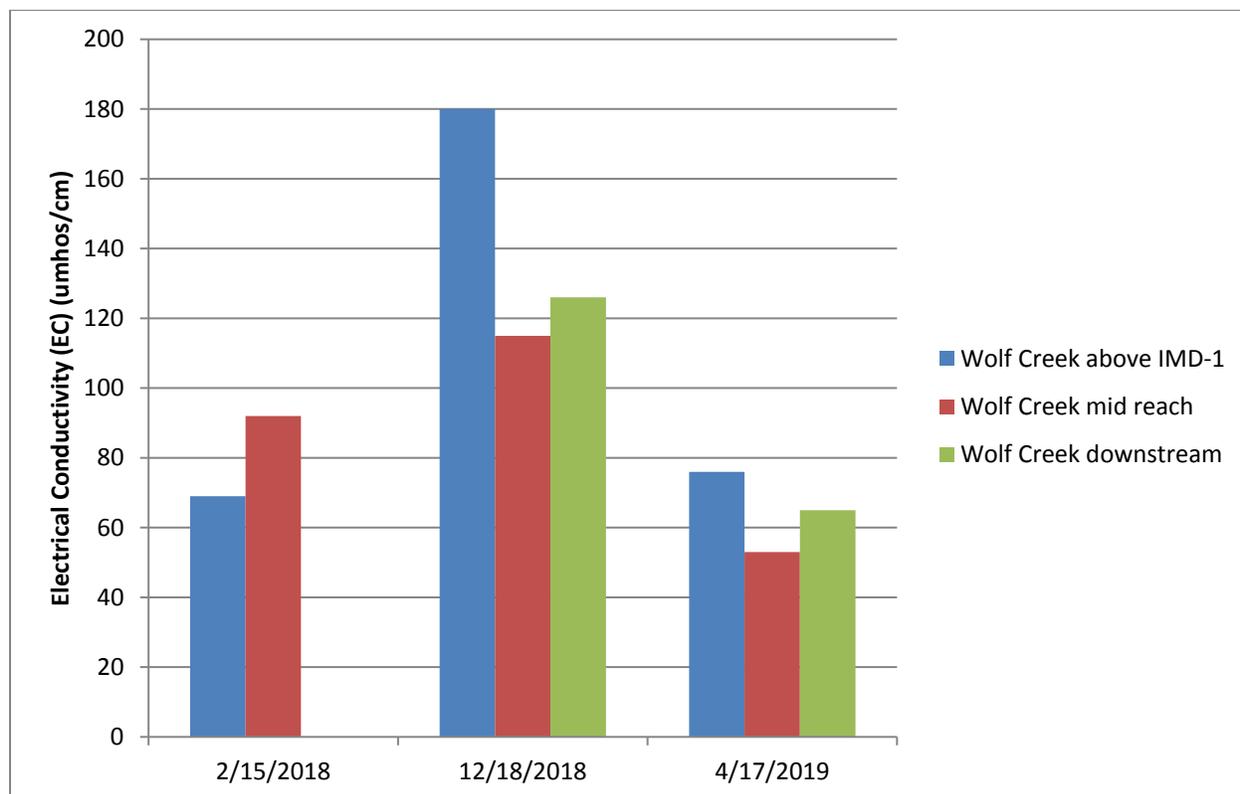
Similar to pH, ORP values vary by location upstream and downstream, and by measurement event. In Wolf Creek, the ORP levels were consistently negative (i.e. reducing) in February 2018 (Table 3.8). In December 2018, the ORP was positive in the upstream sample location, negative at the Centennial Drive bridge, and positive again at the downstream sample location (Table 3.8). In April 2019 and August 2019, the ORP values were positive at all locations monitored (Table 3.8). As discussed in Section 3.4.1.1, above, the ORP in the New Brunswick shaft and in the water from the drains is strongly reducing (i.e. very negative). Based on the ORP values, in February 2018 the flow in Wolf Creek was strongly influenced by groundwater and water from the drains. In December 2018, only the segment of Wolf Creek near Centennial Drive had an observable groundwater component. In April 2019 and August 2019, the large flow contribution from the DS Canal was apparently greater than any discharge of groundwater and flow from the drains, since the ORP values were consistently positive.

Along South Fork Wolf Creek, the ORP values vary by measurement event (see Table 3.8). In February 2018, the ORP was positive at a location upstream of the Mill site along Brunswick Road, but the ORP was negative in the water flowing out of the culvert that passes under the former SPI site and at a location downstream from the end of the culvert. In April 2019 and August 2019, the ORP in South Fork Wolf Creek was positive in the flow coming out of the end of the culvert and at a location downstream from the culvert. The ORP results from South Fork Wolf Creek suggest the following:

- Groundwater discharge and surface runoff from the upstream areas emanating from the Tertiary andesite that caps the underlying metamorphic rocks and from the Mariposa Formation has a positive ORP value;
- During February 2018, groundwater discharge was a major contributor to the flow within South Fork Wolf Creek downstream of Brunswick Road, as evidenced by the negative ORP values;
- During April 2019, surface runoff dominated the flow in South Fork Wolf Creek, based on the positive ORP values; and
- The negative ORP values in the water flowing from the end of the culvert that passes under the Mill site in February 2018, compared with the positive ORP values upstream of the culvert on the same date, indicate that the culvert is “leaky” and groundwater may readily enter the culvert as it passes under the Mill site.

The effect of surface runoff, discharge from the drains and of groundwater, and NID releases from the DS Canal are also apparent in the electrical conductivity (EC) measurements from Wolf Creek. Figure 3.11 shows the available field EC values for upstream, mid-stream, and downstream locations relative to the Idaho site. Higher EC values are most prevalent in December 2018, most likely due to a greater proportion of groundwater discharge and flow from the drains compared to local runoff early in the rainy season. Lower EC values in April 2019 reflect the high proportion of flow due to NID releases to Wolf Creek from the DS Canal.

Figure 3-11 Changes in EC in Wolf Creek Over Time



Acute toxicity tests conducted on the three samples from Wolf Creek collected in December 2018 all had a 100 percent survival rate for rainbow trout (Table 3.7).

For samples collected from Wolf Creek in December 2018, the iron concentration ranged from 240 $\mu\text{g/L}$ in the upstream sample to 310 $\mu\text{g/L}$ in the downstream sample and the manganese concentration ranged from 15 $\mu\text{g/L}$ in the upstream sample to 35 $\mu\text{g/L}$ in the downstream sample (Table 3.7). The increasing concentration from upstream to downstream is indicative of the increasing proportion of groundwater discharge and flow from the drains as Wolf Creek passes through the project site area. A downstream sample was also collected from Wolf Creek in April 2019, with iron present at 220 $\mu\text{g/L}$ and manganese present at 21 $\mu\text{g/L}$ (Table 3.9). The lower iron and manganese concentrations in the downstream sample

in April 2019 reflect the greater proportion of flow due to releases from the DS Canal into Wolf Creek at that time, compared to December 2018.

Table 3-9 April 2019 Laboratory Analytical Results, Idaho-Maryland Mine Project

Laboratory Parameters	Units	IMD-1	SF Culvert	SF Pad	WC-D
		4/17/2019	4/17/2019	4/17/2019	4/17/2019
General Chemistry					
Ammonia as N	ug/L	87	40	<100	<100
Bicarbonate as Ca CO ₃	mg/L	240	23	32	27
Calcium	mg/L	46	4.6	7.1	5.1
Carbonate as CaCO ₃	mg/L	<5.0	<5.0	<5.0	<5.0
Chloride	mg/L	2.3	2.7	2.4	2
Fluoride	mg/L	<0.10	<0.10	<0.10	<0.10
Hardness as CaCO ₃	mg/L	120	11	18	13
Hydroxide as CaCO ₃	mg/L	<5.0	<5.0	<5.0	<5.0
Magnesium	mg/L	18	1.8	2.9	2.8
MBAS	mg/L	<0.10	<0.10	<0.10	<0.10
Nitrate as N	mg/L	<0.40	<0.40	<0.40	<0.40
pH (lab)	std units	7.2	6.82	7.38	7.55
Potassium	mg/L	2.4	1.7	1.5	<1.0
Sodium	mg/L	11	3.1	2.9	2.5
Specific Conductance (lab)	umhos/cm	450	68	82	69
Sulfate as SO ₄	mg/L	0.91	1.3	2.5	2.3
Total Alkalinity	mg/L	240	23	32	27
Total Dissolved Solids	mg/L	250	58	64	56
Metals					
Aluminum	ug/L	<50	210	130	130
Antimony	ug/L	<4.0	<4.0	<4.0	<4.0
Arsenic	ug/L	38	<2.0	<2.0	<2.0
Barium	ug/L	130	<100	<100	<100
Beryllium	ug/L	<1.0	<1.0	<1.0	<1.0
Boron	ug/L	110	<100	<100	<100
Cadmium	ug/L	<1.0	<1.0	<1.0	<1.0
Chromium	ug/L	<10	<10	<10	<10
Copper	ug/L	<50	<50	<50	<50
Iron	ug/L	1800	940	310	220
Lead	ug/L	<5.0	<5.0	<5.0	<5.0
Manganese	ug/L	180	140	57	21
Mercury	ug/L	<1.0	<1.0	<1.0	<1.0
Nickel	ug/L	<10	<10	<10	<10
Selenium	ug/L	<5.0	<5.0	<5.0	<5.0
Silver	ug/L	<10	<10	<10	<10
Thallium	ug/L	<1.0	<1.0	<1.0	<1.0
Vanadium	ug/L	<3.0	<3.0	<3.0	<3.0
Zinc	ug/L	<50	<50	<50	<50

Within South Fork Wolf Creek, the samples from April 2019 contained iron at 940 µg/L in the sample collected from the downstream end of the culvert passing under the former SPI site and 310 µg/L in the sample collected downstream near the drill pad location (Table 3.9). The manganese concentration ranged from 140 µg/L in the sample collected from the downstream end of the culvert passing under the former SPI site to 57 µg/L in the downstream sample (Table 3.9). The higher iron and manganese concentration in the water flowing out of the culvert may be reflective of groundwater seeping into the “leaky” culvert, as described above, whereas the lower concentrations downstream may be due to dilution by surface water flows from the smaller creek that joins the South Fork between these two locations (see discussion in Section 3.2).

The arsenic concentration does not exceed the MCL or NPDES effluent limit in any of the samples from Wolf Creek and South Fork Wolf Creek (Tables 3.7 and 3.9).

Table 3-10 Streamflow and General Water Quality Parameters, South Fork Wolf Creek (Balance, 2020)

Date (MM/DD/YYYY)	Location	Flow (cfs)	Temp (deg C)	Specific Conductance (µsiemens)	pH	Turbidity (NTU)	Flow Condition
9/25/2019	Reach B	0.17	13	93	7.57	NM	Summer Baseflow
	Reach F	0.4	15.3	156	7.8	NM	
12/10/2019	Reach B	NM	NM	NM	NM	NM	Post-storm
	Reach F	3.11	6.7	123	6.68	2.2	
1/24/2020	Reach B	1.56	10.5	126	7.7	9.4	Winter Baseflow
	Reach F	2.53	9.3	174	7.46	4.5	
1/26/2020	Reach B	11.0	8.7	76	7.34	125	Storm Rising Limb
	Reach F	15.3	8.6	97	7.31	115	
1/26/2020	Reach B	9.76	NM	NM	NM	79	Peak Storm Flow (1)
	Reach F	17.3	8.6	99	7.67	48	

Reach B - location of proposed treated water discharge

Reach F - at entrance to box culvert at Ophir Street

NM - Not Measured

(1) - Storm was appx. 1.25 inches in 12 hours

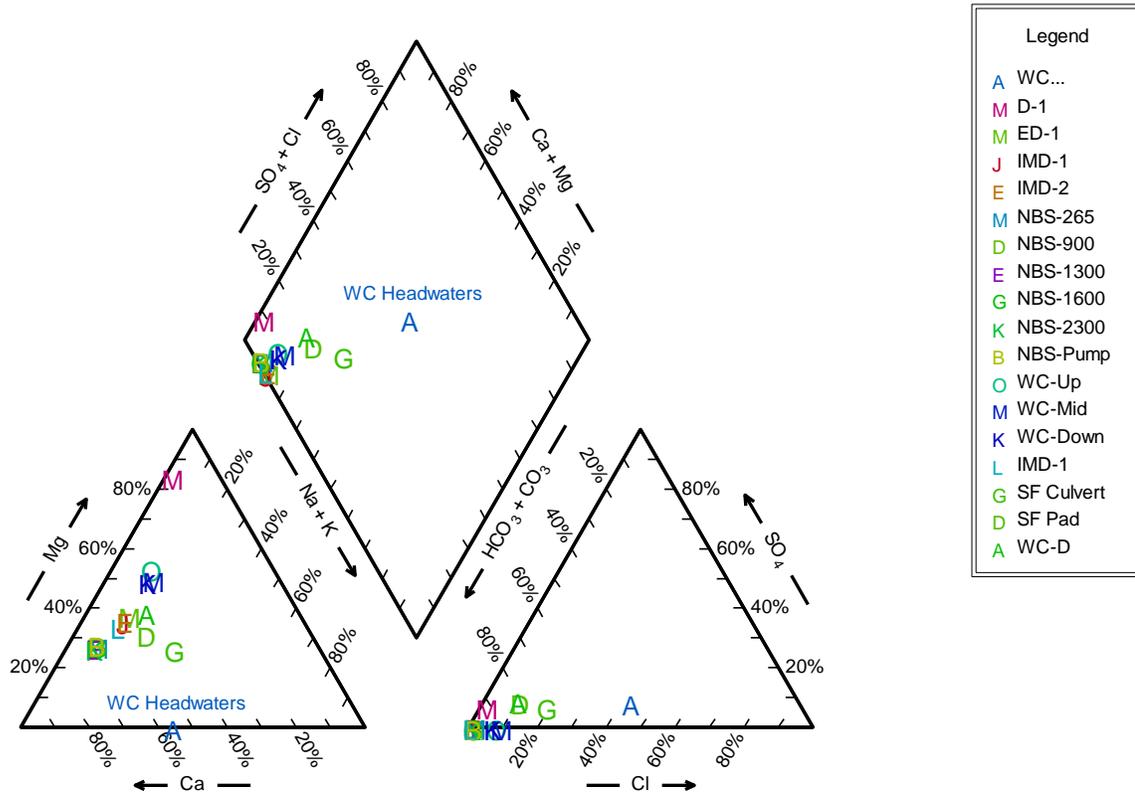
Measurements made by Balance (2020) in South Fork Wolf Creek during different flow conditions indicate that turbidity tends to increase with increases in flow, as expected due to the increasing flow velocity of the water in the creek (Table 3.10). During non-storm periods, the turbidity was less than 10 NTU. During the relatively minor storm event that was monitored, turbidity increased to as much as 125 NTU. The turbidity values were also higher in the upstream location, at the proposed treated water discharge point, than they were at the downstream location. This finding suggests that there are existing sources of fine sediment located upstream of the proposed discharge location and additional runoff that enters South Fork Wolf Creek as the flow moves downstream tends to dilute the turbidity from upstream.

Specific conductance and pH do not appear to be correlated to flow rates in South Fork Wolf Creek (Table 3.10). However, the specific conductance does tend to be higher at the downstream sample location. The higher conductance is indicative of increasing levels of dissolved solids in the water within the creek as it flows downstream. Higher levels of dissolved solids could be due to increased contribution to the flow from groundwater discharge.

3.4.2 Water Chemistry Graphical Interpretation

Graphical interpretation of water quality can be conducted using methods such as Piper Diagrams and Stiff Plots. These graphical formats are standard methods for the interpretation of water types and water quality, as described by the U.S. Geological Survey (Hem, 1989). The plots compare the relative abundance of the positively-charged ions (referred to as cations) of magnesium, calcium, sodium, and potassium in a water sample with the relative abundance of the negatively-charged ions (referred to as anions) of sulfate, bicarbonate, carbonate, and chloride in the same sample.

Figure 3.12 is a Piper Diagram showing all of the water samples collected by EMKO. In addition to the February 2018, December 2018, and April 2019 samples described above, the Piper Diagram also includes the data from a sample collected from the headwaters of Wolf Creek (labeled “WC Headwaters” on Figure 3.12) near Dobbins Drive and north of Idaho-Maryland Road. The headwater sample location is approximately 3 miles upstream (northeast) of the intersection of Centennial Drive and Idaho-Maryland Road (EMKO, 2011). Two of the samples on the Piper Diagram appear to be outliers. One is the sample from the headwaters of Wolf Creek. Whereas the other samples are primarily magnesium or calcium-bicarbonate waters, the headwaters sample contains appreciable levels of sodium and chloride. The other outlier is the sample from the D-1 drain, based on its plotted position relative to other sample locations in the lower left-hand triangle on the Piper Diagram (Figure 3.12). The sample from the D-1 drain contains a substantially greater proportion of magnesium compared to calcium than in the other drain, shaft, and creek samples. Therefore, the water from D-1 appears to be from a different source than the water from the other three drain samples, which is consistent with the observation regarding the ORP value from D-1 as discussed in Section 3.4.1.1.

Figure 3-12 Piper Diagram of Water Quality Data

Samples collected from all depths within the New Brunswick shaft plot in the same position on each of the three components of the Piper Diagram (Figure 3.12). The Stiff Plots for the shaft water samples (Figures 3.13 and 3.14) show a distinctive calcium-bicarbonate plot shape that is nearly identical for all sample depths. The virtually identical water chemistry signature at all depths in the shaft is consistent with the conceptual model discussed in Section 3.5, below. Percolation of rainfall through the shallow fractures within the Brunswick Porphyrite Block would become enriched in calcium and carbonate-related chemical species (in this case, bicarbonate), in accordance with the mineralogy of the rock and veining, as described in Section 3.1. Continued downward movement through the shaft toward the B2300 and B3280 levels would maintain a consistent water chemistry signature, as reflected in the Stiff Plots on Figures 3.13 and 3.14. If the water was not continuously moving downward through the shaft, the deeper water would have a higher mineral content due to longer contact time with the surrounding rock, resulting in more elongated Stiff Plots in the deeper shaft samples than in the shallow shaft samples.

Figure 3-13 Stiff Plots for New Brunswick Shaft Samples NBS-265, NBS-900, and NBS-1300

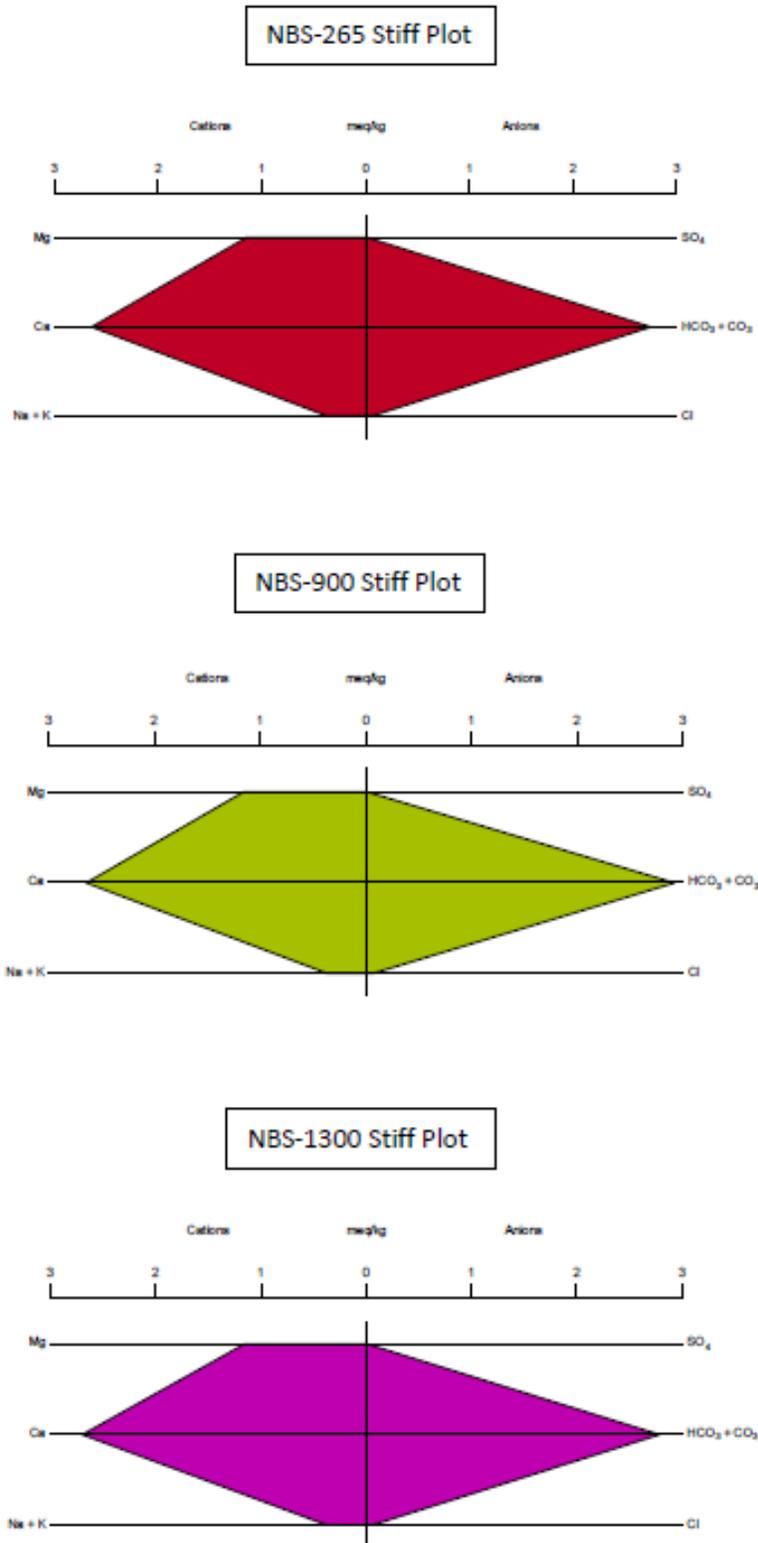
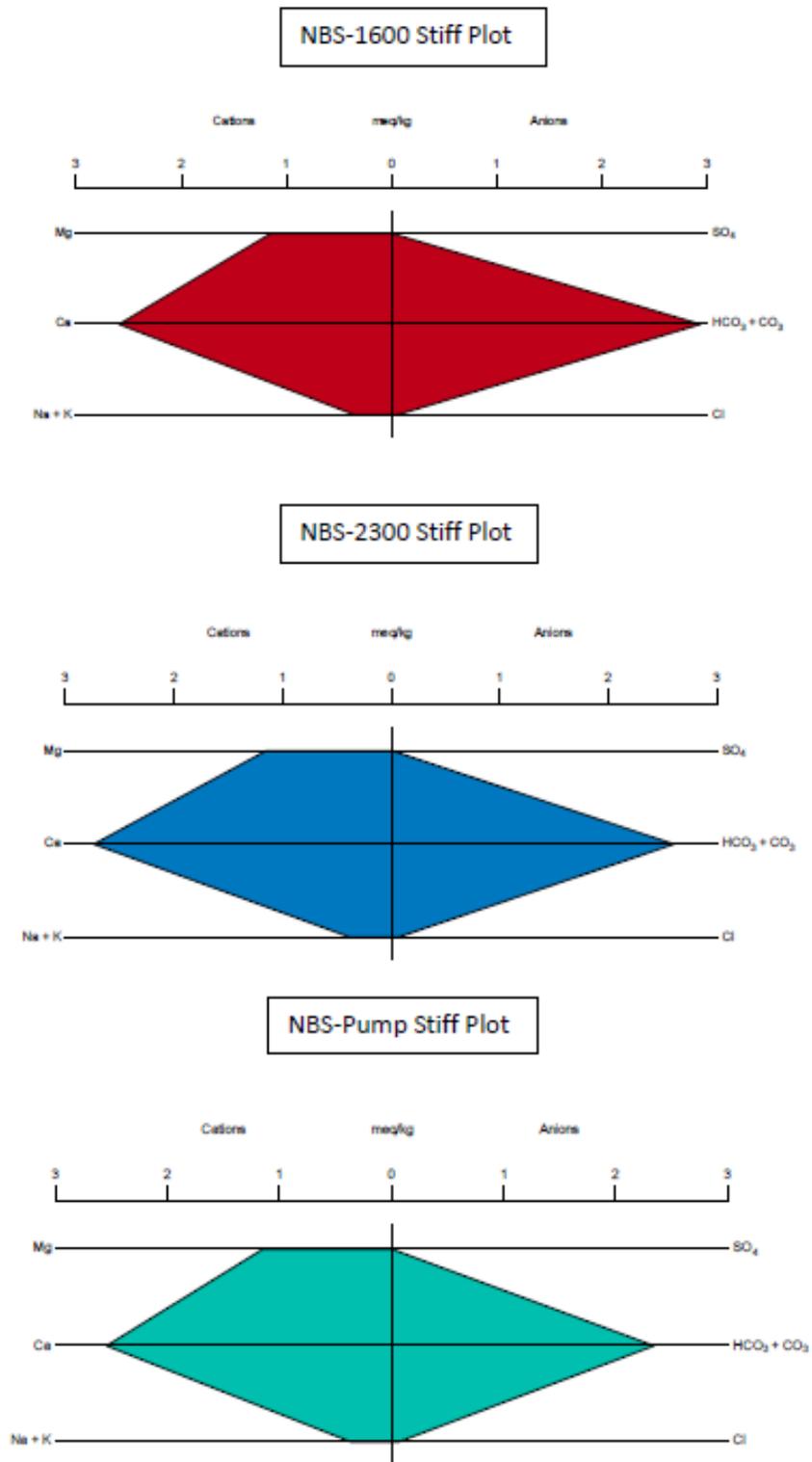


Figure 3-14 Stiff Plots for New Brunswick Shaft Samples NBS-1600, NBS-2300, and NBS-Pump



Samples collected from the ED-1, IMD-1, and IMD-2 drains plot in the same position on each of the three components of the Piper Diagram (Figure 3.12). The Stiff Plots for these three drain samples (Figures 3.15 and 3.16) show a mixed calcium and magnesium-bicarbonate water type, with the Stiff Plot shape being almost identical for all three drain samples and for both sample events for IMD-1. The nearly identical water chemistry signature from the three drains indicates that they are all sourced from the same underground mine workings. As discussed in Section 3.3.3, the water flowing from the drains is interpreted to be coming from the combined Eureka-Idaho-Maryland-Brunswick underground workings. As discussed above, the water that is entering the underground workings via the New Brunswick shaft is a calcium-bicarbonate water due to the mineralogy of the surrounding rock. Much of the Eureka, Idaho, and Maryland underground workings are within more mafic gabbro and serpentinite rocks, which have a higher magnesium content, as described in Section 3.1. Thus, as the calcium-bicarbonate water from the New Brunswick shaft area moves into the other underground workings, the Stiff Plots suggest that the magnesium content of the water increases due to the change in rock type through which the water is passing. The transition from a calcium-bicarbonate water in the New Brunswick shaft to a mixed calcium and magnesium-bicarbonate water is consistent with and supports the conceptual model of groundwater movement through the underground workings, as described in Section 3.4.5, below.

Figure 3-15 Stiff Plots for Drain Samples – ED-1 and IMD-2 February 2018

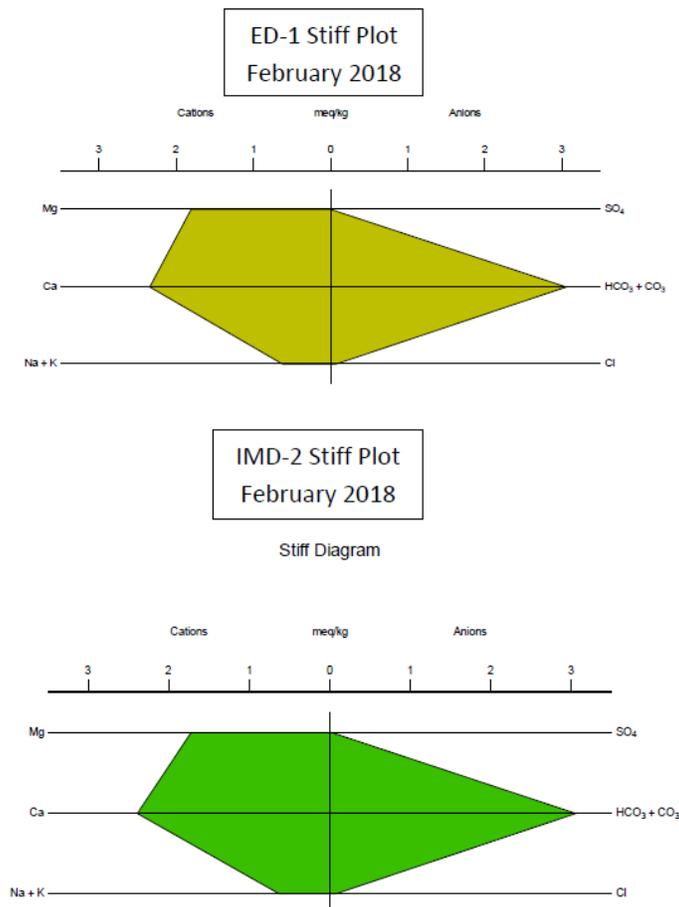
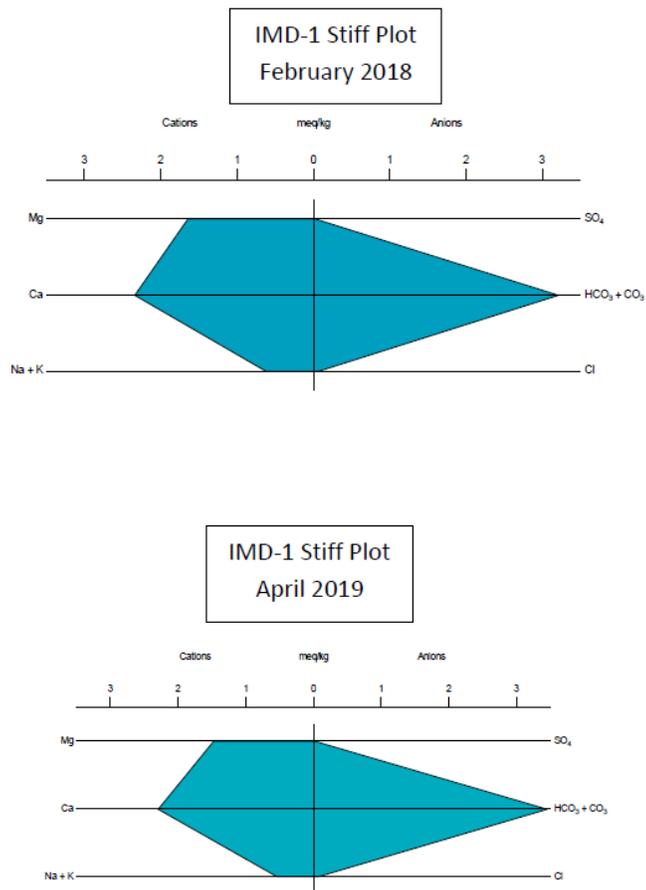


Figure 3-16 Stiff Plots for Drain Samples – IMD-1 February 2018 and April 2019

The three different samples collected along Wolf Creek in the project area in December 2018 plot in the same position on each of the three components of the Piper Diagram (Figure 3.12). However, the downstream sample collected in April 2019 plots in a slightly different position on the Piper Diagram. The Stiff Plots on Figures 3.17 and 3.18 for the Wolf Creek samples show that the December 2018 samples are all a magnesium-bicarbonate water type, with a relatively high proportion of calcium and little or no sulfate. Immediately upstream of and within the Project area, Wolf Creek flows over the gabbro and serpentinite deposits described in Section 3.1. These geologic units, along with discharge of groundwater and water from the drains, apparently impart a magnesium signature on the water and alter it from that observed in the headwaters sample, described above. However, the April 2019 sample from the downstream location has an appreciably lower TDS level than the December 2018 samples from Wolf Creek, with a decrease in the proportion of magnesium to calcium, and an increase in sulfate. The change in the general water chemistry within Wolf Creek in April 2019 can be attributed to the release of water from the DS Canal, as described in Section 3.2.

Addition of the water from the drains into Wolf Creek also alters other water chemistry parameters, beyond just the proportion of calcium relative to magnesium. As can be seen in Tables 3.7 and 3.8, the

most upstream sample from Wolf Creek has the highest pH, temperature, and concentration of total dissolved solids (TDS). In the midstream and downstream samples, the addition of the water from the drains appears to slightly reduce the pH and temperature and to appreciably reduce the TDS concentration, which are all positive effects on water quality. With respect to metals, the addition of the drain water to the creek slightly increases the levels of arsenic, iron, and manganese, while slightly decreasing the levels of copper, nickel and zinc. Despite these changes, the reported concentrations of all metals and other constituents in the Wolf Creek samples are well below the NPDES water quality standards.

Figure 3-17 Stiff Plots for Wolf Creek Samples – WC-Up and WC-Mid December 2018

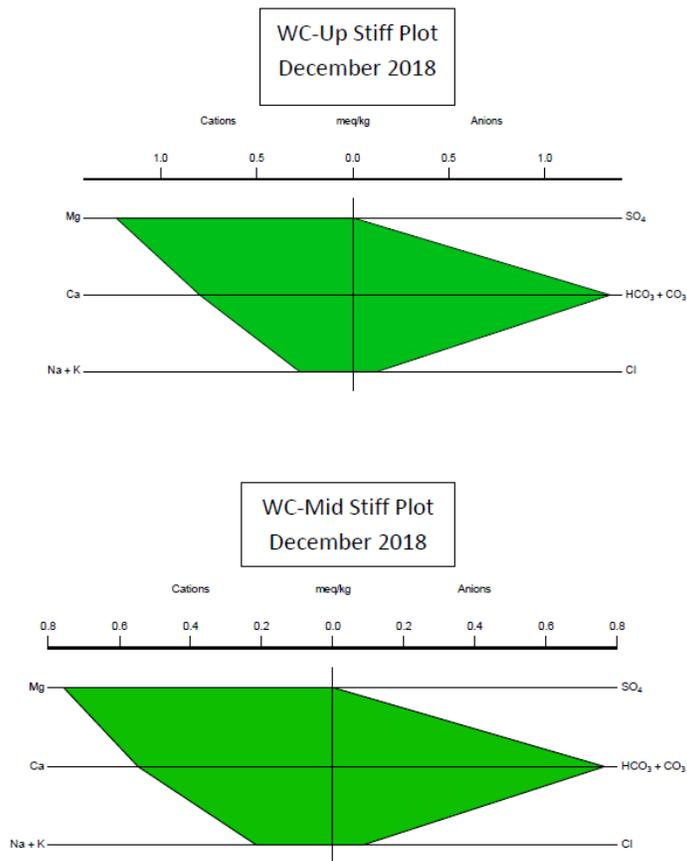
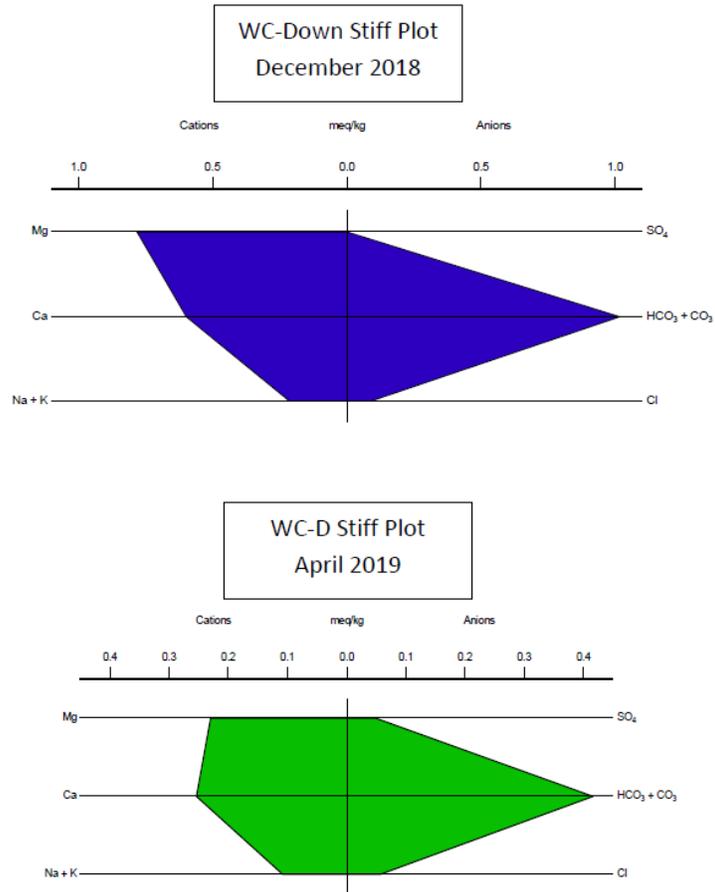
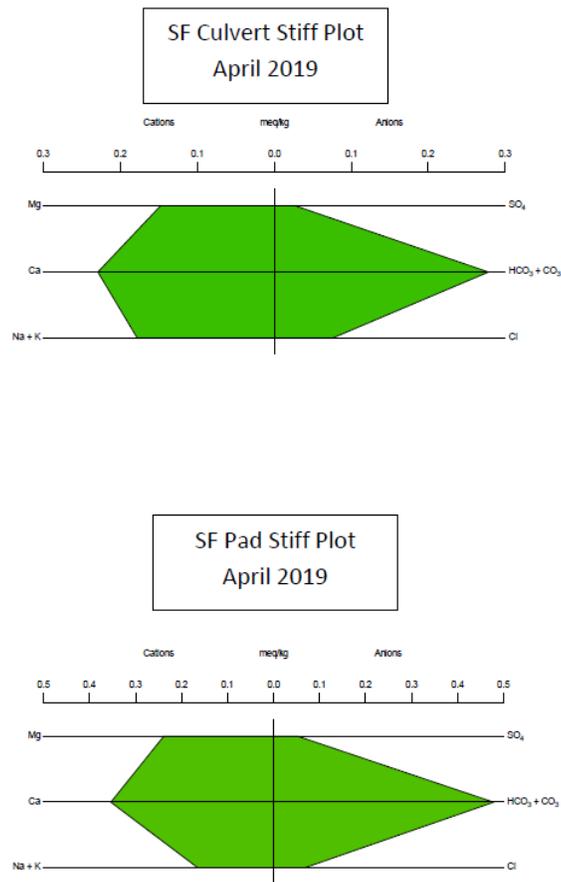


Figure 3-18 *Stiff Plots for Wolf Creek Samples – WC-Down December 2018 and WC-Down April 2019*



The two samples collected in April 2019 from South Fork Wolf Creek plot near each other on the Piper Diagram but are not identical (Figure 3.12). As indicated on the Stiff Plots on Figure 3.19, both samples are predominantly a calcium-bicarbonate water type. However, the sample from the culvert that passes under the former SPI site contains a higher proportion of sodium and chloride than the downstream sample collected near the drill pad location (see Sheet 2 for locations). The water chemistry of the culvert sample is consistent with mixing of upstream water from the area of Tertiary andesite and the Mariposa Formation (similar to the WC Headwaters sample) and groundwater that is seeping into the “leaky” culvert. In the downstream sample from near the drill pad, the sodium and chloride are diluted by surface inflows from the tributary creek and additional groundwater discharge to South Fork Wolf Creek.

Figure 3-19 Stiff Plots for South Fork Wolf Creek Samples – SF Culvert and SF Pad, April 2019



3.4.3 Conceptualization of Groundwater Movement

The existing geology, surface water, and groundwater conditions, as described in Sections 3.1 through 3.4, above, have been used to develop a conceptual model of groundwater movement in the fractured bedrock and existing underground mine workings. The conceptual model described below encompasses the environmental setting and provides a framework for evaluation of potential project effects with respect to hydrology and water quality.

3.4.4 Groundwater Flow in Fractured Bedrock

The primary mechanism of groundwater recharge is percolation of local rainfall through fractures in the bedrock. Since these fractures are open from the ground surface down to the water table, these same fractures would also allow groundwater to discharge to the surface in locations where the ground surface elevation is below the elevation of the groundwater.

The groundwater surface elevation in the three areas of private domestic wells in the Wolf Creek and South Fork Wolf Creek watersheds, as described in Section 3.3.2.1, is consistently above the elevation of

the creeks within the watersheds. The groundwater surface elevations in the East Bennett, Beaver Drive, and Greenhorn areas range from 2,700 ft msl in the west (downslope) part of the East Bennett area to as high as 3,000 ft msl in the east (upslope) part of the Greenhorn area. At the Union Hill shaft, the elevation of the creek bed of South Fork Wolf Creek is approximately 2,655 ft msl. Thus, at that location South Fork Wolf Creek is 45 feet to 345 feet lower than the groundwater surface elevation at the domestic well locations. At Centennial Drive, the elevation of the creek bed of Wolf Creek is approximately 2495 ft msl. Only the northwestern part of the East Bennett area is within the Wolf Creek watershed. As such, Wolf Creek along the Centennial site area is 205 feet to 355 feet lower than the groundwater surface elevation in parts of the East Bennett area where groundwater may flow toward Wolf Creek.

EMKO estimated the baseline, or existing, groundwater volumes that may flow through the fractured bedrock toward the creeks. Groundwater flow is calculated using Darcy's Law (Domenico and Schwartz, 1990), which states that the flow (Q) is equivalent to the hydraulic conductivity of the aquifer (K) times the hydraulic gradient (i), which is the slope of the groundwater surface, times the area (A) across which the groundwater is flowing:

$$Q = K * i * A$$

The data presented on Figure 3.10 indicate that the average hydraulic conductivity of the shallow bedrock (above a depth of 200 ft bgs) is approximately 10 gpd/ft² (Todd Engineers, 2007). In the South Fork Wolf Creek watershed, the average height of the groundwater surface above the creek is about 250 feet while the median distance from the domestic wells to the creek is about 5,000 feet, indicating that the hydraulic gradient is about 0.05 ft/ft. The total area across which groundwater may be flowing toward South Fork Wolf Creek is estimated to be 10,000 feet wide, around the upper perimeter of the watershed, by 200 feet high. Based on these parameters, the average discharge of groundwater to South Fork Wolf Creek from the three areas of domestic supply wells is approximately 1,000,000 gallons per day, or about 1.5 cfs.

For Wolf Creek, the average height of the groundwater surface above the creek elevation is about 275 feet while the distance from the New Brunswick shaft to Wolf Creek is approximately 7,800 feet. Thus, the hydraulic gradient is approximately 0.035 ft/ft. The length along Wolf Creek where groundwater from the project area may discharge is up to 2,000 feet long and up to 275 feet high, or 550,000 ft². Applying Darcy's Law, as defined above, the total outflow of groundwater to Wolf Creek from the project area under existing conditions is approximately 192,500 gallons per day, or about 0.3 cfs.

As discussed in Section 3.2, groundwater recharge averages about 10 to 12 inches per year in the project area, or about one acre-foot per acre. The area of the South Fork Wolf Creek watershed above the box culvert that starts at Ophir Drive in the City of Grass Valley is approximately 1,500 acres (see Section 3.2). Thus, groundwater recharge is in the range of 1,250 to 1,500 acre-feet per year. There may be approximately 80 domestic supply wells in the South Fork Wolf Creek watershed above the project area (see Section 3.3.2.2). The consumptive water use related to the domestic supply wells is unknown but could be in the range of one to two acre-feet per year per well, on average, considering that some of the properties in the Greenhorn area are zoned agricultural. Discounting the potential domestic and

agricultural water use, the net groundwater recharge may be equivalent to an average annual rate of about 1.50 cfs to 1.75 cfs, which is within the range of the rate of groundwater discharge to South Fork Wolf Creek, as described above. Since the rate of groundwater discharge, calculated using Darcy's Law, and the rate of groundwater recharge are generally within the same range, the groundwater in storage within the bedrock fractures is in balance and there should be no long-term trends of increasing or decreasing groundwater levels, outside of normal seasonal fluctuations. As discussed in Section 3.3.2.1, the groundwater levels in the domestic wells are stable over time and do not exhibit long-term increasing or decreasing trends, which is consistent with the discharge and recharge calculations.

The area that discharges to Wolf Creek parallel to and north of East Bennett Drive, overlying much of the existing underground mine workings, is about 225 acres, so that annual average groundwater recharge for this area is in the range of 185 to 225 acre feet per year. This volume of groundwater recharge is equivalent to an average annual rate of about 0.3 cfs, which is consistent with the rate of groundwater discharge to Wolf Creek within the project area. Thus, the rates of groundwater discharge and groundwater recharge are in balance in the part of the Wolf Creek watershed that includes the project area, consistent with the trends observed in the domestic supply wells.

While the rate of groundwater discharge to the creeks may remain relatively constant from year to year, the proportion of groundwater within the creeks will vary seasonally, depending on the amount of local runoff and the amount of NID canal water released to the creeks. As discussed in Section 3.4, the groundwater has a distinct chemistry signature dominated by reducing conditions and elevated levels of iron and manganese. Thus, the water quality within the creeks will vary seasonally depending on the proportion of groundwater that makes up the total flow in the creeks. As discussed in Section 3.4.1.3, these variations are most apparent in the EC and the ORP values measured in the creeks, but will also occur in other parameters, such as iron and manganese.

3.4.5 Groundwater Movement in Mine Workings

As discussed in Section 3.3.4, the transmissivity and hydraulic conductivity of the fractured bedrock decrease rapidly with depth. Based on the transmissivity values shown on Figure 3.9 and the hydraulic conductivity values shown on Figure 3.10, at least 99 percent of natural groundwater flow in the bedrock fractures occurs above a depth of 500 ft bgs in the project area. However, the extensive underground mine workings, as described in Section 3.3.3, provide another mechanism for groundwater to move through the project area.

The elevation of the water in the New Brunswick shaft averages 2,497 ft msl, as discussed in Section 3.3.3.3. This elevation is about 25 feet to 265 feet below the static water level in the domestic supply wells in the East Bennett area (see Section 3.3.2.1). Thus, the underground workings connected to the New Brunswick shaft must have a connection to a point that allows the workings to be drained, resulting in a lower water level in the shaft than in the wells in the surrounding bedrock.

Groundwater in the Brunswick Mine, as observed in the New Brunswick shaft, has a pathway to flow to the drains along Wolf Creek through the B2300 and B3280 levels (see Figure 3.20). Due to the direct hydraulic connection of relatively large open voids, the static water level in all the interconnected mine

workings should be at approximately the same elevation. The elevations of the East Eureka drain (IMD-1) and Eureka drain (ED-1) range from approximately 2,497 ft msl to 2,502 ft msl, respectively. These elevations are comparable to the water levels measured by EMKO in the New Brunswick shaft in February 2019 and April 2019, and to the median water level for the measurements made by IMMC from 2003 to 2006, as described in Section 3.3.3.3. Field observations made by EMKO in 2018 and 2019 as part of this investigation and descriptions by Todd Engineers (2007) indicate that the total flow from the drains may range from 60 gpm to 125 gpm (0.13 cfs to 0.28 cfs).

EMKO observed groundwater seeping into the New Brunswick shaft during sampling activities conducted in February 2018. To maintain a relatively constant water level in the underground mine workings, as reflected by the water level measurements reported from the New Brunswick shaft, the rate of water seepage into the shafts must be comparable to the rate that water is flowing from the drains. Otherwise, the water level in the shaft would increase or decrease over time, depending on whether the rate of inflow was greater than or less than the rate of discharge from the drains.

There are several vertical shafts that are part of the interconnected Eureka-Idaho-Maryland-Brunswick underground workings, as depicted on Figure 3.20. Todd Engineers (2007) has estimated that groundwater is seeping into each of the shafts at an average rate of approximately 20 gpm each. Observations made by EMKO in 2018 are consistent with this estimated rate of inflow for the New Brunswick shaft. If groundwater seepage is occurring from three or four shafts, as depicted on Figure 3.20, then the total rate of seepage into the shafts is in the same range as the outflow from the drains. Thus, groundwater that is seeping into the shafts above the water surface in the underground workings most likely migrates through the mine workings and eventually discharges at the drains along Wolf Creek.

This conceptualization of flow through the underground workings is also supported by the water chemistry data (Section 3.4). The overall general chemistry of the water sampled from the New Brunswick shaft and from the drains is comparable, especially with regard to TDS and ORP measurements (see Section 3.4.1.2). However, the concentrations of iron, manganese, and arsenic are higher in the drain samples than in the New Brunswick shaft. The increased metals concentrations at the drains could be a result of both longer contact time with the bedrock and different geochemistry in the gabbro and serpentinite in the Idaho Mine area compared to the geochemistry of the Brunswick Porphyrite Block, as discussed in Section 3.1. In particular, the relatively larger proportion of magnesium in the drain samples, compared to the samples from the New Brunswick shaft (see Section 3.4.2 and Figures 3.13 and 3.14 vs Figures 3.15 and 3.16), is consistent with the chemical composition of the gabbro and serpentinite.

Furthermore, Todd Engineers (2007) conducted an isotopic analysis of water samples from depths ranging between 580 ft bgs and 1,405 ft bgs in the New Brunswick shaft. The isotopic data indicates that the age of the groundwater in the shaft (i.e. time since recharge occurred) at all depths was less than five to 10 years. If the water in the shaft was static, and not constantly moving through the underground workings to the drains along Wolf Creek, then the water at deeper depths, below the zone of observed seepage, would be much older than the water in the shallower depths within the shaft. In addition, the young age of the groundwater in the shaft indicates that the groundwater in the shaft has not had a long contact

time with the surrounding bedrock, consistent with the relatively modest TDS concentrations (see Section 3.4.2).

Since the water level in the shafts appears to be consistently below the static groundwater levels in the wells in the East Bennett area, groundwater will continually seep into the shafts. As a result, the shafts act as “wells” that constantly draw groundwater from the surrounding shallow bedrock (i.e. above a depth of 500 feet, where the transmissivity is highest). The inflow of water into the shafts should create a local depression in the groundwater table surface around the shafts, referred to as a drawdown cone, or cone of depression.

EMKO prepared an analytical model to simulate the drawdown that might occur around the New Brunswick shaft (or any other vertical or near-vertical shaft in the East Bennett area) due to the constant seepage into the shaft. The analytical model is based on the Theis equation (Domenico and Schwartz, 1990). Based on the properties of the fractured bedrock discussed in Section 3.3.4, the analytical model indicates that the current seepage into the shaft results in drawdowns of the water table of 20 feet at the shaft location, about 8 feet at a distance of 500 feet from the shaft, and about 3.5 feet at a distance of 2,000 feet from the shaft. The overall profile of the drawdown cone is shown on Figure 3.21. The drawdown cones around the shafts are part of the existing environmental setting for the project.

Figure 3-20 Groundwater Movement in Mine Workings

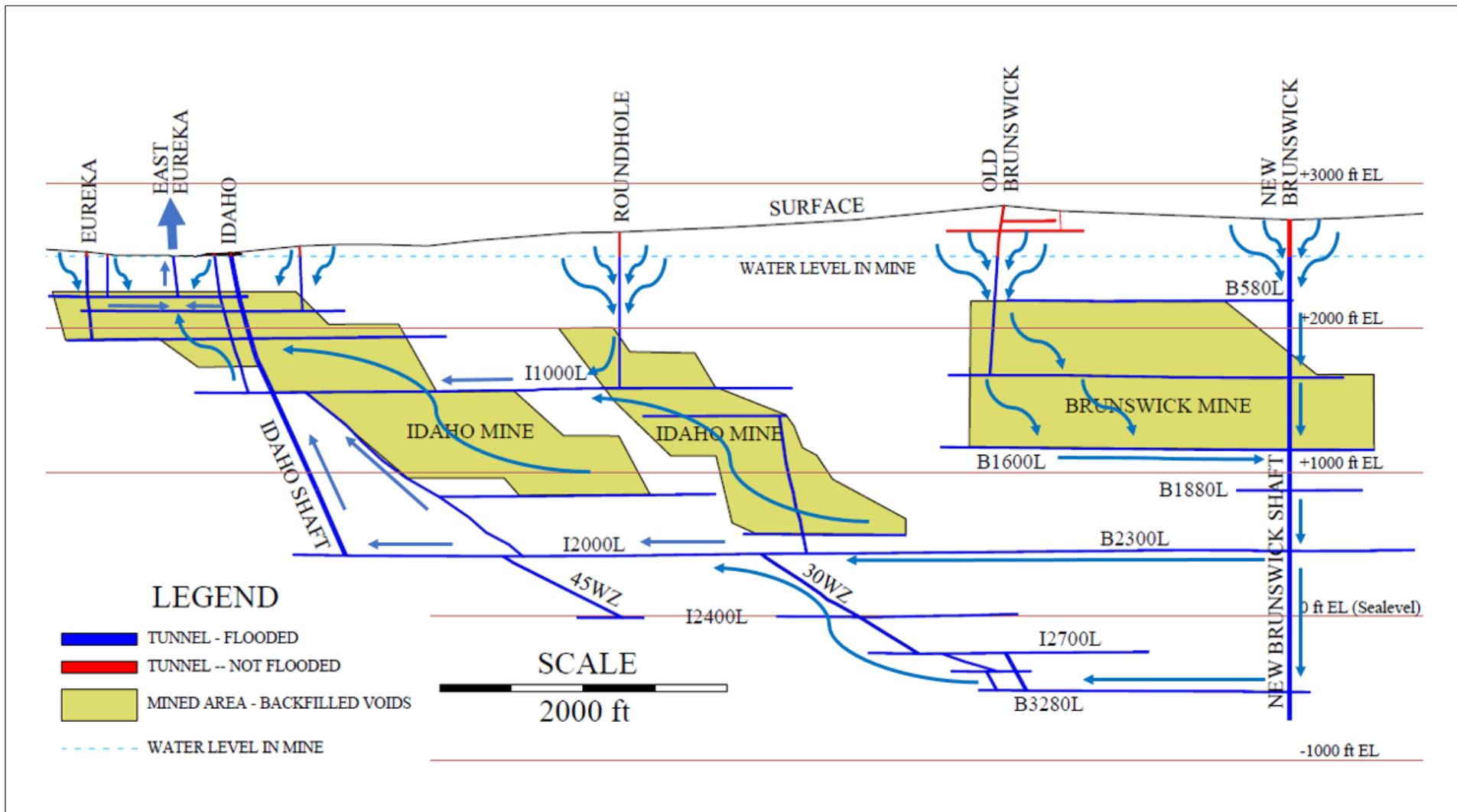
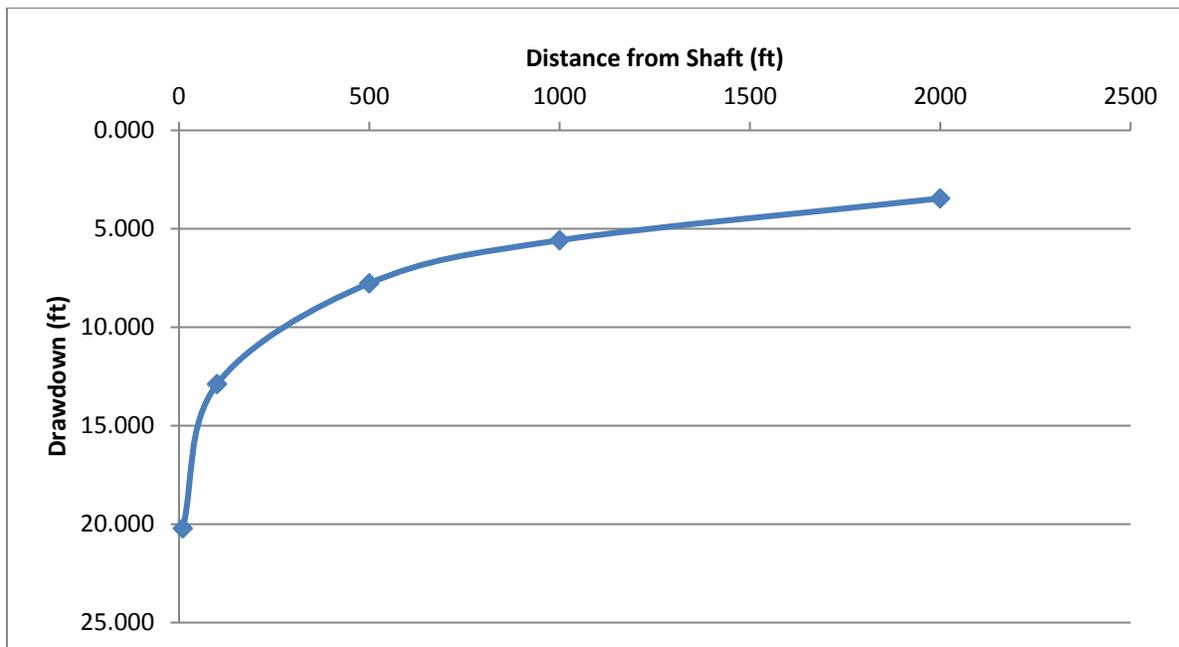
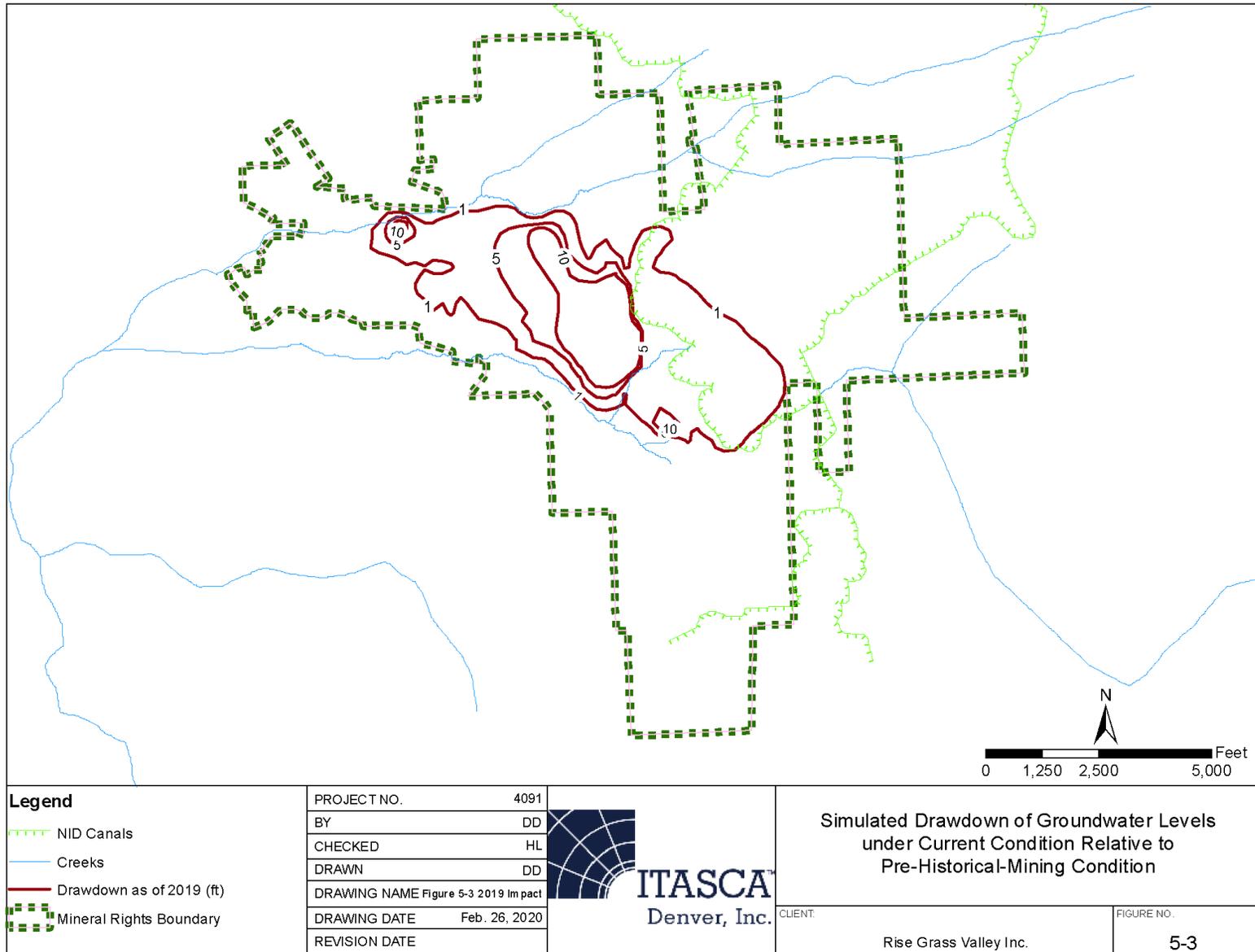


Figure 3-21 Existing Drawdown Profile for New Brunswick Shaft

Itasca Denver, Inc. (Itasca, 2020b) used a numerical model (see additional discussion in Section 4.2) to evaluate the effects of mining on groundwater levels. As part of that effort, Itasca (2020b) simulated to drawdown of the groundwater surface under current conditions due to seepage into the shafts and other underground workings and the related discharge to Wolf Creek through the drains. The model results indicate that there is a small drawdown cone in the area of the New Brunswick shaft and Union Hill Mine of between five and 10 feet, a broad area of drawdown greater than 10 feet overlying an area along Brunswick Road extending from near the intersection with East Bennett Road northward to Idaho-Maryland Road, and a small drawdown cone in the area of the Idaho shaft near Centennial Drive and Wolf Creek. The simulated drawdowns are shown on Figure 3.22 (Figure 5-3 of Itasca, 2020b). The reductions of the groundwater surface simulated by the Itasca (2020b) numerical model are in the same range as those predicted by the analytical model discussed above and shown on Figure 3.22.

Figure 3-22 Simulated Drawdown of Groundwater Levels under Current Conditions Relative to Pre-Historical Mining Conditions



E:\Projects\4091_Rise_grass_valley\Work\mxd\Figures\Figure 5-3 2019 Impact.mxd

4.0 PROJECT EFFECTS

As discussed above, the purpose of this report is to provide an analysis of hydrology and water quality conditions for the proposed Project. This section describes the anticipated conditions that will occur related to surface water runoff, groundwater levels, and water quality during mining and after mining is completed.

4.1 *Surface Water Runoff*

Section 3.2, above, describes the existing hydrologic conditions in the Wolf Creek and South Fork Wolf Creek watersheds. Surface water runoff could be affected by the construction of buildings, pads, and other impermeable surfaces, by the placement of waste rock and tailings in and around the Brunswick and Centennial Industrial Sites, and by dewatering of the underground mine workings. Stormwater detention basins will be constructed as part of the Project improvements for the Brunswick and Centennial industrial sites.

At the Brunswick Industrial Site, a detention basin will be constructed at the downstream toe of the fill slopes, above South Fork Wolf Creek (see Sheet 2). The detention basin will have a surface area of 1.45 acres, a maximum depth of 10.6 feet, and a working volume of 12.1 acre-feet with a minimum freeboard of 3.4 feet. The basin design incorporates an outlet structure that would allow the pond to completely drain between storms (NCE, 2019). Table 3.1 shows the design peak flows from the outlet structure for the two-year, 10-year, 25-year, and 100-year storm events, compared to the existing runoff to South Fork Wolf Creek from the same catchment areas. The detention basin and outlet structure reduce the peak discharge to South Fork Wolf Creek by over 48 cfs for the 2-year storm, by over 60 cfs for the 10-year storm, by over 40 cfs for the 25-year storm, and by over 25 cfs for the 100-year storm.

At the Centennial Industrial Site, a detention basin will be constructed at the downstream toe of the site, above Wolf Creek (see Sheet 3). The detention basin will have a surface area of 0.94 acre, a maximum depth of 7.7 feet, and a working volume of 6.2 acre-feet with a minimum freeboard of 6.3 feet. The basin design incorporates an outlet structure that would allow the pond to completely drain between storms (NCE, 2019). Table 3.1 shows the design peak flows from the outlet structure for the 10-year and 100-year storm events, compared to the existing runoff to Wolf Creek from the site. The detention basin and outlet structure reduce the peak discharge to Wolf Creek by over 27 cfs for the 10-year storm and by over 44 cfs for the 100-year storm.

Initial dewatering of the Idaho-Maryland Mine will occur at a rate of 2,500 gpm, or 5.6 cfs. If this rate of dewatering is achieved it would take approximately 160 days (5.3 months) to dewater the underground workings, assuming an average groundwater inflow rate into the existing mine workings of 850 gpm and total water currently in the mine workings of 385 million gallons. After that time, the dewatering will continue at a rate equal to the groundwater inflow into the mine, ranging from approximately 500 gpm to 1200 gpm seasonally and averaging approximately 850 gpm or about 1.9 cfs. The maximum discharge rate permitted will be 2,500 gpm, which will allow flexibility for unexpected seasonal inflows, operational issues, and increased groundwater inflows from the expansion of the mine during operations.

After treatment (see discussion in Section 4.4), the water pumped from the mine would be discharged to South Fork Wolf Creek downstream of the natural creek that NID uses to discharge water from the DS Canal Extension. The discharge location is shown on Sheet 2.

As reported by Cranmer (1986), a 10-year storm event may result in a peak flow of 658 cfs in South Fork Wolf Creek, with larger storm events having substantially higher peak flow rates. However, as discussed above in this section, the detention pond that will be installed at the Brunswick Industrial Site would reduce peak storm discharges by at least 25 cfs to 60 cfs, depending on the magnitude of the storm event (NCE, 2019). The reductions in peak storm flows due to the detention pond are greater than the proposed maximum discharge of treated water from the mine. Therefore, the Project would result in reduced peak storm flows within South Fork Wolf Creek compared to existing conditions.

As discussed in Section 3.2, base flow in South Fork Wolf Creek may range from 0.17 cfs in the summer to 6.5 cfs in the winter between storm events, at the location of the proposed discharge of the treated mine water (Balance, 2020). During field monitoring in January 2020, Balance (2020) noted that storm flows of 11 cfs upstream of the proposed discharge location and 17.3 cfs downstream of the proposed discharge location did not produce any evidence of bed sediment transport, meaning that there was no erosion or sedimentation occurring in the stream bed during the monitored storm flows. Sediment pebble count analysis conducted by Balance (2020) indicate that the flow rate at which sediment within the channel may become mobilized ranges from 20 cfs to 90 cfs. The combination of creek base flows plus the maximum proposed discharge of treated water at 5.6 cfs is well below the 11 cfs to 17.3 cfs flow at which no bed sediment transport was observed. During larger storm events, the proposed detention pond would reduce the peak flows within South Fork Wolf Creek by much more than 5.6 cfs. Thus, under Project conditions the overall peak storm flows would be lower than they are under existing conditions, resulting in less potential for erosion and sediment transport than under existing conditions.

Groundwater modeling conducted by Itasca (2020b) evaluated the potential reduction in discharge of groundwater to the surface creeks that might occur when the water table is lowered as a result of mine dewatering. Itasca (2020b) reports that by the end of the mining period, the base flow within Wolf Creek may be reduced by 0.75 cfs and the base flow within South Fork Wolf Creek may be reduced by approximately 0.1 cfs. The reduction in base flow in Wolf Creek is nominal compared to the measured flows reported in Section 3.2, above, and the routine discharges to Wolf Creek by NID. The potential reduction of groundwater discharge to South Fork Wolf Creek would be offset by the discharge of 1.9 cfs to 5.6 cfs of treated water produced during dewatering.

4.2 Groundwater Levels during Exploration and Mining

As described in Section 2.2, the Idaho-Maryland Mine consists of a substantial volume of underground workings, with an estimated equivalent of 72.8 miles (117km) of underground tunnels, assuming typical drift dimensions of 7.5ft x 8.5ft (W x H) (AMEC, 2017). The total volume within these workings has been estimated at 532 million gallons by JAA (1991). Rise has estimated the total volume of the mine workings at 540 million gallons, which is very similar to JAA's estimate. However, based on historic documentation describing backfilling of some of the workings, Rise assumed that 75 percent of the stopes were backfilled

and that the backfill material has a porosity of 40 percent. After accounting for the backfilled areas, the total volume of water needing to be removed from the mine is estimated by Rise at 385 million gallons (see Section 3.3.3.2).

Before exploration and mining can proceed, the water within the underground workings must be removed. Removal of the static water within the flooded mine workings is referred to as the “initial dewatering”. As the water level in the mine is lowered during the initial dewatering, groundwater will flow into the mine workings through fractures and contribute to the volume of water that must be pumped during the initial period. Thus, the initial dewatering rate, typically reported in gallons per minute (gpm), is a combination of removal of the static water and removal of groundwater that flows into the newly-dewatered mine workings. Once the initial dewatering is completed, continued pumping is necessary to remove the groundwater that will constantly flow into the mine through fractures within the bedrock and maintain a dry mine. For the purposes of this report, this is referred to as “maintenance dewatering”.

The estimated maintenance dewatering rate for the combined and expanded mines (i.e. the overall Idaho-Maryland Mine including the Brunswick underground workings) prior to mine closure around 1955 is reported to have ranged from 500 gpm to 1,200 gpm seasonally, with an average of approximately 850 gpm (JAA, 1991).

As dewatering begins at the initial rate of up to 2,500 gpm (5.6 cfs), water from the surrounding fractured bedrock would also flow into the mine workings at approximately 850 gpm. Thus, the net dewatering rate during the initial dewatering period would be approximately 1,650 gpm. At this net initial dewatering rate, it would take 162 days to dewater the underground mine workings. After that time, pumping of groundwater that seeps into the mine workings would continue at the inflow rate averaging 850 gpm.

As described in Section 3.3, the groundwater level within the New Brunswick shaft is lower than the groundwater level in the surrounding fractures within the bedrock aquifer, as reflected by the groundwater levels measured in the wells in the East Bennett Road area. The shafts connected to the Idaho-Maryland Mine interconnected underground workings are interpreted to be acting as pumping wells, whereby the rate that water is entering the shafts has equilibrated with the rate that water is discharging from the drains near Wolf Creek. The groundwater flow into the shafts creates some small amount of drawdown in the groundwater surface in the area around the shafts. The current water levels within the wells in the East Bennett Road area, ranging from approximately 2,525 ft msl to 2,765 ft ml, reflect whatever drawdown is occurring due to the flow of groundwater into the shafts and through the underground mine workings.

As dewatering occurs, the water level within the underground workings would decrease from its current depth of approximately 250 ft bgs down to the maximum depth of the New Brunswick shaft at about 3,460 ft bgs. These depths are equivalent to elevations of approximately 2,500 ft msl and -700 ft msl, respectively. Thus, the water level within the mine workings would eventually decrease as much as 3,200 feet due to the Project. As discussed in Section 3.3.4, the transmissivity of the fractured bedrock decreases by several orders of magnitude at deeper depths, due to a reduction in the number of fractures

and a decrease in the width of the fracture openings caused by increased lithostatic pressures at depth. As a result, dewatering of deeper tunnels and drifts would have less impact on groundwater levels in the fractured bedrock than would dewatering of shallower mine workings.

Itasca (2020b) developed a numerical model to assess dewatering rates and the effects of mine dewatering on groundwater levels and creek base flow. The groundwater flow model that was constructed by Itasca utilizes the numerical code *MINEDW*, which was developed by Itasca (2012) to solve 3-D groundwater flow problems with an unconfined (or phreatic) surface using the finite-element method. *MINEDW* has several attributes that were specially developed to address conditions that are often encountered in mine dewatering. This modeling code has been used for numerous mining projects throughout the world. *MINEDW* is a commercially available software package that has been approved by the Nevada Division of Environmental Protection⁶ for use in permitting applications.

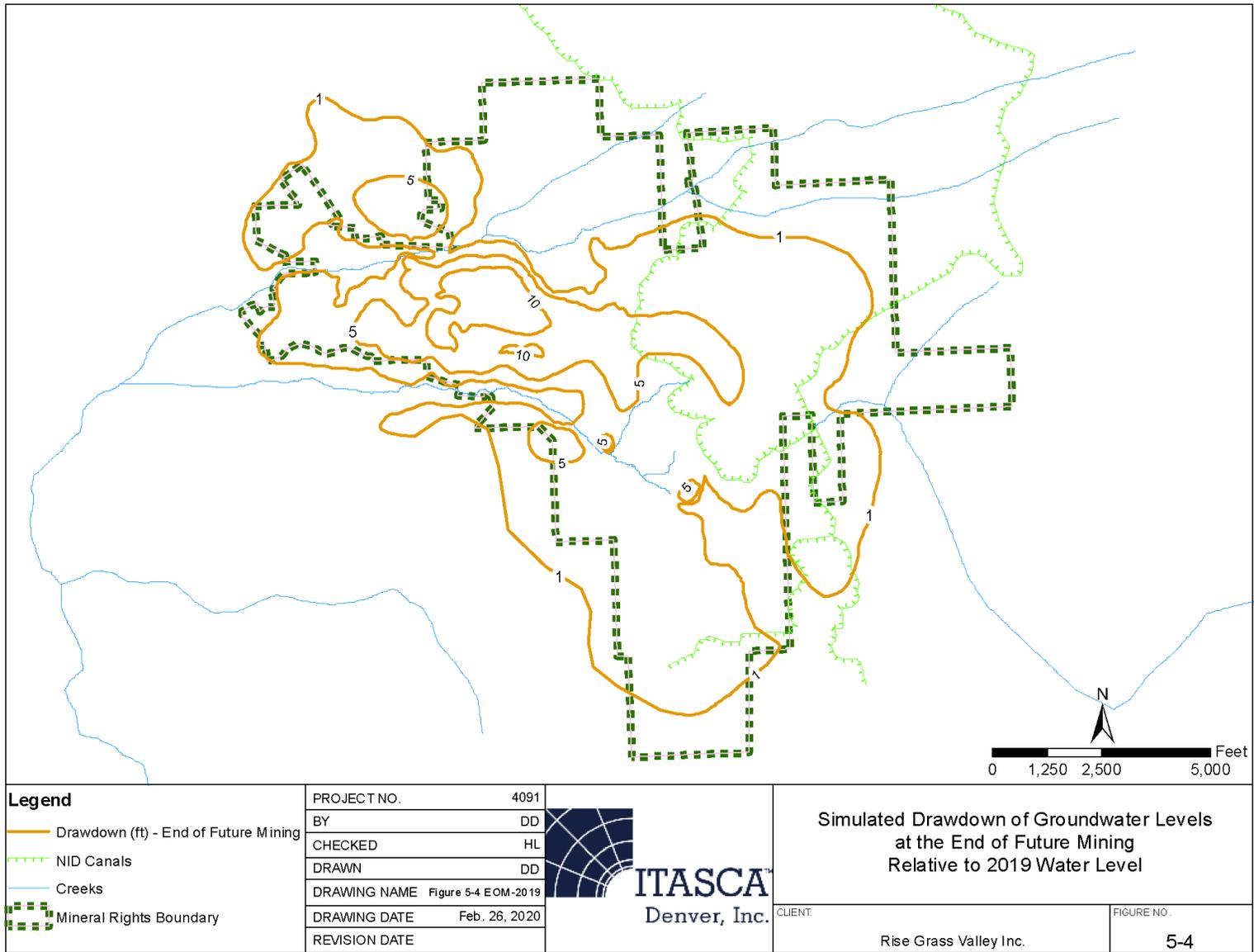
The modeling effort (Itasca, 2020b) evaluated the following scenarios:

- 1) Base case conditions with 25 years of mining;
- 2) Sensitivity analysis evaluating increasing the hydraulic conductivity in the transition zone between the weathered zone and the underlying bedrock;
- 3) Sensitivity analysis evaluating increasing the hydraulic conductivity of the fault zones;
- 4) Sensitivity analysis excluding the fault zones;
- 5) Sensitivity analysis increasing recharge rate by 50%; and
- 6) Expanded mining scenario with additional mining occurring in additional areas from years 26 to 65.

The discussions presented in Sections 4.2.1 and 4.2.2, below, are based on the maximum predicted drawdown in the groundwater surface that would occur under the worst-case sensitivity analysis result for the 25-year mining period. Section 4.2.3 discusses the predicted effects on the groundwater surface for the expanded mining scenario, where exploration and mining would extend into additional areas within the mineral claim boundary for an additional 40 years.

⁶ California does not have an equivalent program for approval of modeling packages for mine permitting.

Figure 4-1 Simulated Drawdown of Groundwater Level at the End of Future Mining Relative to 2019 Water Level (Itasca, 2020b)



4.2.1 Dewatering Effects in the East Bennett Area

There are a substantial number of underground mine workings within the East Bennett area. Sheet 9 shows the mine workings within 600 feet of the ground surface, whereas Sheet 8 shows all of the mine workings of the Idaho-Maryland Mine. The shallower (within 600 feet of ground surface) workings are concentrated in the Brunswick mine area, the Union Hill mine area, and between the East Eureka Shaft and the Idaho Shaft in the Idaho #1 mine area near Wolf Creek. Based on historical accounts of dewatering, it appears that approximately two-thirds of the maintenance dewatering will come from the Brunswick mine area while one-third of the maintenance dewatering will come from the Eureka-Idaho-Maryland mine area. In addition, based on the variation in the transmissivity and hydraulic conductivity of the fractured bedrock, 99 percent of groundwater inflow will occur within 550 feet of the ground surface, as discussed in Section 3.3.5.

Based on the fractured bedrock aquifer properties and the maintenance dewatering rates, it is anticipated that the drawdown near the mine area will cause the water levels in several of the wells in the East Bennett area to be affected. The range of the drawdown and the effect on the well will vary depending on well depth, distance from the mine workings, and the current well productivity (e.g. pumping rate in gpm). Figure 4-1 (Itasca Figure 5-4) shows the modeled drawdown that is predicted to occur at the end of the proposed mining period. The predicted drawdowns are those that would occur in addition to the existing drawdown due to groundwater inflow to the mine under existing conditions, discussed in Section 3.4.5 and shown on Figure 3-22. Throughout the East Bennett Area, the predicted drawdowns range from approximately five to 10 feet.

Table 4-1 Well Parameters and Potential Effects of Mine Dewatering, East Bennett Area

Rise Well ID	1995 EIR Well ID	General Location	Elevation (ft) (Top of Well)	Well Depth (ft)	Well Yield (gal/min)	Water Column (ft)	Drawdown - Basecase (ft)	Drawdown - Max Sensitivity (ft)	Drawdown - Basecase (%)	Drawdown - Sensitivity Max (%)
1		1 - E. Bennett Area	2,747	420	0.5	400	8	8	2.0%	2.0%
2	WS33	1 - E. Bennett Area	2,690	700	3	625	7	8	1.1%	1.3%
5	WS30	1 - E. Bennett Area	2,644	230	10	155	5	5	3.2%	3.2%
6	WS31	1 - E. Bennett Area	2,685	320	3	215	8	8	3.7%	3.7%
7	WS80	1 - E. Bennett Area	2,797	100	30	17.4	7	7	40.2%	40.2%
8	WS45	1 - E. Bennett Area	2,769	300	6.5	218	5	6	2.3%	2.8%
9	WS32	1 - E. Bennett Area	2,747	400	6	295	9	9	3.1%	3.1%
15		1 - E. Bennett Area	2,829	400	0	315	4	4	1.3%	1.3%
16		1 - E. Bennett Area	2,826	140	30	80	5	6	6.3%	7.5%
17		1 - E. Bennett Area	2,684	150	20	70	1	1	1.4%	1.4%
18		1a - Idaho Maryland Area	2,530	560	3	555	2	2	0.4%	0.4%
19	WS122	1 - E. Bennett Area	2,779	220	40	90	2	4	2.2%	4.4%
	WS116	1 - E. Bennett Area	2700	208	15	125.4	2	3	1.6%	2.4%
	WS113	1 - E. Bennett Area	2645	55	ND	54.5	1	1	1.8%	1.8%
	WS114	1 - E. Bennett Area	2710	208	ND	125.4	1	3	0.8%	2.4%
	WS119	1 - E. Bennett Area	2780	145	15	60	3	5	5.0%	8.3%
	WS44	1 - E. Bennett Area	2810	225	4.5	42	3	5	7.1%	11.9%
	WS29	1 - E. Bennett Area	2788	425	10	342.4	5	10	1.5%	2.9%
	WS233	1 - E. Bennett Area	2640	90	ND	56.7	1	1	1.8%	1.8%
	WS235	1 - E. Bennett Area	2805	200	20	81	2	4	2.5%	4.9%
	WS236	1 - E. Bennett Area	2635	199	ND	168	1	1	0.6%	0.6%
	WS240	1 - E. Bennett Area	2650	199	ND	164	4	5	2.4%	3.0%
	WS242	1 - E. Bennett Area	2695	155	15	97	4	4	4.1%	4.1%
	WS121	1 - E. Bennett Area	2690	155	15	72.4	1	3	1.4%	4.1%
	WS201	1 - E. Bennett Area	2860	425	3.5	151	5	5	3.3%	3.3%
	WS216	1 - E. Bennett Area	2770	199	ND	117	8	8	6.8%	6.8%

Rise Well ID	1995 EIR Well ID	General Location	Elevation (ft) (Top of Well)	Well Depth (ft)	Well Yield (gal/min)	Water Column (ft)	Drawdown - Basecase (ft)	Drawdown - Max Sensitivity (ft)	Drawdown - Basecase (%)	Drawdown - Sensitivity Max (%)
	WS90	1 - E. Bennett Area	2590	72	ND	39.75	2	2	5.0%	5.0%
	WS124	1 - E. Bennett Area	2730	208	4	103	10	10	9.7%	9.7%
	WS125	1 - E. Bennett Area	2670	120	13	53	5	5	9.4%	9.4%
	WS243	1 - E. Bennett Area	2640	131	20	49	5	5	10.2%	10.2%
	WS118	1 - E. Bennett Area	2665	200	5	115	6	6	5.2%	5.2%
	WS237	1 - E. Bennett Area	2620	200	5	126	1	2	0.8%	1.6%
	WS110	1 - E. Bennett Area	2830	208	9	125.4	6	6	4.8%	4.8%
129		2 - E. Bennett Industrial Area	2515	140	50	130	1	1	0.8%	0.8%
130	WS95	2 - E. Bennett Industrial Area	2510	100	8	90	1	1	1.1%	1.1%
135		2 - E. Bennett Industrial Area	2535	200	6	180	2	2	1.1%	1.1%

Well Parameter Data Compiled from Well Completion Reports.

Downloaded from California Department of Water Resources Database: <https://data.cnra.ca.gov/dataset/well-completion-reports>

Bright yellow highlight indicates drawdown percentages greater than 10 percent of the existing water column in the well.

Pale yellow highlight indicates drawdown percentages between 7.5 percent and 10 percent of the existing water column in the well.

See discussion in Section 4.2.1 for explanation of the effects of these drawdown percentages.

Table 4-1 lists the known wells in the East Bennett Area (including the Bennett Industrial Area), along with the surface elevation, well depth, well yield, and water column height. Table 4-1 also specifies the predicted drawdown from the Itasca (2020b) model for each well, under the base case scenario and maximum drawdown under the most sensitive case. The predicted drawdown ranges from one foot to 10 feet in the East Bennett Area, or from less than one percent of the total water column height to 40 percent of the total water column height. However, the maximum predicted drawdown does not necessarily correlate with the highest percent of the total water column since wells with smaller water columns may have a higher percent effect than wells with large water columns.

Drawdowns within wells completed in unconfined aquifer conditions are sensitive to the amount of drawdown that occurs as a percent of the total water column. This sensitivity is due to the reduction in the effective transmissivity that occurs as the height of the water column decreases in unconfined aquifers⁷. Simulations using the Theis equation, described in Section 3.5.2 and in Section 4.2.2, indicate that reductions in the water column of 20 percent to 40 percent could cause the production rate of the well to become unstable by incrementally decreasing the water column much more than would occur under existing conditions. For this analysis, a 100 percent factor of safety is applied to the potential reduction resulting in unstable conditions, such that a criterion of 10 percent of the water column is used to define wells that might be substantially affected by dewatering of the underground mine workings. Of the approximate 36 wells in the East Bennett and Bennett Industrial Areas, there are three wells that have at least 10 percent reduction in the water column, under either the base case or most sensitive case, as highlighted in yellow in Table 4-1. There are also four wells that are predicted to have a reduction in the water column of between 7.5 percent and 10 percent. These four wells are highlighted in pale yellow in Table 4-1, to identify wells that could marginally be affected. Sheet 12 shows the locations of the wells in the East Bennett and Bennett Industrial Areas, including the affected wells and marginally affected wells.

As described in Section 2.6, Rise will provide a potable water pipeline in the East Bennett Area and pay for the hookup to the pipeline for wells users that elect to be connected to the potable supply from NID.

4.2.2 Dewatering Effects in Perimeter Areas

Two independent evaluations of the potential effects of mine dewatering on private supply wells outside of the East Bennett Area have been conducted. In the Beaver Drive, Greenhorn, and Mitchell Cross-cut areas, there is a single drift or tunnel near the private wells. For these three areas, the drawdown analysis considers the well that is closest (both in terms of distance and depth) to the existing mine working. This analysis approach contrasts with that used for the East Bennett area, where the mine workings are nearly ubiquitous and include stopes and shafts in addition to the horizontal mine workings. For the first independent evaluation of the Beaver Drive, Greenhorn, and Mitchell Cross-cut areas, a three-step evaluation was conducted by EMKO to estimate the potential magnitude of mine dewatering on the

⁷ In confined aquifers, a reduction in hydrostatic head does not necessarily result in a reduction in the transmissivity because the elevation of the water surface within the well is above the top of the confined aquifer, so reductions in the water column in the well do not result in a change in the effective thickness of the confined aquifer.

nearest wells. The second independent evaluation was conducted by Itasca (2020b) using the *MINEDW* numerical model.

The first step in the EMKO evaluation involves determining what fraction of the total maintenance dewatering rate affects the area of the well. This step includes consideration of both the quantity of mine workings in the area of interest and their depth. The depth consideration is based on the variation in the transmissivity of the fractured bedrock with depth, as discussed in Section 3.3.4. The second step identifies what fraction of the groundwater inflow into the horizontal mine working nearest the well comes from above the drift or tunnel, and thus affects the water level in the nearby well, compared to water that would enter the mine working from below, and would not affect the well, since the perimeter wells are shallower than the mine workings in the same area. The third step involves scaling the overall maintenance dewatering rate to the local well condition and estimating the drawdown that would occur at that specific location. The three-step evaluation approach for each of the three perimeter areas is described in Sections 4.2.2.1, 4.2.2.2, and 4.2.2.3, below. The analytical solution calculations are presented in Appendix A.

4.2.2.1 Beaver Drive Area

The discussion below summarizes the application of the three-step analysis process to the estimation of drawdown at the nearest well to the underground mine workings in the Beaver Drive area. The wells in the Beaver Drive Area are listed in Table 4-2. The nearest well to the mine workings is designated as Well 31 (WS4 in the 1995 EIR).

STEP 1:

The drift that extends under the Beaver Drive area is approximately 2,000 to 3,000 feet long, which is less than one percent of the 71 miles of total horizontal underground mine workings. As a conservative assumption, it is assumed that one percent of the total volume of mine workings is present under the wells in this area, within the single drift at a depth of approximately 1,450 feet below ground surface. The nearest well to this drift is 295 feet deep. Based on the difference between the depth of the well nearest to the mine working and the depth of the mine working, the transmissivity at the mine working was assumed to be 10 percent of transmissivity at the depth of the well (see Figure 3.10). Thus, the overall fraction of the total maintenance dewatering rate that occurs in the Beaver Drive area is 0.001 (calculated by multiplying one percent of the mine workings [0.01] by 10 percent of the transmissivity [0.1]). That fraction multiplied by the average maintenance dewatering rate of 850 gpm indicates that the total volume of groundwater inflow into the drift below the Beaver Drive area is 0.85 gpm.

STEP 2:

Because the mine workings are generally horizontal (as opposed to a vertical boring or shaft), the proportion of the flow into the drift that comes from below and the proportion that comes from above needs to be estimated. Only the flow from above the drift is presumed to affect water levels in the wells in the Beaver Drive area. The distance between the bottom of the nearest well at Beaver Drive and the underlying drift is about 1,160 feet. Using different fractured bedrock transmissivity values for the depth

of the well and the depth of the drift, (see Figure 3.10) the drawdown at a distance of 1,160 feet was calculated for both the drift and the well at the local maintenance dewatering rate of 0.85 gpm. The pumping rate for the drift was then adjusted until the drawdown at 1,160 feet due to pumping from the drift is equivalent to the drawdown at 1,160 feet from pumping the well at 0.85 gpm. That evaluation indicated that approximately 68 percent of the groundwater entering the drift comes from above the drift. Thus, the effective maintenance dewatering rate from the drift affecting the well is about 68 percent of 0.85 gpm, or about 0.58 gpm.

STEP 3:

Once the effective maintenance dewatering rate from the drift affecting the well is estimated, then the drawdown due to the dewatering is calculated. The drift under the Beaver Drive area is horizontal, or nearly so, such that the effects of pumping are actually spread out along the full length of the underground opening. However, to estimate the effect on the nearest well, it was assumed that the mine working was a vertical well that exists within the Beaver Drive area. The drawdown from that hypothetical well was then calculated at various distances to determine the presumed effect at the distance that is equivalent to the nearest well, in this case 1,160 feet. Assuming that the mine working behaves like a vertical well is an extremely conservative assumption because the calculations place the entire groundwater outflow due to dewatering in one location, as opposed to being spread out over several thousand feet along the length of the mine working.

FINDINGS:

The procedure used to estimate the effects of maintenance dewatering on the Beaver Drive area is based on multiple conservative assumptions, each of which results in an over-estimate of the total drawdown at the nearest well. The use of multiple conservative assumptions indicates that the actual effect at the well of interest would be appreciably less than that calculated by this approach. Notwithstanding the use of multiple conservative assumptions, the estimated drawdown in the groundwater surface at the nearest well to the drift, Well 31, would be approximately 0.26 foot (3.1 inches) after one year and approximately 1.9 feet (23 inches) after 25 years. Well 31 has a total depth of 295 feet and a total water column of 250 feet (Table 4-2). The conservatively estimated drawdowns are extremely small compared to the length of the water column and indicate that after 25 years, the available height of water in the well would decrease by less than 0.8 percent. This change is also much smaller than the normal seasonal fluctuations in groundwater levels of 20 to 50 feet per year observed in the wells in the Beaver Drive area, as described in Section 3.3.2.2, and therefore would not alter the available groundwater supply at the well location.

Table 4-2 also shows the drawdowns that are predicted by the Itasca (2020b) numerical model for the wells in the Beaver Drive Area. The base case drawdowns range from one foot to three feet, while the maximum drawdowns under the worst-case sensitivity analysis range from two to three feet. These drawdowns are consistently less than five percent of the total water column height, with the maximum predicted drawdown being less than two percent of the total water column in all but two wells. There are no wells in the Beaver Drive Area where the total predicted drawdown would exceed, or even approach, 10 percent of the total water column.

Table 4-2 Well Parameters and Potential Effects of Mine Dewatering, Beaver Drive Area

Rise Well ID	1995 EIR Well ID	General Location	Elevation (ft) (Top of Well)	Well Depth (ft)	Well Test (gal/min)	Water Column (ft)	Drawdown - Basecase (ft)	Drawdown - Max Sensitivity (ft)	Drawdown - Basecase (%)	Drawdown - Sensitivity Max (%)
29	WS10	3 - Beaver Drive	2,949	250	4	205	2	3	1.0%	1.5%
30		3 - Beaver Drive	2,949	400	2	355	2	3	0.6%	0.8%
31	WS4	3 - Beaver Drive	2,932	295	3	250	3	3	1.2%	1.2%
32	WS7	3 - Beaver Drive	2,948	350	3.25	288.5	2	2	0.7%	0.7%
33	WS22	3 - Beaver Drive	2,919	300	4	255	2	3	0.8%	1.2%
34	WS6	3 - Beaver Drive	2,877	250	4	188.5	1	2	0.5%	1.1%
35		3 - Beaver Drive	2,865	125	30	47	1	2	2.1%	4.3%
36	WS21	3 - Beaver Drive	2,916	325	6	280	2	3	0.7%	1.1%
38		3 - Beaver Drive	2,899	250	0	Well deepened				
38	WS25	3 - Beaver Drive	2,899	350	2	Well deepened				
38		3 - Beaver Drive	2,899	700	0	622	2	2	0.3%	0.3%
40	WS85	3 - Beaver Drive	2,945	175	7.5	130	2	3	1.5%	2.3%
42		3 - Beaver Drive	2,862	200	5.5	122	1	2	0.8%	1.6%

Well Parameter Data Compiled from Well Completion Reports.

Downloaded from California Department of Water Resources Database: <https://data.cnra.ca.gov/dataset/well-completion-reports>

4.2.2.2 Greenhorn Area

The same procedure described above for the Beaver Drive area was also used to evaluate the potential for maintenance dewatering to affect groundwater levels in wells in the Greenhorn area east of Brunswick Road. A full discussion of each step in the evaluation for the Greenhorn area is not provided here; however, the main parameters used and the findings are summarized below.

Similar to the Beaver Drive area, a single lateral drift is present under the Greenhorn area, extending approximately 2,000 feet northeast from the Brunswick mine. The drift is approximately 1,185 feet below ground surface, while the nearest well, Well 45 (WS75 in the 1995 EIR, see Table 4-3) extends to a depth of 140 feet. The distance between the bottom of the well and the drift is approximately 1,040 feet. It was assumed that the lateral drift is approximately one percent of the total underground mine working volume and that the transmissivity of the fractured bedrock at the depth of the drift is 10 percent of the transmissivity at the depth of the well. Thus, the maintenance dewatering rate is conservatively assumed to be 0.001 times the full dewatering rate of 850 gpm, or 0.85 gpm. However, due to the shallower depth of the nearest well, compared to that in the Beaver Drive area, the fraction of the maintenance dewatering rate that is estimated to affect the well is about 89 percent of the total maintenance dewatering rate from the drift.

Using the same set of multiple conservative assumptions described above, the actual effect at Well 45 in the Greenhorn area would be appreciably less than that calculated by this approach. Notwithstanding the use of multiple conservative assumptions, the estimated drawdown in the groundwater surface at Well 45 would be approximately 0.19 foot (2.3 inches) after one year and approximately 0.43 foot (5.2 inches) after 25 years. Well 45 has a total water column of 100 feet. The conservatively estimated drawdowns are extremely small compared to the length of the water column and indicate that after 25 years, the available height of water in the well would decrease by less than 0.5 percent. This change is also much smaller than the normal seasonal fluctuations in groundwater levels of 10 to 30 feet per year observed in the wells in the Greenhorn Drive area, as described in Section 3.3.2.2, and therefore would not alter the available groundwater supply at the well location.

Table 4-3 also shows the drawdowns that are predicted by the Itasca (2020b) numerical model for the wells in the Greenhorn Area. The base case drawdowns range from one foot to five feet, while the maximum drawdowns under the worst-case sensitivity analysis range from one to six feet. These drawdowns are consistently less than seven percent of the total water column height for the base case scenario. For the worst-case sensitivity analysis, one well (Well 180) has a predicted drawdown of eight percent (highlighted in pale yellow on Table 4-3). The location of Well 180 is shown on Sheet 12. Wells 179 and 180 were drilled at the same address according to the well completion reports. Well 179 was drilled in 1981 with a reported depth to water of 80 feet. Well 180 was drilled in 2000 and the reported depth to water was 150 feet. Wells 179 and 180 are located near Well WS188 and at a similar surface elevation. The reported depth to water in Well WS188 is 75 feet. Thus, the deeper water level reported at the time Well 180 was drilled may not be representative of the actual static water level at this location. In either case, a reduction in the water column of eight percent is less than the 10-foot criterion with 100 percent factor of safety described in Section 4.2.1.

There are no other wells in the Greenhorn Area where the total predicted drawdown would exceed, or even approach, 10 percent of the total water column.

Table 4-3 Well Parameters and Potential Effects of Mine Dewatering, Greenhorn Area

Rise Well ID	1995 EIR Well ID	General Location	Elevation (ft) (Top of Well)	Well Depth (ft)	Well Test (gal/min)	Water Column (ft)	Drawdown - Basecase (ft)	Drawdown - Max Sensitivity (ft)	Drawdown - Basecase (%)	Drawdown - Sensitivity Max (%)
43		4 - Greenhorn	2,924	175	150	135	4	5	3.0%	3.7%
44	WS230	4 - Greenhorn	2,966	175	45	135	5	6	3.7%	4.4%
45	WS75	4 - Greenhorn	2,896	140	150	100	4	5	4.0%	5.0%
46		4 - Greenhorn	2,883	110	30	75	5	5	6.7%	6.7%
47	WS221	4 - Greenhorn	2,818	90	50	70	2	2	2.9%	2.9%
48	WS94	4 - Greenhorn	2,801	400	12	370	1	2	0.3%	0.5%
49	WS93	4 - Greenhorn	2,801	400	15	370	1	2	0.3%	0.5%
50		4 - Greenhorn	2,846	160	25	140	2	2	1.4%	1.4%
51		4 - Greenhorn	2,870	105	100	90	3	5	3.3%	5.6%
52		4 - Greenhorn	2,842	240	20	190	2	2	1.1%	1.1%
56		4 - Greenhorn	2872	300	7	285	2	2	0.7%	0.7%
57		4 - Greenhorn	2850	75	60	60	2	2	3.3%	3.3%
58		4 - Greenhorn	2842	175	60	160	2	2	1.3%	1.3%
59		4 - Greenhorn	2880	175	6	85	2	2	2.4%	2.4%
61		4 - Greenhorn	2870	125	3	100	2	2	2.0%	2.0%
62		4 - Greenhorn	2870	150	100	100	2	2	2.0%	2.0%
63		4 - Greenhorn	2866	125	60	80	2	2	2.5%	2.5%
64	WS66	4 - Greenhorn	2855	150	60	140	2	2	1.4%	1.4%
65	WS91	4 - Greenhorn	2867	500	3	490	2	2	0.4%	0.4%
66		4 - Greenhorn	2860	150	100	140	2	2	1.4%	1.4%
67		4 - Greenhorn	2896	155	100	145	2	2	1.4%	1.4%
68	WS81	4 - Greenhorn	2906	300	4	290	2	2	0.7%	0.7%
69		4 - Greenhorn	2906	280	ND	270	2	2	0.7%	0.7%
70		4 - Greenhorn	2919	380	25	230	2	2	0.9%	0.9%
71		4 - Greenhorn	2936	230	40	62.5	2	2	3.2%	3.2%
72		4 - Greenhorn	2961	250	3.5	65	2	2	3.1%	3.1%

Rise Well ID	1995 EIR Well ID	General Location	Elevation (ft) (Top of Well)	Well Depth (ft)	Well Test (gal/min)	Water Column (ft)	Drawdown - Basecase (ft)	Drawdown - Max Sensitivity (ft)	Drawdown - Basecase (%)	Drawdown - Sensitivity Max (%)
73		4 - Greenhorn	2954	247	5	127	2	2	1.6%	1.6%
74		4 - Greenhorn	2947	195	30	95	2	2	2.1%	2.1%
75		4 - Greenhorn	2938	130	3	30	2	2	6.7%	6.7%
76		4 - Greenhorn	2994	100	8	Unknown	2	2		
77		4 - Greenhorn	2994	340	20	85	2	2	2.4%	2.4%
100		4 - Greenhorn	2967	780	6	345	2	2	0.6%	0.6%
101		4 - Greenhorn	2951	450	7.5	300	2	2	0.7%	0.7%
163		4 - Greenhorn	2860	280	25	155	1	1	0.6%	0.6%
164		4 - Greenhorn	2860	110	5	Unknown	1	1		
165		4 - Greenhorn	2920	330	20	170	1	1	0.6%	0.6%
166		4 - Greenhorn	2930	480	4	180	1	1	0.6%	0.6%
167		4 - Greenhorn	2800	440	12	290	1	1	0.3%	0.3%
168		4 - Greenhorn	2850	270	0	145	2	2	1.4%	1.4%
169		4 - Greenhorn	2780	540	30	440	1	1	0.2%	0.2%
170		4 - Greenhorn	2760	200	25	130	1	1	0.8%	0.8%
171		4 - Greenhorn	2780	280	20	240	1	1	0.4%	0.4%
172	WS20	4 - Greenhorn	2800	75	75	65	1	1	1.5%	1.5%
173		4 - Greenhorn	2860	123	125	123	2	2	1.6%	1.6%
174		4 - Greenhorn	2870	100	100	70	2	3	2.9%	4.3%
175	WS19	4 - Greenhorn	2880	100	10	70	2	3	2.9%	4.3%
176		4 - Greenhorn	2890	120	100	90	3	4	3.3%	4.4%
177		4 - Greenhorn	2900	120	60	100	3	4	3.0%	4.0%
178		4 - Greenhorn	2920	110	15	70	3	4	4.3%	5.7%
179		4 - Greenhorn	2985	150	25	70	3	4	4.3%	5.7%
180		4 - Greenhorn	2985	200	30	50	3	4	6.0%	8.0%
181		4 - Greenhorn	2910	100	12	60	2	3	3.3%	5.0%
182		4 - Greenhorn	2910	100	11	70	2	3	2.9%	4.3%
183		4 - Greenhorn	2880	250	15	215	2	2	0.9%	0.9%

Rise Well ID	1995 EIR Well ID	General Location	Elevation (ft) (Top of Well)	Well Depth (ft)	Well Test (gal/min)	Water Column (ft)	Drawdown - Basecase (ft)	Drawdown - Max Sensitivity (ft)	Drawdown - Basecase (%)	Drawdown - Sensitivity Max (%)
184		4 - Greenhorn	2850	275	25	235	1	1	0.4%	0.4%
185		4 - Greenhorn	2850	250	40	200	1	1	0.5%	0.5%
186		4 - Greenhorn	2895	300	12	100	2	2	2.0%	2.0%
187		4 - Greenhorn	2840	320	30	220	2	2	0.9%	0.9%
188		4 - Greenhorn	3000	250	9	175	2	2	1.1%	1.1%
189		4 - Greenhorn	2905	260	20	60	2	3	3.3%	5.0%
190		4 - Greenhorn	2905	300	12	100	2	3	2.0%	3.0%
191		4 - Greenhorn	2870	300	30	270	2	2	0.7%	0.7%
192		4 - Greenhorn	2870	265	17	235	2	2	0.9%	0.9%
193		4 - Greenhorn	2820	150	13	130	1	1	0.8%	0.8%
194		4 - Greenhorn	2910	200	3-4	Well deepened				
194		4 - Greenhorn	2910	300	20	250	2	2	0.8%	0.8%

Well Parameter Data Compiled from Well Completion Reports.

Downloaded from California Department of Water Resources Database: <https://data.cnra.ca.gov/dataset/well-completion-reports>

Pale yellow highlight indicates drawdown percentages between 7.5 percent and 10 percent of the existing water column in the well.

See discussion in Section 4.2.1 for explanation of the effects of these drawdown percentages.

4.2.2.3 Other Outlying Areas

Additional outlying areas are described in Section 3.3.2.1. Table 4-4 lists the wells in these outlying areas and provides the primary well parameters. The nearest underground working to these outlying areas is a single lateral drift, referred to as the Mitchell Cross-cut, which extends approximately 1,500 feet north of the Idaho #3 mine. The drift is approximately 1,030 feet below ground surface. Based on the methods described above for the Beaver Drive and Greenhorn Areas, it was assumed that the lateral drift is approximately one percent of the total underground mine working volume and that the transmissivity of the fractured bedrock at the depth of the drift is 10 percent of the transmissivity at the shallower well depths. Thus, the maintenance dewatering rate is conservatively assumed to be 0.001 times the full dewatering rate of 850 gpm, or 0.85 gpm. As seen in the discussions above for the Beaver Drive and Greenhorn Areas, a local groundwater dewatering rate of 0.85 gpm would not affect the water column in the /Outlying Area wells by more than one percent of the total water column height, which would be less than one foot to less than 6.2 feet of total drawdown, depending on the well (see Table 4-4). Although hydrographs showing seasonal change in wells in the Outlying Areas are not available, the estimated drawdowns are much smaller than the normal seasonal fluctuations in groundwater levels observed in other areas in the vicinity of the Idaho-Maryland Mine, which may range from 10 to 50 feet per year, as described in Section 3.3.2.2.

Table 4-4 also shows the drawdowns that are predicted by the Itasca (2020b) numerical model for the wells in the Outlying Areas. The base case drawdowns range from zero to two feet, while the maximum drawdowns under the worst-case sensitivity analysis range from one to two feet. These drawdowns are consistently less than five percent of the total water column height. As discussed in Section 4.2.1, drawdowns of at least 20 percent of the well column are generally required to potentially affect the use of a groundwater well and for this analysis, a 100 percent factor of safety has been applied such that any drawdowns that are at least 10 percent of the total water column are further evaluated. There are no wells in the Outlying Areas where the total predicted drawdown would exceed, or even approach, 10 percent of the total water column.

Table 4-4 Well Parameters and Potential Effects of Mine Dewatering, Outlying Areas

Rise Well ID	1995 EIR Well ID	General Location	Elevation (ft) (Top of Well)	Well Depth (ft)	Well Test (gal/min)	Water Column (ft)	Drawdown - Basecase (ft)	Drawdown - Max Sensitivity (ft)	Drawdown - Basecase (%)
78		5- Wood Rose	2809	100	20	70	1	2	1.4%
79		5- Wood Rose	2842	100	40	90	2	2	2.2%
80	WS217	5- Wood Rose	2871	100	30	85	2	2	2.4%
81		5- Wood Rose	2869	300	38	208	1	2	0.5%
82		5- Wood Rose	2897	720	1.5	620	2	2	0.3%
82		5- Wood Rose	2897	560	1	Well deepened			
82	WS26	5- Wood Rose	2897	180	5	Well deepened			
85		5- Wood Rose	2893	100	10	90	2	2	2.2%
86		5- Wood Rose	2970	350	6	290	1	2	0.3%
87		5- Wood Rose	2970	350	10	170	1	2	0.6%
94		5- Wood Rose	2980	480	12	300	1	2	0.3%
162		5- Wood Rose	2830	460	3.5	415	1	1	0.2%
89		6 - Burma Rd	2958	420	4	270	1	2	0.4%
90		6 - Burma Rd	2967	600	0.5	500	1	2	0.2%
91		6 - Burma Rd	2900	110	20	Unknown	1	2	
150		6 - Burma Rd	2900	125	60	83	1	1	1.2%
151		6 - Burma Rd	2930	180	10	138	1	1	0.7%
152		6 - Burma Rd	2930	300	3-4	258	1	1	0.4%
153		6 - Burma Rd	2945	160	30	110	1	1	0.9%
154		6 - Burma Rd	2915	325	8.5	275	1	1	0.4%
155		6 - Burma Rd	2900	125	40	105	1	1	1.0%
156		6 - Burma Rd	2910	100	100	70	1	1	1.4%
157		6 - Burma Rd	2920	100	20	50	1	1	2.0%
158		6 - Burma Rd	2900	120	24	80	1	1	1.3%
159		6 - Burma Rd	2920	120	10	90	1	1	1.1%

Rise Well ID	1995 EIR Well ID	General Location	Elevation (ft) (Top of Well)	Well Depth (ft)	Well Test (gal/min)	Water Column (ft)	Drawdown - Basecase (ft)	Drawdown - Max Sensitivity (ft)	Drawdown - Basecase (%)
160		6 - Burma Rd	2960	150	15	90	1	1	1.1%
161		6 - Burma Rd	2880	500	8	400	1	1	0.3%
145		7 - Leduc Acres	2865	110	30	50	1	1	2.0%
146		7 - Leduc Acres	2865	105	60	45	1	1	2.2%
147		7 - Leduc Acres	2880	120	60	60	1	1	1.7%
148		7 - Leduc Acres	2860	100	12+	40	1	1	2.5%
149		7 - Leduc Acres	2805	300	6	260	1	1	0.4%
140		8 - Cedar Ridge	2830	100	30	60	1	2	1.7%
141		8 - Cedar Ridge	2795	540	2	500	1	1	0.2%
142		8 - Cedar Ridge	2815	80	75	40	1	1	2.5%
143		8 - Cedar Ridge	2840	400	6.5	360	1	1	0.3%
144		8 - Cedar Ridge	2850	140	12-15	100	1	1	1.0%
195		9-North Brunswick	2790	120	25	60	0	1	0.0%
196		9-North Brunswick	2845	140	15	80	0	1	0.0%
197		9-North Brunswick	2820	200	20	140	0	1	0.0%
198		9-North Brunswick	2790	120	15	60	0	1	0.0%

Well Parameter Data Compiled from Well Completion Reports.

Downloaded from California Department of Water Resources Database: <https://data.cnra.ca.gov/dataset/well-completion-reports>

4.2.3 Future Exploration and Mining

Additional exploration and mining may occur as part of the project within the mineral rights boundary owned by Rise. The Itasca (2020b) finite element 3-D computer modelling was used to assess a range of possible future mining scenarios. The future scenarios would extend from 26 years to 60 years after project approval, if they were implemented. Sheet 15 shows the locations and extent of the potential future mining scenarios that were evaluated by Itasca (2020b).

Sheet 12 shows the drawdown contours predicted by the Itasca (2020b) model for the different sensitivity analyses and the potential future mining. Relatively shallow mining of pillars and remnant mineralization near the existing mine workings would occur at depths greater than 500 ft bgs or approximately 2,100 ft msl. However, the majority of the potential future mining would occur at depths greater than 1,000 ft bgs, or approximately 1600 ft msl. At these depths, the hydraulic conductivity and transmissivity of the fractured bedrock is very low, as discussed in Section 3.3.5, and would not result in substantial additional dewatering (Itasca, 2020b). With only one minor exception, the predicted drawdowns from the potential future mining fall within the area of the maximum drawdowns under the worst-case sensitivity analysis. In the one area that falls outside of the maximum sensitivity contours, referred to as the North Brunswick Area in Table 4-4 (see Sheet 12 for outline of the North Brunswick Area and related well locations), the additional drawdown due to future mining ranges from zero to one foot, or no more than 1.7 percent of the total water column height in the four wells in the area. Therefore, the potential additional future mining would not alter the predicted maximum drawdowns discussed in Section 4.2.2 above.

4.3 Post-Mining Groundwater Conditions

Once mining is completed, dewatering would cease and groundwater would begin to accumulate again within the underground mine workings. If the drains that currently exist along Wolf Creek are not sealed while the mine is dewatered, then water from within the mine would begin to discharge from those drains again once the water level in the mine reaches an elevation of approximately 2,500 ft msl. While substantial additional underground workings are anticipated to be constructed as part of the project, these new workings will be below 2,500 ft msl. Thus, once the mine fills with water again, the additional underground workings would be below the water level and would not contribute inflow into the mine as a passive “well”, as illustrated on the top part of Figure 3.20. As a result, the rate of drainage would be expected to be the same as the current rate at which the drains flow, which is approximately 60 to 70 gpm, or 0.13 cfs to 0.16 cfs. Groundwater levels in the wells would recover to their approximate pre-project levels.

If the drains along Wolf Creek were sealed, for example by sealing the shafts or tunnels that lead to the area of the drains, then water would no longer flow through the underground mine workings toward the drains. Since the mine workings would no longer be connected to the drains, the water level in the shafts would rise until they reached the same elevation as the surrounding groundwater in the fractured bedrock in the area of the shafts. As discussed in Section 3.4.5, the Itasca (2020b) numerical model simulated the drawdown of the groundwater surface under current conditions due to seepage into the shafts and other underground workings and the related discharge to Wolf Creek through the drains. The model results indicate that there is five to 10 feet of drawdown under current conditions in the area of the New Brunswick shaft and Union Hill Mine and a broad area of drawdown greater than 10 feet overlying an area along Brunswick Road extending from near the intersection with East Bennett Road northward to Idaho-Maryland Road (see Figure 3.22 (Figure 5-3 of Itasca, 2020b)). Therefore, if the drains are sealed, the final static water levels in the fractured bedrock in the East Bennett Road area may be five to 10 feet higher than they are currently.

As discussed in Sections 3.3.1 and 3.3.4, groundwater is recharged due to local percolation of rainfall into the fractures within the bedrock. In addition, the groundwater tends to flow from topographically high areas to topographically low areas, for example from ridges and upslope areas down toward the creeks and drainages. Thus, if the drains are sealed, groundwater would continue to flow downslope from the East Bennett Road area toward Wolf Creek and South Fork Wolf Creek. Sealing of the drains would not alter the overall net discharge of groundwater to the creeks.

EMKO estimated the groundwater flow volume that may occur through the fractured bedrock toward the drainages. Groundwater flow is calculated using Darcy’s Law (Domenico and Schwartz, 1990), which states that the flow is equivalent to the hydraulic conductivity of the aquifer (K) times the hydraulic gradient (i), which is the slope of the groundwater surface, times the area (A) across which the groundwater is flowing:

$$Q = K * i * A$$

As discussed in Section 3.3.5, the hydraulic conductivity of the shallow bedrock (above a depth of approximately 200 ft bgs) may range from 1.0 gpd/ft² to 30 gpd/ft² (Todd Engineers, 2007). The elevation to which groundwater would rise in the upper part of the East Bennett Road area would be in the range of 2,770 ft msl, while the elevation of Wolf Creek near the drain locations is approximately 2,500 ft msl. The distance from the New Brunswick shaft to Wolf Creek is approximately 7,800 feet. Thus, the hydraulic gradient would be approximately 0.035 ft/ft. Since fractures are present that allow rainfall to percolate to groundwater, those same fractures would allow groundwater that rises to the elevation of the ground surface to discharge as springs and flow to surface drainages. In the Wolf Creek area, the total area of such drainage could be 2,000 feet long and up to 270 feet high, or 540,000 ft². Applying Darcy's Law, as defined above, the total outflow of groundwater that may discharge to Wolf Creek and/or South Fork Wolf Creek after mining is completed and if the drains were sealed could vary from 12.5 gpm to 375 gpm, or approximately 0.03 cfs to 0.84 cfs. This range brackets the current estimated discharge rate of the drains along Wolf Creek of approximately 60 to 70 gpm, or 0.13 cfs to 0.16 cfs.

As described in Section 3.2, the base flow rate in Wolf Creek may range from 10 cfs to 50 cfs while the base flow rate in South Fork Wolf Creek may be less than one cfs. The peak storm flows on South Fork Wolf Creek are estimated to range from 650 cfs to 1,100 cfs. Based on the larger watershed size, peak storm flows on Wolf Creek in the vicinity of the Centennial Industrial Site could range from 800 cfs to 1,800 cfs. Thus, the flow rates in the creeks are substantially higher than the potential discharge rates from either the drains or groundwater seepage that would occur after mining is completed.

4.4 Mined Material Geochemistry

As described in Section 2.3, the mine will produce two mining waste materials. Mine development in nonmineralized "barren" rock (i.e. nongold bearing) is expected to result in the production of approximately 500 tons per day (182,500 tons per year) of barren rock. The barren rock would be crushed to a size of 6-inch underground, brought to surface and then used as engineered fill on the Centennial and Brunswick Industrial Sites.

Ore production through tunneling and long-hole blasting produces 1,000 tons per day (365,000 tons per year) of ore. The mineral process plant removes gold and most sulfide minerals which are sold as gold concentrates. The remaining processed ore results in sand tailings. Approximately 50 percent of the sand tailings, or about 500 tons per day, will be returned to the underground mine as backfill after processing. The other half of the sand tailings, again about 500 tons per day, will be used for engineered fill on the Centennial and Brunswick Industrial Sites.

Approximately 1,000 tons per day of engineered fill would be produced by the mine, which would be composed of approximately 500 tons of Barren Rock and 500 tons of Sand Tailings. Barren Rock and Sand Tailings used as engineered fill would be blended and compacted. Geotechnical Reports prepared by NV5 (NV5, 2019) recommend that a blend of either 100% sand tailings or a blend of up to 2 parts Barren Rock to 1 part Sand Tailings be used as engineered fill.

4.4.1 Barren Rock Used as Engineered Fill

Most of the underground work that would occur as part of the project would be tunneling to access the ore deposit and to provide access routes to move material and provide ventilation. These workings would be almost exclusively within barren meta-andesite rock. Cross cuts into the mineralized veins would produce some altered meta-andesite, as well as diabase and serpentinite in some of the Idaho vein areas. Table 4-5 shows the estimated daily barren rock production by geologic material type. The mass and percentages generally represent the amount of barren rock material that would be placed in the waste rock pile each day.

Table 4-5 *Estimated Daily Barren Rock Production*

Material Type	Tons per Day	Percent of Material Produced
Meta-Andesite	481	96
Altered Meta-Andesite	12	2
Diabase	5	1
Serpentinite	2	1
TOTAL	500	100

There are some areas where blocks of meta-sedimentary rocks are present in the meta-andesite unit. This rock type has not been included in the estimated barren rock but could be present in minor volumes in future mining during the project.

Rise completed 19 drill exploration drill core holes, totaling 67,500 linear feet, from 2017-2019. Exploration drilling was designed to test a variety of mineralization throughout the deposit in areas where mining is expected to occur. Drill core was logged by company geologists in Grass Valley. The core was sawed in half in zones of interest and sent to ALS Laboratories in Reno, Nevada to be assayed. ALS Laboratories crushed and homogenized the sample to -2mm size, split a 1 kg sample, pulverized the split sample, and assayed a split of the pulverized sample.

A California-licensed Professional Geologist from Benchmark Resources collected six drill core samples in Grass Valley on October 29, 2019 from barren rock intervals as shown in Table 4-6. Core sample locations and depth intervals are shown on Sheets 5, 6, and 7.

Table 4-6 *Core Samples Collected by Benchmark Resources*

Sample Name	Description	Date	Time	Bag #	Hole #	Elevation Interval
MA-1	Meta Andesite/Porphyrite	29/10/2019	10:45 AM	Y973551	I-19-13	167'-177'
MS-1	Meta Sediment/Porphyrite	29/10/2019	11:00 AM	Y973560	I-19-13	1,067'-1,077'
MA-2	Meta Andesite/Porphyrite	29/10/2019	11:05 AM	Y973594	I-19-13	3,959.7-3,969.7
MAA-1	Meta Andesite Altered/Porphyrite	29/10/2019	11:20 AM	core box	I-19-13	3,357'-3,360'
S-1	Serpentinite	29/10/2019	11:25 AM	core box	I-18-11	4,725.6'-4,725.7'
MA-3	Meta Andesite Altered/Porphyrite	29/10/2019	11:45 AM	core box	I-18-10	3,265'-3,266'

The barren rock samples were sent to ACZ Laboratories in Steamboat Springs, Colorado. ACZ Laboratories performed total metals analysis and leaching tests using deionized water (DI-WET), using EPA methods in a California Certified lab, on each of the samples. The DI-WET test is intended to simulate leaching from the waste rock pile by rainfall. Static Acid-Based Accounting (ABA) tests were also conducted by ACZ. Table 4-7 provides a summary of total metals and DI-WET results. Certified laboratory reports are provided in Appendix D.

As indicated in Table 4-7, the barren rock samples did not leach most heavy metals, including cadmium, chromium, cobalt, copper, mercury, and zinc. Other metals did not leach at concentrations that exceed water quality standards, except for arsenic in the altered meta-andesite and serpentinite samples. Arsenic is present in the meta-andesite and meta-sediment samples at total concentrations ranging from 0.2 milligrams per kilograms (mg/kg, equivalent to parts per million or ppm) to 6.1 mg/kg, which is generally within or below typical natural background levels of arsenic in California (DTSC, 2018; USGS, 2013). However, in the altered meta-andesite and the serpentinite, the total arsenic concentrations were 34.8 mg/kg and 36.8 mg/kg. The DI-WET results show that the arsenic within the meta-andesite and meta-sediments will leach at concentrations of 0.005 milligrams per liter (mg/L, equivalent to parts per million, or ppm) or less, which is one-half of the typical water quality standard for arsenic of 0.01 mg/L. In contrast, the altered meta-andesite leached arsenic at 0.0148 mg/L, which is 50 percent greater than the water quality standard. The serpentinite sample leached arsenic at 0.169 mg/L, which is almost 17 times greater than the water quality standard. However, as shown in Table 4-5, the altered meta-andesite and serpentinite are anticipated to comprise only two percent and one percent, respectively, of the barren rock volume that would be placed in the waste rock pile. Based on the arsenic DI-WET leaching concentrations in Table 4-7 and the material percentages shown in Table 4-5, the bulk average arsenic concentration in rainfall that would percolate through the waste rock pile, assuming it included no sand tailings, would be 0.004 mg/L, which is only 40 percent of the water quality standard. The DI-WET test uses a much finer particle size of -2mm crushed material than the -6 inch barren rock that will be produced from the mine. Thus, the barren rock used in the engineered fill will have a substantially smaller surface area to volume ratio than the crushed material used for the DI-WET analysis. The smaller surface area to volume ratio should result in lower concentrations of metals leaching from the engineered fill than identified in the DI-WET leaching tests.

The DI-WET leaching data indicate that the water that percolates through the barren rock in the engineered fill would be a calcium-sodium-bicarbonate water with a specific conductance of approximately 70 micromhos per centimeter ($\mu\text{mhos/cm}$), a hardness of about 15 mg/L, an alkalinity of 30 mg/L, and a pH of 9.7. The low specific conductance, hardness, and alkalinity are consistent with limited water contact with hard rock. The relatively high pH value, however, is inconsistent with the pH values measured in the New Brunswick shaft, the drains, and in surface water. As indicated in Section 3.4.1, the existing pH in water within and draining from the underground mine workings, and within the creeks flowing across the bedrock, ranges from 5.78 to 7.8 (see Tables 3-5, 3-6, 3-8, 3-9, and 3-10). The elevated pH from the DI-WET analyses may be a result of the fine crushing of the samples for the leaching tests. Whatever the reason, the pH results from the DI-WET tests are not consistent with site-specific measurements made under actual field conditions.

The ABA results are presented in Table 4-8. Both the alkaline nature of the host rock and the presence of carbonate veins result in a relatively strong net acid neutralization potential.

In addition to the barren rock samples, Rise provided 48 crushed core samples, taken from -2mm assay rejects, for trace element test work. This material provides information on the variability of trace metals that may be present in the rock that would be produced from tunneling in barren rock in different lithologies. Forty samples were from meta-andesite, five samples were from meta-sediment, one sample was from diabase, and one sample was from serpentinite. These samples were analyzed for trace elements by ACZ in Colorado using EPA methods by a California Certified Lab. Table 4-9 summarizes the analytical results from ACZ for the 48 rock samples. For most metals, the concentration in the crushed core samples were similar to or less than the concentrations in the barren rock samples. All sample locations are shown on Sheets 5, 6, and 7.

4.4.2 Sand Tailings Used as Engineered Fill

Rise Grass Valley Inc. prepared a metallurgical sample composite for testwork and preparation of a tailings sample, representative of expected tailings to be produced by the IM Mine Project.

Rise completed 19 exploration drill core holes, totaling 67,500 feet, from 2017-2019. Exploration drilling was designed to test a variety of mineralization throughout the deposit in areas where mining is expected to occur. Drill core was logged by company geologists in Grass Valley. Mineralized core was sawed in half and assayed for gold at ALS Laboratories in Reno, Nevada. ALS Laboratories crushed and homogenized the sample to -2mm size, split a 1 kg sample, pulverized the split sample, and assayed a split of the pulverized sample.

Rise selected mineralized samples for metallurgical testwork by reviewing drill logs and maps. Samples were selected to represent materials representative of future mining. Factors considered in selection were gold grades, minimum mining widths, mineralization style, and locations throughout the potential mining areas. Sample locations and depth intervals are shown on Sheets 5, 6, and 7.

A composite sample was prepared from 76 samples of the -2mm material remaining from assaying. A portion of the material from each sample was weighed to represent the interval length and merged to make the metallurgical sample. Sufficient material was available for most samples, except for five samples where no material was available from the assay lab. The 76 samples created a composite metallurgical sample of approximately 46 kilograms (kg) (about 100 pounds).

The 46 kg metallurgical sample was shipped in July 2019 to McClelland Laboratories in Reno, Nevada for testwork. McClelland homogenized the sample and then split the sample into approximately 12 kg sub-samples. McClelland processed each sub-sample with a process designed to simulate that planned to be used for mineral processing at the IM Mine Project. Each sample was crushed and ground with gravity concentration of gold followed by sulfide flotation. The testwork resulted in four flotation tailings samples, labeled F1-F4, which were done at progressively coarser grind sizes. Testwork results showed acceptable

gold recoveries and concentrate grades for each grind size tested. The McClelland Metallurgical Testing Report is included in Appendix H.

Flotation tailings samples (F1-F4) were shipped by McClelland Labs to a California-licensed Professional Geologist from Benchmark Resources in November 2019 who then submitted the samples to ACZ Laboratories in Steamboat Springs, Colorado.

ACZ Laboratories performed total metals analysis and DI-Wet testing, using EPA methods in a California Certified lab, on each of the tailings samples as shown in Table 4-7. As indicated in Table 4-7 the tailings samples did not leach most heavy metals, including barium, beryllium, cadmium, chromium, cobalt, iron, lead, manganese, mercury, molybdenum, and zinc. Other metals did not leach at concentrations that exceed water quality standards, including arsenic. Arsenic is present in the tailings samples at total concentrations ranging from 1.2 mg/kg to 2.0 mg/kg, which is below typical natural background levels of arsenic in California (DTSC, 2018; USGS, 2013). The DI-WET arsenic concentrations from the tailings samples was less than 0.002 mg/L in all four samples, which is less than 20 percent of the water quality standard. Thus, using the sand tailings within the engineered fill would not result in metals leaching from the fill material at concentrations that exceed regulatory limits.

The DI-WET leaching data indicate that the water that percolates through the sand tailings in the engineered fill would be a calcium-bicarbonate water with a specific conductance of approximately 110 $\mu\text{mhos/cm}$, a hardness of about 35 mg/L, an alkalinity of 45 mg/L, and a pH of 9.4. As with the barren rock, discussed above, the relatively high pH value is inconsistent with the pH values measured in the New Brunswick shaft, the drains, and in surface water, where the existing pH values range 5.78 to 7.8 (see Tables 3-5, 3-6, 3-8, 3-9, and 3-10). The elevated pH from the DI-WET analyses of the sand tailings may be a result of the fine crushing of the samples for the leaching tests.

ACZ also completed Static Acid Based Accounting testwork on the samples as shown in Table 4-8. As with the barren rock, the alkaline nature of the host rock and the presence of carbonate veins result in a relatively strong net acid neutralization potential.

Table 4-7 Tailings & Barren Rock Samples - Total Metals and DI-WET Results

Constituent	Test Type	Units	Tailings Samples				Rock Samples					
			F-1	F-2	F-3	F-4	MA-1	MA-2	MA-3	MAA-1	MS-1	S-1
METALS												
Aluminum	Total	mg/Kg	16100	16300	16300	16300	23000	24400	31100	421	22900	41300
	DI-WET	mg/L	0.17	0.18	0.26	0.28	0.94	1.08	0.6	0.49	0.99	0.32
Antimony	Total	mg/Kg	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.1	<0.2	0.6
	DI-WET	mg/L	0.0018	0.0015	0.0031	0.0020	0.0006	0.0041	0.0016	0.0104	0.0021	0.1050
Arsenic	Total	mg/Kg	1.7	1.4	2.000	1.2	0.2	6.1	0.5	34.8	0.7	36.8
	DI-WET	mg/L	0.0018	0.0013	0.0019	0.0014	<0.0002	0.0051	0.0014	0.0148	0.0005	0.1690
Barium	Total	mg/Kg	18.4	16.6	17.9	17.6	2.3	9.4	122	1.6	18.3	1.1
	DI-WET	mg/L	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.23	<0.007	<0.007	<0.007
Beryllium	Total	mg/Kg	0.23	0.22	0.22	0.22	0.07	0.16	0.09	<0.04	0.13	<0.04
	DI-WET	mg/L	<.00008	<.00008	<.00008	<.00008	<.00008	<.00008	<.00008	<.00008	<.00008	<.00008
Boron	Total	mg/Kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	7
	DI-WET	mg/L	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02	0.13
Cadmium	Total	mg/Kg	0.61	0.62	0.62	0.59	0.29	0.18	0.25	0.35	0.37	<0.03
	DI-WET	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Chromium	Total	mg/Kg	73	75	88	88	144	43	152	<1	54	1740
	DI-WET	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt	Total	mg/Kg	13	13	13	13	24	18	27	6	22	76
	DI-WET	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	Total	mg/Kg	86	86	87	84	141	43	87	27	89	30
	DI-WET	mg/L	<0.01	0.01	0.02	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	Total	mg/Kg	35500	36000	35200	35200	45600	42100	54900	15500	33700	36800
	DI-WET	mg/L	<0.03	<0.03	<0.03	<0.03	0.05	0.08	0.20	<0.03	<0.03	0.33
Lead	Total	mg/Kg	11.80	9.34	10.20	8.88	1.45	4.44	0.59	22.80	1.08	1.92
	DI-WET	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	0.0001	<0.0001	0.0002
Manganese	Total	mg/Kg	1000	1010	990	994	604	747	1230	311	696	176

Constituent	Test Type	Units	Tailings Samples				Rock Samples					
			F-1	F-2	F-3	F-4	MA-1	MA-2	MA-3	MAA-1	MS-1	S-1
	DI-WET	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury	Total	ng/g	39.9	45.1	41.9	71.3	25.9	35.1	11.4	43.4	19.0	25.7
	DI-WET	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Molybdenum	Total	mg/Kg	22	33	42	37	<2	<2	<2	271	<2	3
	DI-WET	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.06	<0.02	<0.02
Nickel	Total	mg/Kg	31.1	31.5	30.3	29.9	51.0	26.8	52.5	3.0	32.4	1810.0
	DI-WET	mg/L	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	0.012
Selenium	Total	mg/Kg	0.11	0.12	0.13	0.11	1.07	0.12	0.26	0.96	0.40	0.20
	DI-WET	mg/L	0.0003	0.0002	0.0003	0.0003	0.0001	<0.0001	<0.0001	0.0004	0.0003	<0.0001
Silver	Total	mg/Kg	0.23	0.21	0.23	0.2	0.12	0.42	0.74	0.59	0.17	<0.05
	DI-WET	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Thallium	Total	mg/Kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	DI-WET	mg/L	<0.0001	<0.0001	0.0003	0.0001	<0.0001	<0.0001	0.0010	0.0002	0.0001	<0.0001
Vanadium	Total	mg/Kg	72.0	73.2	73.4	73.0	126.0	167.0	147.0	4.9	129.0	63.4
	DI-WET	mg/L	0.008	0.010	0.018	0.014	0.030	0.035	0.029	0.007	0.040	0.031
Zinc	Total	mg/Kg	65	63	63	63	60	59	82	11	47	17
	DI-WET	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
GENERAL CHEMISTRY PARAMETERS												
Bicarbonate	DI-WET	mg/L	40.7	40.2	43.5	44.6	21.6	26.2	28.0	32.4	19.9	<2
Calcium	DI-WET	mg/L	9.0	8.5	7.5	8.3	6.0	4.6	4.5	8.8	4.1	<0.1
Carbonate	DI-WET	mg/L	4.5	3.2	2.6	3.1	2.8	4.4	3.0	14.4	9.9	73.6
Chloride	DI-WET	mg/L	1.7	1.9	2.8	2.5	4.4	3.3	0.7	6.6	1.4	0.7
Conductivity	DI-WET	umhos/cm	105	100	115	118	61	67	74	106	57	200
Fluoride	DI-WET	mg/L	<0.1	<0.1	<0.1	<0.1	0.2	0.2	0.1	<0.1	0.2	<0.1
Hardness	DI-WET	mg/L	38	36	33	36	18.0	14.0	15.0	38.0	12.0	4.5
Hydroxide	DI-WET	mg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	30
Magnesium	DI-WET	mg/L	3.8	3.5	3.5	3.8	0.6	0.6	0.9	3.9	0.3	1.1
Nitrate	DI-WET	mg/L	0.06	0.08	0.28	0.24	<0.02	<0.02	0.05	<0.02	<0.02	<0.02

Constituent	Test Type	Units	Tailings Samples				Rock Samples					
			F-1	F-2	F-3	F-4	MA-1	MA-2	MA-3	MAA-1	MS-1	S-1
Nitrite	DI-WET	mg/L	0.03	0.03	0.06	0.05	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
pH	DI-WET	std units	9.4	9.3	9.3	9.3	9.7	9.6	9.7	9.7	10.0	10.6
Potassium	DI-WET	mg/L	3.8	4.2	7.8	7.4	1.2	3.0	1.8	<0.2	1.6	2.7
TDS	DI-WET	mg/L	64	72	78	78	76	72	68	86	54	178
Sodium	DI-WET	mg/L	3.7	3.6	5.1	4.7	4.9	6.9	8.6	7.4	6.7	38.7
Sulphate	DI-WET	mg/L	8.4	6.3	8.5	8.7	3.3	1.4	6.6	1.9	1.1	2.8
Total Alkalinity	DI-WET	mg/L	45.2	43.4	46.1	47.7	24.4	30.6	31.0	46.7	29.8	104.0

Table 4-8 Tailings & Barren Rock Samples - ABA Results

Parameter	Units	Tailings Samples				Rock Samples					
		F-1	F-2	F-3	F-4	MA-1	MA-2	MA-3	MAA-1	MS-1	S-1
Acid Generation Potential	t CaCO ₃ /Kt	1.25	1.56	1.88	1.88	35.3	12.5	1.25	60.9	6.25	4.38
Acid Neutralization Potential	t CaCO ₃ /Kt	199	194	204	189	241	150	134	83	200	36
Acid-Base Potential	t CaCO ₃ /Kt	198	192	202	187	206	138	133	22.1	194	31.6
ANP to AGP Ratio	t CaCO ₃ /Kt	159	124	109	101	6.82	12	107	1.36	32	8.23
Neutralization Potential as CaCO ₃	%	19.9	19.4	20.4	18.9	24.1	15	13.4	8.3	20	3.6
pH, Saturated Paste											
Max Particle Size	um	250	250	250	250	250	250	250	250	250	250
pH	units	8.6	8.3	8.9	8.7	9.4	9.4	9.3	9.7	9.8	10.1
Sulfur Forms											
Sulfur HCl Extractable	%	<0.01	<0.01	<0.01	<0.01	0.94	0.11	0.01	<0.01	0.11	<0.01
Sulfur HNO ₃	%	0.04	0.04	0.06	0.05	0.02	0.27	0.04	1.78	0.06	0.13
Extractable											
Sulphur Hot H ₂ O	%	<0.01	0.01	<0.01	0.01	0.13	<0.01	<0.01	0.16	<0.01	<0.01
Sulphur Residual	%	<0.01	<0.01	<0.01	<0.01	0.04	0.03	<0.01	0.04	0.05	0.02
Sulphur Total	%	0.04	0.05	0.06	0.06	1.13	0.4	0.04	1.95	0.2	0.14

Table 4-9 Barren Rock Crushed Core Samples – Total Metals Results

Rock Type	Hole ID	Sample ID	From	To	Length	Al	Sb	As	Ba	Be	B	Cd	Cr	Co	Cu	Fe	Pb	Mg	Mn	Ni	Se	Ag	Th	V	Zn
			ft	ft	ft	mg/kg																			
Dia	I-18-11	Y973586	4107.8	4117.6	9.8	23500	<0.2	7.4	0.9	<0.04	31	<0.03	319	99	75	59200	0.53	830	<2	1400	0.23	<0.05	<0.05	18	20
MA	B-18-02	Y973583	948.0	958.0	10.0	23100	<0.2	2.2	4.7	0.05	<2	0.47	112	25	220	35900	0.59	666	<2	35.3	0.26	0.13	<0.05	125	42
MA	I-18-10	Y973584	2926.0	2936.0	10.0	26100	<0.2	5.6	4.6	0.06	<2	0.28	122	23	65	33700	0.92	571	<2	51.5	<0.05	0.06	<0.05	103	48
MA	I-18-10	Y973585	3104.4	3114.4	10.0	26300	<0.2	0.8	13.8	0.08	<2	0.26	135	25	67	35700	0.85	741	<2	53.1	0.2	0.06	<0.05	124	63
MA	I-18-10	Y973587	3332.0	3342.0	10.0	26700	<0.2	1.5	2.3	<0.04	<2	0.39	156	35	66	45000	0.27	847	<2	55.4	0.22	0.06	<0.05	136	56
MA	I-18-12	Y973589	3665.7	3675.7	10.0	24500	<0.2	1.9	14.7	0.05	<2	0.45	142	31	99	39400	0.37	737	<2	43.5	0.23	0.13	<0.05	106	49
MA	I-18-12	Y973588	3819.9	3829.9	10.0	26900	<0.2	0.5	14.7	0.05	<2	0.49	93	33	98	44300	0.32	768	<2	47.7	0.24	0.13	<0.05	129	50
MA	I-19-13	Y973551	167.0	177.0	10.0	19800	<0.2	0.4	4.9	0.05	<2	0.42	100	21	54	32900	1.19	590	<2	36	0.45	0.09	<0.05	97.8	50
MA	I-19-13	Y973552	267.0	277.0	10.0	21700	<0.2	0.5	6.7	0.04	<2	0.3	115	20	49	28800	0.59	640	<2	41	<0.05	0.06	<0.05	109	43
MA	I-19-13	Y973553	367.0	377.0	10.0	26500	<0.2	0.5	5.7	<0.04	<2	0.47	160	23	64	35200	0.96	603	<2	64.6	0.1	0.08	<0.05	123	46
MA	I-19-13	Y973554	467.0	477.0	10.0	21900	<0.2	1.3	4.1	<0.04	<2	0.4	81	23	75	35100	0.65	550	<2	40.9	0.25	0.09	<0.05	102	48
MA	I-19-13	Y973555	567.0	577.0	10.0	22000	<0.2	4.3	4.7	0.05	<2	0.38	150	24	58	32100	0.74	557	<2	63.3	0.12	0.08	<0.05	109	43
MA	I-19-13	Y973556	667.0	677.0	10.0	25000	<0.2	1.3	5.1	0.07	<2	0.4	156	25	58	35800	0.69	633	<2	54.1	0.12	0.08	<0.05	117	48
MA	I-19-13	Y973557	767.0	777.0	10.0	33100	<0.2	7.0	11.9	0.13	<2	0.41	126	31	79	51200	0.88	933	<2	48.6	0.36	0.11	<0.05	191	72
MA	I-19-13	Y973558	867.0	877.0	10.0	25000	<0.2	3.1	4.5	0.05	<2	0.34	82	25	61	38200	0.73	598	<2	36.8	0.27	0.08	<0.05	114	56
MA	I-19-13	Y973564	1467.0	1477.0	10.0	27600	<0.2	1.6	6.6	0.09	<2	0.51	122	24	58	40200	0.63	611	<2	43.6	0.34	0.09	0.07	162	60
MA	I-19-13	Y973565	1577.0	1587.0	10.0	17400	<0.2	1.8	6.7	0.16	<2	0.92	139	35	19	57700	0.74	778	<2	37.1	0.11	0.1	<0.05	200	69
MA	I-19-13	Y973566	1677.0	1687.0	10.0	25200	0.3	2.0	12.4	0.2	<2	0.68	143	41	15	63600	1.23	1130	<2	53.4	0.12	0.07	0.08	172	103
MA	I-19-13	Y973567	1777.0	1787.0	10.0	22900	<0.2	2.8	14.8	0.16	<2	0.96	137	42	23	47400	0.94	1050	<2	56	0.11	0.1	0.08	188	101
MA	I-19-13	Y973568	1890.0	1900.0	10.0	22100	<0.2	1.9	7.9	0.12	<2	0.7	169	39	34	47800	0.38	815	<2	54	0.09	0.08	0.06	173	69
MA	I-19-13	Y973569	1977.0	1987.0	10.0	27700	<0.2	4.9	11.7	0.12	<2	0.77	196	42	29	38400	0.37	1090	<2	69.6	0.08	0.08	0.06	179	81
MA	I-19-13	Y973570	2077.0	2087.0	10.0	33900	<0.2	2.7	20.2	0.16	<2	0.61	210	44	23	45200	0.29	1080	<2	75.8	0.2	0.08	0.15	208	88
MA	I-19-13	Y973571	2187.0	2197.0	10.0	28500	<0.2	2.2	6.8	0.15	<2	0.69	163	41	72	63500	0.17	1140	<2	56.8	0.1	0.09	0.14	235	75
MA	I-19-13	Y973572	2277.0	2287.0	10.0	21700	<0.2	2.2	2.7	0.06	3	0.76	45	28	57	27700	0.16	519	<2	33.5	0.42	0.09	<0.05	94.8	35
MA	I-19-13	Y973573	2387.0	2397.0	10.0	30000	<0.2	0.9	2.1	0.11	<2	0.52	152	32	52	41200	0.52	878	<2	49.4	0.1	0.11	<0.05	160	53
MA	I-19-13	Y973574	2477.0	2487.0	10.0	32000	<0.2	2.4	3.5	0.11	<2	0.47	146	35	51	44500	0.57	853	<2	52.9	0.14	0.08	<0.05	144	66
MA	I-19-13	Y973575	2587.0	2597.0	10.0	27500	<0.2	1.4	2	0.07	<2	0.48	177	32	62	44500	0.22	773	<2	49.1	0.24	0.07	<0.05	153	85
MA	I-19-13	Y973576	2677.0	2687.0	10.0	31500	<0.2	1.3	33	0.06	<2	0.41	313	47	52	46100	0.18	801	<2	260	0.07	<0.05	0.19	120	53
MA	I-19-13	Y973577	2757.0	2767.0	10.0	31400	<0.2	1.5	8.5	0.13	<2	0.48	118	38	57	56400	0.42	952	<2	38.7	0.29	0.06	<0.05	176	55
MA	I-19-13	Y973578	2837.0	2847.0	10.0	28800	<0.2	0.7	2.5	0.05	<2	0.39	138	35	81	46000	0.28	762	<2	46.7	0.35	0.06	<0.05	142	40
MA	I-19-13	Y973579	2917.0	2927.0	10.0	29300	<0.2	0.8	2.7	0.05	<2	0.39	137	35	83	44500	0.27	770	<2	49	0.39	0.06	<0.05	143	38

Groundwater Hydrology and Water Quality Analysis Report for the Idaho-Maryland Mine Project

Rock Type	Hole ID	Sample ID	From	To	Length	Al	Sb	As	Ba	Be	B	Cd	Cr	Co	Cu	Fe	Pb	Mg	Mn	Ni	Se	Ag	Th	V	Zn
			ft	ft	ft	mg/kg																			
MA	I-19-13	Y973580	3017.0	3027.0	10.0	29400	<0.2	1.5	1.2	0.06	<2	0.38	137	33	88	41000	0.76	761	<2	61.5	0.19	0.08	<0.05	98.4	48
MA	I-19-13	Y973581	3117.0	3127.0	10.0	17600	<0.2	0.9	11.1	0.09	<2	0.52	29	18	110	32200	0.59	496	<2	14.9	0.23	0.09	<0.05	130	42
MA	I-19-13	Y973582	3217.0	3227.0	10.0	32600	<0.2	3.7	3.2	0.05	<2	0.24	158	35	57	45500	0.8	795	<2	60.4	0.22	0.07	<0.05	136	46
MA	I-19-13	Y973590	3583.0	3593.0	10.0	40100	<0.2	2.0	6.3	0.08	<2	0.24	204	40	71	60800	0.93	1100	<2	79.6	0.41	0.13	<0.05	201	56
MA	I-19-13	Y973591	3687.0	3697.0	10.0	27200	<0.2	0.5	3.3	0.08	<4	0.25	170	27	52	35500	0.56	628	<2	51	0.11	0.05	<0.05	125	38
MA	I-19-13	Y973592	3781.2	3791.2	10.0	29800	<0.2	1.8	1.6	0.09	<4	0.25	124	33	51	41000	0.29	704	<2	43.1	0.18	<0.05	<0.05	134	35
MA	I-19-13	Y973593	3878.3	3888.3	10.0	34300	<0.2	2.0	2.6	0.17	<4	0.39	174	37	88	47000	0.53	846	<2	48	0.23	0.07	<0.05	175	93
MA	I-19-13	Y973594	3959.7	3969.7	10.0	23900	<0.2	6.1	7.6	0.2	<4	0.24	73	22	115	39700	4.01	587	<2	28.8	0.13	0.13	<0.05	168	57
MA	I-19-13	Y973595	4313.0	4323.0	10.0	33900	<0.2	3.2	11.8	0.19	<4	0.25	228	27	38	39900	1.42	610	<2	89.4	0.07	<0.05	<0.05	174	53
MA	I-19-13	Y973596	4767.9	4772.7	4.8	37800	<0.2	1.2	6.8	0.29	<4	0.46	162	38	46	65300	0.47	945	<2	52.4	0.2	0.07	<0.05	247	75
MS	I-19-13	Y973559	967.0	977.0	10.0	16400	<0.2	1.1	11.2	0.11	<2	0.68	74	17	60	32800	2.71	541	<2	30.2	1.89	0.2	<0.05	102	72
MS	I-19-13	Y973560	1067.0	1077.0	10.0	26600	<0.2	5.6	31.1	0.12	<2	0.6	80	26	75	42000	1.69	744	<2	35.9	0.69	0.13	<0.05	139	60
MS	I-19-13	Y973561	1157.0	1167.0	10.0	23000	<0.2	1.0	25.6	0.09	<2	0.29	63	19	63	31200	1.39	527	<2	26	0.43	0.1	<0.05	99	50
MS	I-19-13	Y973562	1267.0	1277.0	10.0	6620	<0.2	0.6	14.2	0.07	<2	0.47	21	6	26	11000	0.88	276	<2	10.2	0.85	0.11	<0.05	31	42
MS	I-19-13	Y973563	1367.0	1377.0	10.0	16700	<0.2	0.6	48	0.07	<2	0.52	35	12	27	25200	1.42	438	<2	17	0.36	0.14	<0.05	80.8	55
S	I-19-13	Y973597	4772.7	4774.6	1.9	76200	<0.2	1.0	2.1	0.21	<10	0.04	746	42	<5	76800	0.31	1060	<2	550	<0.05	<0.05	<0.05	130	100

Notes:
Dia = Diabase, MA = Meta-Andesite, MS = Meta-Sediments, S = Serpentinite

4.4.3 Sand Tailings Used as Underground Cemented Paste Backfill

Rise intends to backfill some of the mine workings with cemented paste backfill (CPB). CPB typically consists of tailings mixed with cement and water. Use of CPB for backfilling has several advantages, including:

- Introduction of lime in the cement, which can act to offset any acid generation potential from sulfide minerals in the mine wall rock;
- Reduction of the above-ground land surface area needed for tailings storage and disposal and potential related impacts; and
- Lower porosity and permeability in the tailings material, reducing the potential to mobilize metals and other constituents in the tailings.

There are two primary water-quality concerns related to the use of CPB. The first is that it can potentially increase the pH in the surrounding water when the mine is re-flooded. The second is that some cement materials have been documented to leach hexavalent chromium (Cr^{+6}). Rise retained Itasca (2020a) to conduct a desktop study of CPB use for the project, its potential impacts on water quality, and site-specific considerations for use in the Idaho-Maryland Mine.

Itasca (2020a) determined that use of CPB for the project is an environmentally favorable method for tailings disposal because it can significantly reduce any potential release of metals from the tailings and will minimize the area of above-ground surface disturbance needed for tailings disposal. Itasca (2020a) recommends that additional testing and engineering be conducted prior to implementation to select the proper source of the Portland cement binding agent to minimize the presence of Cr^{+6} in the mixture, and identify the minimum time that should be allowed for the mixture to cure before allowing it to become inundated in the mine workings.

Itasca (2020a) concludes that, based on the available data, the use of CPB composed of tailings, Portland cement, and water is an environmentally favorable disposal alternative for tailings because, when used properly, it significantly limits solute release and reduces the surface footprint of the mine. The CPB will contribute additional net neutralization potential to the backfilled areas and is not anticipated to negatively affect groundwater as a result of solute leaching because of the low metals content, low sulfide content, and net-neutralizing character of the CPB materials.

4.5 Water Quality

As discussed in Section 3.4, the water within the underground mine workings, as measured in samples collected from the New Brunswick shaft and from the drains, has elevated levels of iron and manganese which exceed both the secondary drinking water standards and the NPDES effluent limits for these metals. Arsenic has been detected on a few occasions in water from the shaft at concentrations below its MCLs and NPDES effluent limit. However, elevated levels of arsenic have been detected in water samples collected from some of the drains. The laboratory water quality data from the drains and shaft are summarized in Tables 3-6, 3-7, and 3-9.

As described in Section 2.0, water would initially be pumped from the New Brunswick shaft at a rate of about 2,500 gpm for approximately six months to dewater the existing underground mine workings. Pumping would then occur at a rate averaging approximately 850 gpm to remove groundwater that would enter the existing and new underground mine workings (i.e. maintenance dewatering). Over the life of the operation the maintenance dewatering could increase as new mine workings are constructed. However, since most of the proposed new mine workings are at depths where the transmissivity and hydraulic conductivity are very low, the incremental additional inflow of groundwater into the mine will be a small percentage of the overall maintenance dewatering rate. Itasca estimated that groundwater inflow, for the base case mine plan, would reach a maximum value of 1,100 gpm with the stable predicted inflow being 900 gpm. With additional water entering historic shafts during the rainy season total pumping could range up to 1,400 gpm. In Itasca's sensitivity analysis, with increased mining areas, the groundwater inflow was predicted to increase by an additional 100 gpm (Itasca, 2020b). Thus, the maximum permitted discharge of 2,500 gpm would be sufficient for the life of the project and would provide flexibility during operations.

For the dewatering operations, the water would initially be pumped to an existing clay-lined pond to the southeast of the shaft. The water would then be treated by a series of oxidation and filtration steps before being discharged. Linkan Engineering prepared a water treatment plant design report which included bench testing of water samples from the Brunswick Shaft (Linkan, 2019). The treated water would be discharged to South Fork Wolf Creek downstream of the natural creek that NID uses to convey water from the DS Canal Extension to the creek. The water treatment system would be designed to lower the concentrations of iron, manganese, and any elevated arsenic to the MCL and NPDES effluent limits or less. The oxidation and filtration would remove cis-1,2-DCE and other constituents that might potentially exceed the NPDES effluent limits on occasion, such as ammonia. The oxidation process would also raise the dissolved oxygen content of the water to be within the allowable NPDES limits. The treatment would occur within a closed system with appropriate containment structures. Treatment residuals would be managed in accordance with applicable federal, state, and local waste management requirements.

The temperature of the water within the mine workings and the drains remains relatively constant, between 14 and 15 degrees C (see Table 3.5). The water temperature in South Fork Wolf Creek varies seasonally, from about 9 degrees C in the winter, to 12 degrees C in the spring, to 15 degrees C in late summer. The NPDES requirements indicate that the discharge should not alter the temperature of the receiving water by more than 5 degrees F, which is about 2.8 degrees C. During the summer, the temperature of the discharge from the mine would be comparable to the temperature of the receiving water in South Fork Wolf Creek. During the winter and early spring, the temperature of the water in the mine would be more than 2.8 degrees C warmer than the creek. However, after being pumped from the mine, the water would be stored within a surface pond before treatment and discharge. During the winter and early spring, the ambient temperature should cool the water in the pond. In addition, the rate of discharge would be less than the typical flow rates in South Fork Wolf Creek during the winter and early spring, such that the discharge should not alter the temperature in the creek by more than 2.8 degrees C. Therefore, the discharge would comply with the temperature criteria in the NPDES permit.

Blasting will occur within the underground mine workings. The water treatment system has been designed to treat for ammonia to prevent any potential impacts to water quality from blasting residuals or material that did not completely detonate.

Once mining is completed, the underground workings would be allowed to fill with water. Due to the nature of the geology, reducing conditions would occur within the water that fills the mine workings, just as they occur now. The reducing conditions would prevent oxidation of any sulfide minerals present and, therefore, conditions that would be potentially conducive to the formation of acid mine drainage would not develop. The laboratory testing conducted on the drill core samples (Section 4.4.1) demonstrates that all of the lithologies have high ratios of neutralization potential versus acid generation potential, ranging from a ratio of 6.5 to 300 times greater. The analytical testing completed on the tailings samples (Section 4.4.2), which would be used as underground backfill, also shows acid neutralization up to 204 times greater than acid generation potential.

The water within the underground workings is currently deficient in oxygen, as demonstrated by the reducing conditions and the DO levels measured in the samples from the shaft and the drains (Table 3-5). As a result, there is insufficient oxygen present to oxidize sulfide minerals that may be exposed within the surfaces of the underground workings. However, once the mine is dewatered, oxygen would be available in the air within the mine to potentially oxidize sulfide minerals. Any potential acid generated during the oxidation would be quickly neutralized by the carbonate minerals in the host rock. However, the process of sulfide oxidation and subsequent neutralization has the potential to create elevated TDS levels in the water that is seeping into the mine and being removed by the maintenance dewatering (Gomo, 2018). Oxidation of pyrite in the presence of carbonate minerals (e.g. calcite and dolomite) may occur based on the following formula (Equation 5 of Gomo, 2018):



The resulting oxidation results in elevated levels of sulfate, calcium, and magnesium in the water. The iron hydroxide ($\text{Fe}(\text{OH})_3$) is insoluble at neutral to alkaline pH levels and will precipitate out of the water. The carbon dioxide (CO_2) will potentially increase the alkalinity or could become a gas. Since the carbonate minerals neutralize the oxidation of the pyrite, acidic pH is not generated and acid mine drainage does not occur. However, the increase in sulfate, calcium, and magnesium would increase the TDS and electrical conductivity of the water in the mine workings in areas where sulfide minerals are present. As discussed in Section 4.4, the percentage of the mine workings that may encounter altered and mineralized rock is anticipated to be only a small fraction of the volume of the new underground workings to be constructed as part of the project. In addition, backfilling of stopes and other mineralized areas with CPB will reduce the number of exposed surfaces that may contain sulfide mineralization within the dewatered mine workings. However, if elevated TDS and conductivity levels are generated during dewatering, the treatment system would be adjusted to meet applicable discharge standards (see Section 4.6), in accordance with the permit requirements. The Report of Waste Discharge submitted to RWQCB would address this potential issue, provide a quantitative analysis of its potential, and define the measures that would mitigate such an occurrence if identified during operation of the treatment system.

Once mining is completed and the underground workings are allowed to flood with groundwater, the same reducing conditions that occur now within the mine workings will develop again. Once reducing conditions are re-established, oxidation of sulfide minerals will no longer occur in the subsurface, such that elevated TDS and conductivity will not be generated. The DI-WET leaching tests indicate that the general water type will not be altered by the additional mining. The same general pH, TDS, and other water quality conditions that have been consistently measured in samples from the shafts, drains, and creeks since the early 1990s are expected to persist after mining is completed due to the geologic conditions in the subsurface and along the creek beds.

Once the underground workings fill with water above an elevation of approximately 2,500 ft msl, discharge through the drains, if they are not plugged once mining is completed, or by seepage through fractures that reach the ground surface, would occur. The discharge from the drains or fractures would be expected to have similar characteristics to the water that currently flows from the drains, unless parts of the underground workings that may be prone to mobilization of certain elements, such as arsenic, are sealed. In any case, the existing geologic and water quality conditions indicate that any future discharge would have elevated iron and manganese levels comparable to those observed now, as discussed in Section 3.4.

4.6 Discharge Requirements

As described in Section 2.2, the water produced during dewatering would be treated prior to discharge to South Fork Wolf Creek. It is anticipated that the discharge would occur in compliance with California Regional Water Control Board Central Valley Region Order No. R5-2016-0076, NPDES No. CAG995002, which was adopted on October 14, 2016. This order is a general Waste Discharge Requirements permit for Limited Threat Discharges to Surface Water. The discharge of treated water from the mine would be covered as a Tier 3 discharge of hard rock mine wastewater. Under Table 3 of the Limited Threat Discharge permit, Tier 3 discharges to surface water that are greater than 250,000 gallons per day (greater than 175 gpm) and/or that are longer than four months are allowed if the water to be discharged (with or without treatment) meets the applicable screening levels in the permit.

Effluent limitations are listed in Section V and screening levels are listed in Attachment I of the Low Threat Discharge permit. Table 4-10 summarizes these values and provides a comparison with existing water quality data from the New Brunswick shaft and the proposed water treatment criteria. With the proposed treatment described in Sections 2.2 and 4.5, all parameters would meet the screening levels and effluent limitations. Rise will be required to file a Notice of Intent (NOI) for coverage under the Limited Threat Discharge permit, which will include a detailed description of the dewatering, treatment, and discharge components of the project. The water quality and geochemical data presented in Sections 3.4 and 4.4 of this report were developed based, in part, on the requirements of the Limited Threat Discharge permit.

In addition to the numerical limits listed in Table 4-10. The Low Treat Discharge permit also has narrative limits, including the following:

- Acute toxicity – 70 percent survival rate for any one bioassay and a 90 percent median survival rate for three consecutive bioassays;

- Dissolved oxygen – the discharge shall not cause i. The monthly median of the mean daily dissolved oxygen concentration to fall below 85 percent of saturation in the main water mass; ii. The 95 percentile dissolved oxygen concentration to fall below 75 percent of saturation; and iii. The dissolved oxygen concentration to be reduced below 5.0 mg/L at any time for waterbodies designated as warm freshwater habitat (WARM); or iv. The dissolved oxygen concentration to be reduced below 7.0 mg/L at any time for waterbodies designated as cold freshwater habitat (COLD) and/or spawning, reproduction, and/or early development (SPWN).
- Temperature – the natural temperature shall not increase by more than 5 degrees Fahrenheit; and
- Turbidity - i. Shall not exceed 2 Nephelometric Turbidity Units (NTU) where natural turbidity is less than 1 NTU; ii. Shall not increase more than 1 NTU where natural turbidity is between 1 and 5 NTUs; iii. Shall not increase more than 20 percent where natural turbidity is between 5 and 50 NTUs; iv. Shall not increase more than 10 NTU where natural turbidity is between 50 and 100 NTUs; nor v. Shall not increase more than 10 percent where natural turbidity is greater than 100 NTUs.

The above limits, and other general surface water limitations, are detailed in Section VIII. Receiving Water Limitations of the Low Threat Discharge permit.

Table 4-10 Low Threat Discharge Permit Limits, Current Concentrations, and Treatment Goals

Tier 3 Constituent	Units	Screening Level	Tier 3 Effluent Limit		Existing Shaft	After Treatment
			Average Monthly	Maximum Daily		
Aluminum	ug/L	200	310	620	16	
Ammonia, as N	ug/L	NA	25	25	<100	<25
Iron	ug/L	300	470	930	1400	<300
Manganese	ug/L	50	80	160	230	<50
Nitrate + Nitrite	mg/L	10	10	20	<0.40	
pH	std units	6.5-8.5	6.0-9.0	6.0-9.0	6.8	
Settleable Solids	mL/L	0.1	--	0.1	NM	<0.1
Specific Conductance (EC)	umhos/cm	900			400	
Total Dissolved Solids (1)	mg/L	500	1000	1500	210	
Total Suspended Solids	mg/L	10	20	30	NM	<10
Turbidity	NTU	5			NM	<5
Antimony	ug/L	6	6	12	<5	
Arsenic	ug/L	10	10	20	2.1	<10
Beryllium	ug/L	4	4	8	<1.0	
Cadmium	ug/L	3.4	50	100	<0.25	
Chrome +3	ug/L	290	270	540	0.32	
Chrome +6	ug/L	10	8	16	NM	
Copper	ug/L	13	150	300	0.4	
Lead	ug/L	5.3	300	600	<0.50	
Mercury	ug/L	0.05	1	2	<0.050	
Nickel	ug/L	74	69	140	<5.0	
Selenium	ug/L	5	4.1	8.2	<5.0	
Silver	ug/L	8.2	3.1	6.3	<1.0	
Thallium	ug/L	1.7	1.7	3.4	0.12	
Zinc	ug/L	170	750	1500	5.5	
Cyanide	ug/L	5.2	4.3	8.5	2.2	
cis-1,2-DCE	ug/L	--	--	0.5	4.2	<0.5

NOTES:

Screening Levels and Effluent Limits are for Receiving Waters with Municipal and Domestic Supply Beneficial Use (MUN)

(1) TDS levels are part of the salinity standard. The values shown are the secondary MCL, upper level, and short-term maximum. For hardness-dependent metals, limits are based on the measured hardness of 180 mg/L from the pumped sample from the shaft (NBS Pump) (see Table 3-7)

pH, TSS, cadmium, copper, lead, mercury, and zinc effluent limits are based on Table 12 of the Low Threat Discharge Permit

After Treatment levels only shown for constituents that currently exceed screening levels or effluent limits

4.7 Additional Permitting Requirements Related to Water Quality

In response to Rise's application for a conditional use permit and reclamation plan for the project, the RWQCB submitted two letters to the Nevada County Planning Department outlining permitting and regulatory compliance requirements for the proposed project activities. Any discharge of material to the ground surface, to waters of the U.S., or to waters of the state must be consistent with the Water Quality Control Plan for the Sacramento and San Joaquin Valley Basin (Basin Plan). The Basin Plan ensures protection of beneficial uses of water and includes programs to achieve water quality objectives. Discharges must comply with the state Antidegradation Policy (State Water Board Resolution 68-16) to maintain the highest water quality possible consistent with the maximum benefit to the people of California. Historical and on-going discharges of mercury related to mining in the Sierra Nevada foothills has resulted in the development of a total maximum daily load (TMDL) for mercury. The project must comply with this TMDL. However, as documented in Tables 3-6, 3-7, and 3-9, mercury has not been detected in any of the water samples from the New Brunswick shaft, and has not been detected in any of the drains, nor in Wolf Creek, or in South Fork Wolf Creek. Mercury was also not detected in the DI-WET leachate samples from the barren rock and tailings samples.

In addition to the to the Low Threat Discharge Permit discussed in Section 4.6, the following additional permits will be a necessary part of the project to meet regulatory requirements:

- Construction Storm Water General Permit – Order No. 2009-009-DWQ. Compliance is required for all construction projects that disturb more than one acre. The Construction General Permit requires preparation and implementation of a Storm Water Pollution Prevention Plan (SWPPP) that defines Best Management Practices (BMPs) and monitoring requirements. Rise will need to file a Notice of Intent (NOI) to comply with the Construction General Permit using the California Stormwater Multiple Application and Report Tracking System (SMARTS) online tool (<https://smarts.waterboards.ca.gov/smarts/faces/SwSmartsLogin.xhtml>).
- Industrial Storm Water General Permit – Order No. 2014-0057-DWQ. Storm water discharges from industrial sites must be managed in accordance with this permit. For the Industrial General Permit, a SWPPP must be prepared and an NOI filed using the SMARTS online tool, similar to what is required for the Construction General Permit.
- Federal Clean Water Act Section 404 Permit. Work within or adjacent to Waters of the U.S. that may involve the discharge of dredged or fill material may require a Section 404 permit from the U. S. Army Corps of Engineers. Re-alignment of the culvert under the Brunswick Industrial Site, the treated water discharge outfall into South Fork Wolf Creek, and the storm water detention pond outfalls into Wolf Creek and South Fork Wolf Creek may require permitting. The Section 404 permit, along with a Streambed Alteration Agreement (see below), ensure that facilities built in or adjacent to a stream would not violate any water quality standards, create substantial erosion or siltation, or exacerbate flooding.
- Section 1600 Streambed Alteration Agreement. Work that may alter the bed or bank of a river, stream or lake requires a Streambed Alteration Agreement (SAA) from the California

- Department of Fish and Wildlife. For this project, the SAA would generally parallel the Section 404 Permit and have similar requirements.
- Federal Clean Water Act Section 401 Permit – Water Quality Certification. If a Section 404 or other federal permit must be obtained for this project, then a Water Quality Certification must also be obtained from the RWQCB.
 - Waste Discharge Requirements (WDRs). Rise will need to submit a Report of Waste Discharge (RoWD) to the RWQCB to obtain WDRs for use of the engineered fill, which is a mining waste, to create the elevated pad areas at the Centennial and Brunswick Industrial Sites. The WDRs will specify discharge limits to protect groundwater and surface water quality.

As stated above, compliance with the above permits is a required component of the project. These permits are intended to ensure that construction activities, on-going operations from the project, and reclamation activities minimize or avoid effects on water supply, water quality, and surface water.

5.0 IMPACT ANALYSIS

5.1 *Threshold Criteria*

Chapter 3 of Title 14 of the California Code of Regulations provides guidelines for the implementation of CEQA. As amended in December 2018, Appendix G of the CEQA guidelines provides an Environmental Checklist Form with criteria that are relevant to the evaluation of a project's potential environmental effects. Section X provides criteria related to Hydrology and Water Quality. These criteria address whether a project would:

- a) Violate any water quality standards or waste discharge requirements or otherwise substantially degrade surface or groundwater quality;
- b) Substantially decrease groundwater supplies or interfere substantially with groundwater recharge such that the project may impede sustainable groundwater management of the basin;
- c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of impervious surfaces, in a manner which would:
 - i) Result in substantial erosion or siltation on- or off-site;
 - ii) Substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site;
 - iii) Create or contribute to runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff; or
 - iv) Impede or redirect flood flows.
- d) In flood hazard, tsunami, or seiche zones, risk release of pollutants due to project inundation; or
- e) Conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan.

These criteria are evaluated below for the proposed project.

5.2 *Project Evaluation*

- A. *Would the project violate any water quality standards or waste discharge requirements or otherwise substantially degrade surface or groundwater quality?***

STORMWATER

The Project will involve grading and construction activities at the New Brunswick shaft, the Brunswick Industrial Site, the treated water discharge location along South Fork Wolf Creek, along East Bennett Road for installation of the potable water supply pipeline, and at the Centennial Industrial Site. Construction work in each of these areas would result in disturbance of more than 1 acre of land. Thus, compliance with the State Water Resources Control Board (SWRCB) general permit to discharge storm water associated with construction activity is required. The general permit is known as the SWRCB, Order No. 2009-0009-DWQ (as amended by Orders 2010-0014-DWQ and 2012-006-DWQ), National Pollutant

Discharge Elimination System General Permit No. CAS000002, Waste Discharge Requirements for Discharges of Storm Water Runoff Associated with Construction Activity (Construction General Permit). Rise would be required to submit a Notice of Intent (NOI) for coverage under the Construction General Permit and prepare a construction Stormwater Pollution Prevention Plan (C-SWPPP).

The C-SWPPP would need to address any Project-related activities that have the potential to release pollutants, including sediment, in stormwater, such as:

- Excavation work;
- Material stockpiling;
- Waste and soil screening;
- Loading and hauling of materials; and
- Winterization of incomplete activities.

The C-SWPPP must identify the Best Management Practices (BMP)s that would be implemented during construction and the final closure fieldwork to ensure that polluted stormwater runoff does not leave the site. The C-SWPPP would also need to include a monitoring program to document the effectiveness of the BMPs. Compliance with the C-SWPPP and implementation of the BMPs will prevent degradation of surface water quality during construction activities.

On-going operations at the New Brunswick shaft, the water treatment facility, and the ore processing area will also require compliance with the Industrial General Permit, known as SWRCB Order No. 2014-0057-DWQ, National Pollutant Discharge Elimination System General Permit No. CAS000001, Waste Discharge Requirements for Discharges of Storm Water Runoff Associated with Industrial Activity. Rise would be required to submit a Notice of Intent (NOI) for coverage under the Industrial General Permit and prepare an industrial Stormwater Pollution Prevention Plan (I-SWPPP). The I-SWPPP would address any activities that would have the potential to release pollutants to stormwater, including material and chemical storage, vehicle operation and maintenance, and material handling and transport.

Both the C-SWPPP and the I-SWPPP would need to address any Project-related activities that have the potential to release pollutants

DEWATERING AND SURFACE WATER

Water that would be pumped from the underground mine workings would contain certain constituents that exceed existing water quality standards, in particular iron and manganese. However, prior to discharge to South Fork Wolf Creek, the water would be treated to reduce the levels of these compounds to meet or exceed water quality standards (Linkan, 2019), as described in Section 4.6. The water treatment system would also remove or lower the concentration of other constituents such as arsenic, cis-1,2-DCE, and ammonia, which may not exceed water quality standards but could contribute in some way to a cumulative reduction in surface water quality. The project would be required to obtain coverage under an applicable NPDES permit, such as Central Valley Regional Water Quality Control Board Order No. R5-2016-0076 (NPDES No. CAG995002) for Limited Threat Discharges to Surface Waters. This permit would also include Waste Discharge Requirements for the project as a Tier 3 discharge, which include

discharges of wastewater from hard rock mines. Section 4.6, above, presents the narrative water quality standards in the Limited Threat Discharge permit. Table 4-10 lists the discharge limits, current concentrations within the water in the underground workings, and the treatment goals for discharges of treated water from the mine. It is expected that the discharge would meet the dissolved oxygen and temperature requirements of the NPDES permit. If necessary, pH would need to be adjusted prior to discharge. Compliance with the water quality standards and waste discharge requirements in Order No. R5-2016-0076 would prevent any degradation of surface water quality due to dewatering.

WATER WITHIN THE UNDERGROUND WORKINGS

Approximately 50 percent of the sand tailings would be used to backfill the underground workings. The backfill would be placed as Cemented Paste Backfill (CPB). Use of CPB for the project is an environmentally favorable method for tailings disposal because it can significantly reduce any potential release of metals from the tailings and will minimize the area of surface disturbance needed for tailings disposal. However, the Portland cement used for the CPB must be low in Cr⁺⁶ to prevent potential leaching of hexavalent chromium into the surrounding water. Evaluations of the minimum cure time are also necessary to determine how long the CPB should be in place before becoming inundated in the mine workings once dewatering ceases.

Water within the flooded mine workings has low DO levels, creating reducing conditions. The low oxygen levels and reducing conditions prevent the oxidation of sulfide minerals, such as pyrite, that are exposed within the surfaces of the underground workings. After dewatering, though, oxygen would be available from the air within the underground workings, potentially resulting in oxidation of sulfide minerals. Any acid generated during the oxidation would be quickly neutralized by the carbonate minerals in the host rock. However, the process of sulfide oxidation and subsequent neutralization would potentially create elevated TDS levels in the water that would seep from the limited areas of sulfide mineralization that would be exposed but not removed from the mine, due to dissolution of calcium, magnesium, and sulfate. If elevated TDS levels are generated during dewatering, the treatment system would need to be adjusted to meet applicable discharge standards and antidegradation requirements. Once mining is completed and the underground workings are allowed to flood with groundwater, the same reducing conditions that occur now within the mine workings will develop again, preventing oxidation of sulfide minerals. Water quality in the re-flooded mine workings would then have the same general pH, TDS, and other water quality conditions that occur under existing conditions.

FILL AREAS

The Project would involve creating fill areas at the Brunswick and Centennial Industrial Site areas. The engineered fill material would consist of 50 percent barren rock and 50 percent sand tailings from the primary ore processing operations. Ore processing would not involve the use of mercury or cyanide. Acid-base accounting analyses conducted by ACZ Labs demonstrates that the barren rock and the sand tailings have a net acid neutralization capacity such that the fill areas would not create acid mine drainage.

DI-WET leach tests conducted on the barren rock and sand tailings material by ACZ indicate that the bulk material proportions in the fill would not leach metals at concentrations above applicable water quality

standards (see Table 4-7). The conductivity and TDS in the water that leaches through the fill material is projected to be relatively low, based on the DI-WET tests. The DI-WET tests suggest that the pH of the water that percolates through the engineered fill could be above 9.0. This relatively high pH value, however, is inconsistent with the pH values measured in the New Brunswick shaft, the drains, and in surface water, which range from 5.78 to 7.8. The elevated pH from the DI-WET analyses may be a result of the fine crushing of the samples for the leaching tests. Whatever the reason, the pH results from the DI-WET tests are not consistent with site-specific measurements made under actual field conditions. Rise will be required as part of the project to submit a Report of Waste Discharge (RoWD) and obtain Waste Discharge Requirements (WDRs) from the RWQCB for construction of the engineered fill areas. The engineered fill would be a Group C mining waste. Additional testing may be necessary as part of the RoWD to evaluate the expected pH of any rainfall that might percolate through the engineered fill. However, percolation is expected to be minimal because the engineered fill will be graded and compacted to allow runoff to be conveyed rapidly to the stormwater detention ponds. The side slopes will be vegetated and have drainage channels at appropriate spacings. The top surface will be compacted and eventually covered with impermeable surfaces during subsequent development of the industrial sites after reclamation is completed. In any case, the WDRs will specify appropriate monitoring and limitations to prevent the discharge of water containing pH levels outside of applicable water quality standards

POST-MINING

After mining is completed, water from the underground mine workings would eventually begin to seep from the existing drains or from bedrock fractures if the drains are sealed. The water that would seep from the underground workings is anticipated to have similar water quality to the water that currently discharges from the existing drains. Specifically, it may contain elevated levels of iron and manganese. Therefore, the conditions after mining is completed would be the same as the existing, or baseline, conditions, such that re-activation of the seeps would not represent a potentially significant impact under CEQA. Although part of the existing environmental setting, some of the seeps have elevated arsenic levels that could pose a threat to human health or the environment. However, as noted in Section 3.4.2, despite these existing discharges from the drains, the reported concentrations of all metals and other constituents in the Wolf Creek samples are well below the NPDES water quality standards. After mining is completed and before the mine is allowed to flood, an application could be made with the Regional Water Board for an individual permit to cover the mine drainage. An individual permit allows for dilution of the receiving waterbody to be considered. Alternatively, surface treatment of the water from the drains, prior to discharge to Wolf Creek, could be considered, similar to the drainage from the inactive Newmont Northstar Mine. If any area of the underground mine workings are sealed, or the drains themselves are sealed, substantial care should be taken to ensure that new discharges from other shafts or from bedrock fractures do not occur in a way that could create a significant environmental impact. The option of sealing the underground workings will require detailed underground investigation and planning before consideration and therefore cannot be considered at this stage of the project but may become a viable solution after operations commence.

SUMMARY

Prior to creating any ground disturbance, dewatering of the underground workings and discharge of treated water, and construction of the engineered fill areas, Rise will need to apply for and obtain coverage under a range of permits, as described in Sections 4.6 and 4.7. Compliance with stormwater requirements requires submittal of an NOI, development of appropriate SWPPPs, implementation of BMPs, and monitoring to prevent polluted runoff from affecting surface waters.

For dewatering of the underground mine workings, the water treatment system (Linkan, 2019) has been designed to treat the water within the underground workings to meet the narrative water quality standards described in Section 4.6 and to meet the numeric standards listed in Table 4-10. Rise will need to submit a NOI or RoWD and obtain WDRs (likely in the form of an NPDES permit using the Low Threat Discharge permit) prior to discharge of treated mine dewatering water. The Conditional Use Permit, either as a mitigation measure or as a condition of approval, should require that the RoWD be submitted at least six months prior to construction of the water treatment system and that the WDR permit be received before dewatering can begin. Flexibility in design and operation of the water treatment system would be appropriate to ensure that elevated pH and TDS conditions could be addressed if encountered during dewatering. Treatment of the water from the underground workings to meet the water quality standards and treatment goals listed in Table 4-10 can be readily accomplished with standard water treatment technologies (Linkan, 2019). The monitoring required by the Limited Threat Discharge permit would verify that the water being discharged meets the applicable water quality criteria and waste discharge requirements and is not otherwise substantially degrading surface or groundwater quality, as specified in the CEQA Appendix G criterion listed at the beginning of this section.

Prior to use of CPB, additional documentation would be needed to verify that Cr⁺⁶ levels in the Portland cement used for the mixture are minimal and will not leach. The Conditional Use Permit, either as a mitigation measure or as a condition of approval, should require that the source of the Portland cement to be used for the CPB be specified and that testing data showing the Cr⁺⁶ levels do not leach above water quality standards must be provided to the County prior to the use of CPB. In addition, the County should require that a RoWD for use of CPB be submitted to RWQCB at least six months prior to the proposed initial use of CPB and that the WDR permit be received prior to initiating any mine backfilling using CPB.

Compliance with the applicable permit requirements for the project would prevent potentially significant impacts related to water quality standards and waste discharge requirements. The Standard Conditions and monitoring requirements in these permits would verify that water quality standards and waste discharge requirements are not violated. Restoration of the post-mining discharge through the drains would be comparable to existing conditions and, thus, not an impact under CEQA. However, additional compliance measures may be required by RWQCB to address Basin Plan, antidegradation, and other water quality standards.

B. Would the Project substantially decrease groundwater supplies or interfere substantially with groundwater recharge such that the project may impede sustainable groundwater management of the basin?

The Project site is not located within a groundwater basin that has been identified by DWR, and the nearest groundwater basin is located more than 15 miles to the west. Sustainable groundwater management programs must be implemented in groundwater basins that DWR has designated as medium or high priority, or that exhibit critical conditions of overdraft. Thus, the Project could not impede sustainable groundwater management within a groundwater basin, since no such basin exists in the Project vicinity.

However, groundwater is present within fractured bedrock throughout the region and there are numerous private supply wells in the area. The existing shafts act as passive wells such that groundwater in the fractures that intersect the shafts flows downward into the mine workings and eventually is discharged from the drains along Wolf Creek. The current inflow of water into and out of the mine workings is approximately 60 gpm to 70 gpm. As described in Section 4.2, the inflow of groundwater into the shafts creates a small amount of drawdown in the groundwater surface in areas overlying the underground mine workings. Under existing conditions, this drawdown only affects wells in the East Bennett Road area.

Initial dewatering for the project would occur from the New Brunswick shaft at an initial rate of approximately 2,500 gpm for approximately six months. After that time, the steady state pumping rate to remove the groundwater inflow is anticipated to average approximately 850 gpm. During the initial dewatering, the volume of water extracted would consist of at least 1,650 gpm of water that is currently present within the mine workings and average of approximately 850 gpm of groundwater that is drawn into the mine workings by the pumping. Itasca estimated that pumping rates could reach a maximum value of approximately 1,500 gpm during the rainy season and after 65 years of mining. (Itasca,2020b). Thus, throughout the duration of the Project, the anticipated rate of groundwater removal from the fractured bedrock would range from an average of 850 gpm up to the maximum permitted discharge rate of 2,500 gpm.

Analytical and numerical modeling evaluations have been conducted to estimate the additional drawdown that would occur due to dewatering of the existing mine workings and expansion areas. Data from numerous well completion reports for private supply wells in the region, as well as studies conducted by the USGS and others, demonstrate the hydraulic conductivity and transmissivity of the fractured bedrock decreases appreciably with depth. Thus, within the depth of the existing and proposed mine workings, approximately 99 percent of the groundwater flowing into the mine occurs within 550 feet of the ground surface. Most of the proposed additional mining, and potential exploration and expansion into new areas, would occur below depths of 550 feet.

Within the East Bennett area, the maximum additional drawdown due to the proposed project would be in the range of five to 10 feet. Any potential effects on wells in this area would be addressed by installing

a potable water line along East Bennett Road and offering well owners a connection to the potable supply at no cost. The potable water would be sourced through NID's potable water system.

In other areas around the perimeter of the mine workings and in areas where expansion could occur, the projected maximum drawdown in private wells is less than two feet. In all cases, based on the information available through the well completion reports, the maximum potential additional drawdown in the perimeter areas is less than 10 percent of the available water column in individual wells. The maximum drawdown is also substantially less than the normal seasonal fluctuation in the groundwater levels of 10 feet to 30 feet or more. Thus, in the perimeter areas and including a safety factor of 100% in calculations, the project would not have any significant impact on groundwater supplies.

The development of new operating facilities at the New Brunswick shaft, the water treatment system, and fill areas would occur on land that has already been disturbed and partially paved for previous industrial activities on the mining site and the former SPI property. Therefore, the actions that would occur as part of the Project in these areas would not result in the compaction of soils or installation of impermeable surfaces (e.g. pavement) in areas where those effects have not already occurred due to past activities. Installation of the potable water lines would occur within East Bennett Road, consisting of paved, disturbed, and previously compacted soils due to the long history public right-of-way uses along the potable water line route. Thus, the project would not result in any appreciable new areas of compacted soils or impermeable surfaces that could substantially restrict or otherwise interfere with groundwater recharge.

Numerical modeling also indicates that dewatering could lower groundwater levels sufficiently to reduce the base flow in South Fork Wolf Creek by as much as 0.1 cfs. However, the water that is pumped from the mine would be treated and then discharged to South Fork Wolf Creek at rates ranging from 5.6 cfs during initial dewatering to 1.9 cfs during maintenance dewatering. Thus, lowering of the groundwater table would not result in a reduction in base flows within South Fork Wolf Creek as a result of the project.

Dewatering of the mine would also eliminate seepage from the drains and base flow in Wolf Creek. The base flow within Wolf Creek is approximately 25 cfs to 30 cfs. However, NID releases an average of approximately 35 cfs from the DS Canal to Wolf Creek on an annual basis. Itasca (2020b) estimates that mine dewatering would reduce base flow in Wolf Creek by 0.75 cfs due to reduction in groundwater discharge. Dewatering would also eliminate flow from the drains, which ranges from 60 gpm to 125 gpm (0.13 cfs to 0.28 cfs). Thus, the total reduction in base flow to Wolf Creek could be slightly more than one cfs. This flow reduction is minimal and would be barely perceptible compared to the base flow rate of 25 cfs to 30 cfs and the NID releases averaging 35 cfs.

Any reduction in available groundwater supplies to wells in the East Bennett area would be addressed, at Rise's expense, by installing a potable water supply line in East Bennett Road and providing individual well owners with a connection to the potable water line. To prevent any potentially significant impacts to water supplies in the East Bennett Road area, the Conditional Use Permit should specify, either as a mitigation measure or as a condition of approval, that the potable water supply line be installed prior to the initiation of mine dewatering. Historical activities with impermeable surfaces or compacted soils

currently exist in areas where major Project improvements and engineered fill will be developed. Thus, the Project would not result in substantial additional areas of compacted soils, such that it would not affect groundwater recharge. Reductions in base flows in South Fork Wolf Creek due to dewatering would be offset by the treated water discharge. Reductions in base flows and drain discharges to Wolf Creek would be minimal compared to the current base flow rate and the NID discharges. Overall, the Project would not result in any significant impacts to groundwater supplies and would not interfere substantially with groundwater recharge.

- C. *Would the Project substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of impervious surfaces, in a manner which would:***
- i) Result in substantial erosion or siltation on- or off-site?***
 - ii) Substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?***
 - iii) Create or contribute to runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?***
 - iv) Impede or redirect flood flows?***

The project would not significantly alter the drainage patterns of the project site, would not alter the course of a stream or river and would not add impervious surfaces.

The fill areas at the Centennial Industrial Site and the Brunswick Industrial Site would be graded to minimize runoff. Stormwater conveyance channels would be constructed in accordance with Nevada County hydrology and hydraulics standards to convey the runoff from up to a 100-year storm event without causing erosion or siltation. Runoff from the fill areas would be conveyed to stormwater retention basins that would hold back the peak flows and release the water at a lower rate and at a later time than currently occurs from those site areas. As a result, the project would reduce peak storm flows in both Wolf Creek and South Fork Wolf Creek. The detention pond at the Centennial Industrial Site would reduce peak storm discharges to Wolf Creek by 25 cfs to 60 cfs, depending on the return period of the storm event. For South Fork Wolf Creek, the detention basin and outlet structure at the Brunswick Industrial Site would reduce the peak discharge by over 48 cfs for the 2-year storm, by over 60 cfs for the 10-year storm, by over 40 cfs for the 25-year storm, and by over 25 cfs for the 100-year storm.

Hydrology and geomorphology surveys of South Fork Wolf Creek indicate that the base flow may range from 0.17 cfs in the summer to 6.5 cfs in the winter, in the area of the proposed treated water discharge. Based on direct field observations, storm flows of less than 23 cfs do not result in substantial erosion or sedimentation within South Fork Wolf Creek. Pebble counts conducted along South Fork Wolf Creek indicate that the flow rate at which sediment within the channel may become mobilized ranges from 20 cfs to 90 cfs. The combination of creek base flows plus the maximum proposed discharge of treated water at 5.6 cfs is substantially below the 23 cfs threshold defined by the geomorphology study.

During larger storm events, the proposed detention pond would reduce the peak flows within South Fork Wolf Creek by 25 cfs to 60 cfs. Thus, under Project conditions, the addition of up to 5.6 cfs minus the reduction in peak flow due to the detention basin would result in overall peak storm flows that would be lower than they are under existing conditions, resulting in less potential for erosion and sediment transport.

The Project would not discharge water to existing or planned drainage systems. Downstream of the project site, South Fork Wolf Creek flows into existing drainage improvements at Ophir Road that extend under the City of Grass Valley. The base flow plus the maximum project dewatering rate of 5.6 cfs would not exceed the capacity of the existing drainage facilities. During storm events, the detention basin at the Brunswick Industrial Site would reduce peak storm flows on South Fork Wolf Creek, thus providing additional capacity within the current drainage facilities under Grass Valley.

Placement and grading of materials to create the usable industrial areas would occur outside of any flood hazard zones. The dewatering discharge outfall would also be constructed in an area that is outside of a mapped flood hazard zone in South Fork Wolf Creek. The outfall, however, would be within waters of the U.S. so it would have to be constructed in accordance with the requirements of a Clean Water Act Section 404 permit from the U.S. Army Corps of Engineers for dredge and fill activities within waters of the U.S. and a Fish and Game Code Section 1600 Streambed Alteration Agreement from the California Department of Fish and Wildlife. Under these permits, the outfall would need to be constructed in a manner that would not measurably reduce the capacity of the stream channel or flood plain of South Fork Wolf Creek. Therefore, the Project would not impede or redirect flood flows.

Overall, the Project would enhance the existing drainage patterns both at, and downstream of the site. Base flow in South Fork Wolf Creek would be maintained or slightly enhanced due to the treated water discharge. The combined flows from the treated water discharge and existing base flow would be below the levels that could potentially result in erosion or sediment transport. Peak storm flows would be reduced to levels less than current peak storm flows due to the detention basins that would be constructed below the engineered fill areas. The reduction in peak storm flows would reduce erosion and sedimentation within South Fork Wolf Creek and enhance the capacity of storm drain systems under the City of Grass Valley.

D. Would components of the Project located in flood hazard, tsunami, or seiche zones risk release of pollutants due to Project inundation?

Due to its distance from the ocean or any other large enclosed bodies of water, the Project is not located in an area that would be subject to tsunamis or seiches.

According to the Federal Emergency Management Agency (FEMA) flood hazard maps for the Project area, Maps 06057C0631E, 06057C0632E, 06057C0633E, 06057C0650E (FEMA, 2019), the only part of the Project site that is located within a flood hazard zone is the northern edge of the Centennial Industrial Site along Wolf Creek. The proposed work at the Centennial Site is outside of the flood zone.

Placement of waste rock and tailings on the Centennial Industrial Site for future industrial development would occur outside of the flood hazard zone under applicable construction stormwater requirements, as discussed in Section 5.0, Item C, above.

The outfall from the treated water dewatering discharge pipe in South Fork Wolf Creek would need to be constructed in accordance with the requirements of a Clean Water Act Section 404 permit from US Army Corps of Engineers and a Streambed Alteration Agreement from California Department of Fish and Wildlife. Under these permits, the Project would need to be constructed in a manner such that it would not release pollutants, including sediment, as a result of inundation.

Stormwater detention ponds that would be constructed as part of the fill areas at the Centennial Industrial Site and the Brunswick Industrial Site have been designed with several feet of freeboard. Thus, even if an earthquake were to occur during a design storm event and a seiche were to form in the ponds, there would not be any substantial overtopping or release of water that could result in a release of pollutants.

The Geotechnical Report prepared by NV5 (NV5, 2019) provides recommendations for the repair of the clay lined sediment control pond on the Brunswick Industrial Site, which will ensure stability of the pond. The Conditional Use Permit should specify, either as a mitigation measure or as a condition of approval, that the recommended repairs be completed and verified by the County (e.g. through a grading permit or building permit) prior to initiating dewatering of the mine.

E. Would the Project conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan?

The current water quality control plan for the region is the Water Quality Control Plan for the Sacramento and San Joaquin River Basins, which is also referred to as the Basin Plan (CVRWQCB, 2019). The Project would be required to operate under an applicable Waste Discharge Requirements permit (WDRs) from the Central Valley Regional Water Quality Control Board (CVRWQCB) for placement of any waste material on land. The dewatering discharge to South Fork Wolf Creek would also need to comply with the requirements of the applicable NPDES permit Order R5-2016-0076 (NPDES No. CAG995002) for Limited Threat Discharges to Surface Water as a Tier 3 discharge (see additional discussion in Section 5.0, Item A). The WDR and NPDES requirements ensure that the project would not conflict with or obstruct implementation of the Basin Plan.

As discussed in Section 3.3, the Project is not located in or near a DWR-designated groundwater basin. Therefore, there will be no sustainable groundwater management plans developed for groundwater in the Project area. However, installation of the potable water supply line along East Bennett Road, and offering hookup at no cost to well owners, would address any potential significant decrease in groundwater supplies to existing groundwater users in the Project vicinity. To prevent any potentially significant impacts to water supplies in the East Bennett Road area, the Conditional Use Permit should specify, either as a mitigation measure or as a condition of approval, that the potable water supply line be installed prior to the initiation of mine dewatering.

5.3 Conclusions

The IM Mine Project is located in an area with a very long history of above ground and underground disturbance related to mining. Despite that history, mining has not caused appreciable impacts to hydrology and water quality in the project area. Surface water in Wolf Creek and South Fork Wolf Creek meets applicable ambient water quality criteria. Water from within the underground workings at the New Brunswick shaft also meets applicable water quality standards, except for iron and manganese. Water from within the shaft does not contain elevated levels of arsenic or other heavy metals and there is no acid mine drainage, with neutral pH values in both surface water and water within the mine.

The Project includes specific measures that would prevent impacts to groundwater supplies and to water quality due to Project actions. The only area where water levels in private supply wells would be potentially affected by mine dewatering is the area along East Bennett Road. The potential reduction of available groundwater in private domestic wells due to drawdown of the groundwater surface would be addressed by the provision of an alternative potable supply, with the Project proponent installing connections to a new NID water line along East Bennett Road. The potential drawdowns in the groundwater surface in the perimeter areas would be less than the existing seasonal fluctuations and would not reduce the available groundwater supply to those users. Future mining in the perimeter areas would not affect groundwater wells in those areas due to the depth of the proposed exploration and mining activities.

Mining, industrial, and transportation-related activities have already occurred over large areas of the proposed project. These prior activities would have caused compaction of the soils in those areas. The Project would not substantially expand areas where soil compaction may have already occurred and, thus, would not reduce groundwater recharge.

Base flows within Wolf Creek and South Fork Wolf Creek would not be significantly affected by mine dewatering. Any reduction in flow in Wolf Creek due to reduced groundwater levels would be minimal compared to the base flow and NID flows from the DS Canal. Within South Fork Wolf Creek, the base flows would be enhanced by the treated water discharge, which would more than offset any loss of groundwater discharge to the streambed due to dewatering. The storm water detention basins below the engineered fill areas would attenuate peak flows such that peak discharges from the Centennial and Brunswick Industrial Sites during storm events would be less than they are now. The reduction in peak discharges to South Fork Wolf Creek during storm events would more than offset the treated water discharge. Thus, the overall potential for erosion and sedimentation in South Fork Wolf Creek would be less as part of the Project than under existing conditions.

Treatment of water pumped from the underground mine workings prior to discharge would meet the requirements of applicable waste discharge requirements and comply with water quality standards in applicable NPDES permits. The natural geologic conditions and mineralogy would maintain reducing conditions and prevent the potential formation of acid mine drainage. However, post-mining mitigation measures may need to be identified to address the discharge of water through either existing drains or by seepage through naturally-occurring fractures once the underground workings fill back up with

groundwater. These measures might include sealing off areas of the underground workings that are the primary source of arsenic in the existing drain water, sealing the underground workings sufficiently to prevent seepage of water from the connected mine workings, obtaining an Individual NPDES permit upon closure, or treating of the mine water seeps after closure.

The Project will need to comply with a wide range of regulatory requirements and obtain several regulatory permits, besides County approval of a Conditional Use Permit and Reclamation Plan. Implementation of the requirements identified in this report, as well of the standard conditions of applicable SWPPPs, a 404 Permit, and a Streambed Alteration Agreement would prevent the release of pollutants, including sediment, prevent erosion, and prevent flood flows from being impeded or redirected, within both Wolf Creek and South Fork Wolf Creek. A Section 401 Water Quality Certification will also need to be obtained from the RWQCB to verify that the project complies with applicable water quality standards. Preparation of the RoWD and issuance of WDRs by the RWQCB will ensure that water quality is protected and applicable standards are met for the engineered fill areas. These additional permits and regulatory requirements are necessary for the Project to move forward. Thus, they are part of the Project and not mitigation measures. As such, compliance with these permits and requirements will result in the Project having no significant environmental impacts related to hydrology and water quality, based on the CEQA Appendix G criteria.

6.0 REFERENCES

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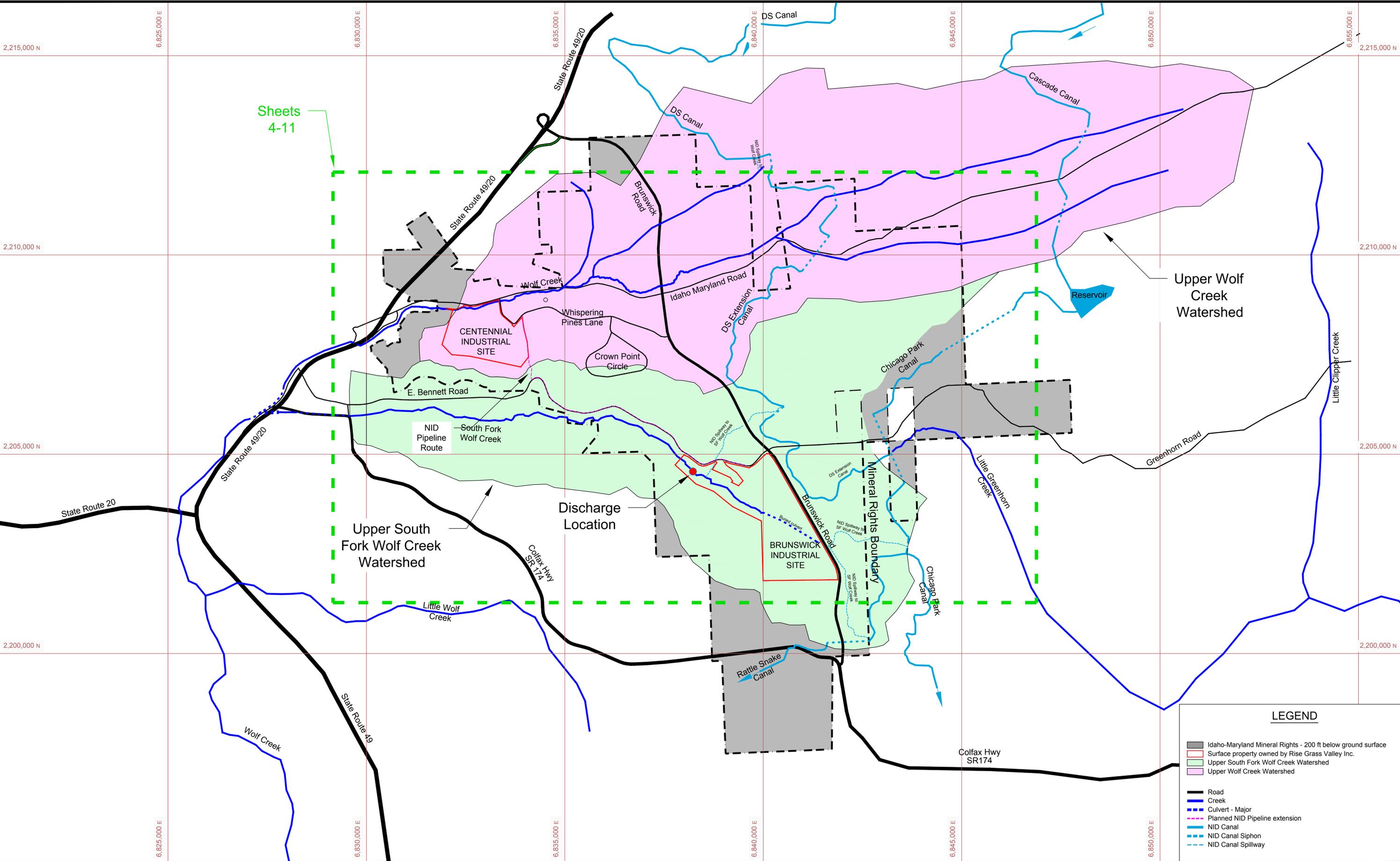
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7.0 SHEETS



Sheets
4-11

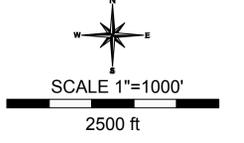
LEGEND	
	Idaho-Maryland Mineral Rights - 200 ft below ground surface
	Surface property owned by Rise Grass Valley Inc.
	Upper South Fork Wolf Creek Watershed
	Upper Wolf Creek Watershed
	Road
	Creek
	Culvert - Major
	Planned NID Pipeline extension
	NID Canal
	NID Canal Siphon
	NID Canal Spillway

Idaho-Maryland Mine Project
 Rise Grass Valley Inc.
 PO Box 271
 Grass Valley, California, USA 95945

Brunswick Industrial Site
 Nevada County, SEC. 31, T.16N, R.9E., M.D.M
 Total Area = 118.93 Acres
 Assessor Parcel Numbers:
 09-630-37, 09-630-39, 09-441-03, 09-441-04,
 09-441-05, 09-441-34
 Current Zoning M1-SP / Proposed Zoning M1-ME

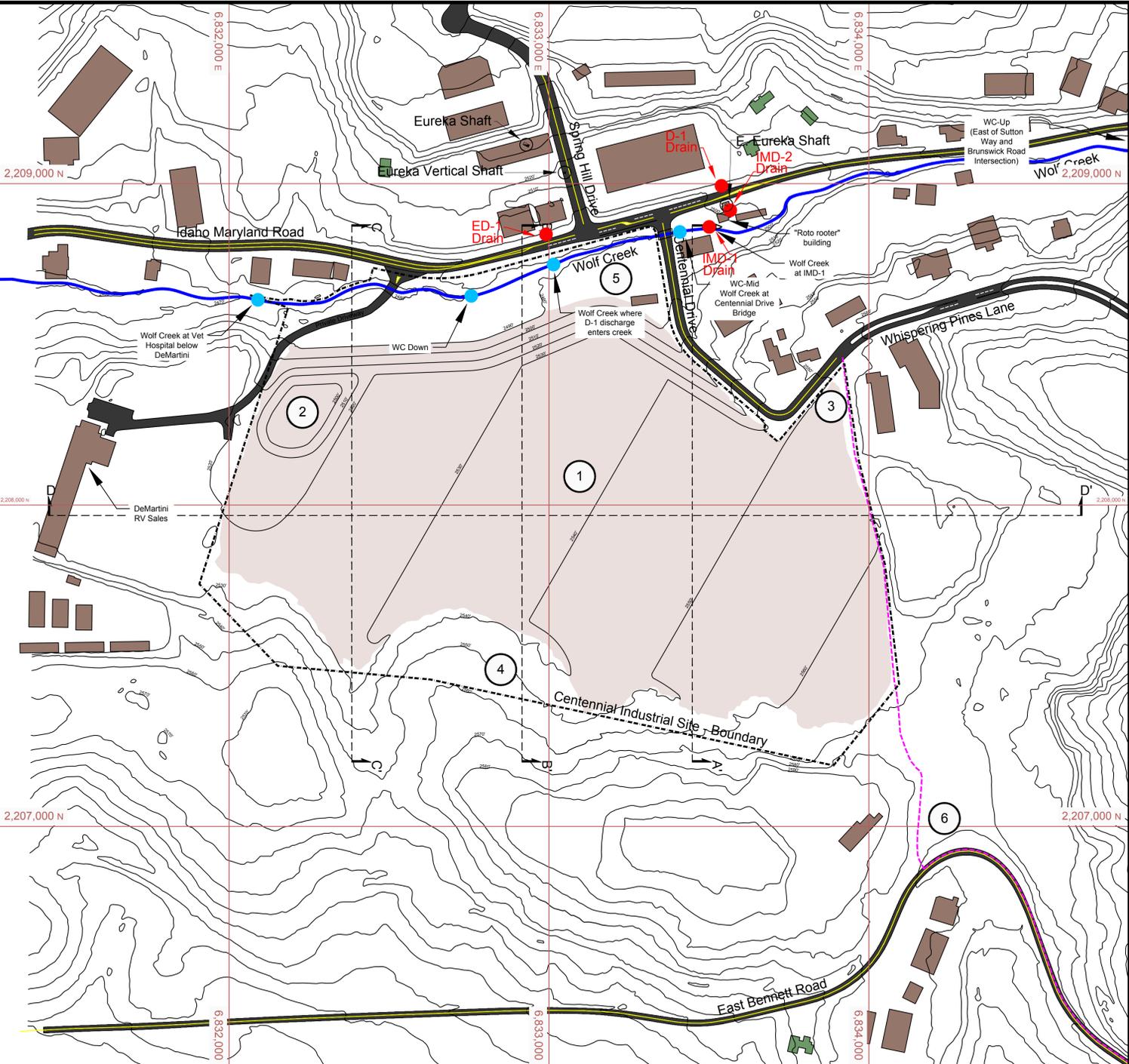
Centennial Industrial Site
 Nevada County, SEC. 26, T.16N, R.8E., M.D.M
 Total Area = 56.41 Acres
 Assessor Parcel Numbers:
 09-550-32, 09-550-37, 09-550-38, 09-550-39,
 09-550-40, 09-560-36
 Current Zoning M1 / Proposed Zoning M1

Idaho-Maryland Mineral Rights (100% owned)
 Total Area = 2585 Acres
 Mineral rights contiguous at 200 feet below
 ground surface



Sheet 1
Project Overview
Mineral Rights and Surface Properties
 Major Roads, Creeks, Watershed, and Discharge Location

Drawnby : Rise Grass Valley - Feb 1 / 20



PLAN VIEW - SCALE 1" = 200'

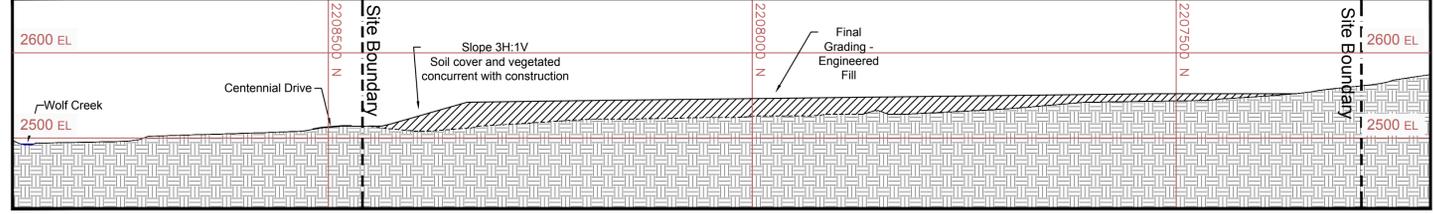
LEGEND (Plan view)

- Engineered Fill (Plan View)
- Residential Structure
- Commercial / Industrial Structure
- Elevation Contour Line - 10 foot intervals
- Creek
- Centennial Industrial Site - Boundary
- Section Line
- Proposed NID potable water pipe extension

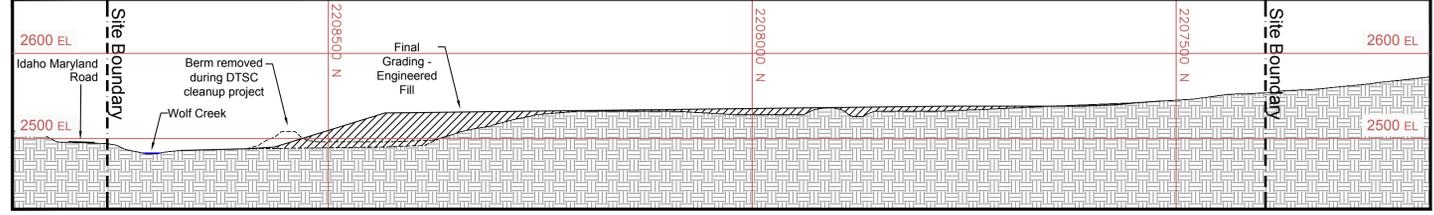
LEGEND (Section view)

- 1 Engineered Fill - Transport of engineered fill from Brunswick Site, placement, grading, and compaction in lifts to create new area for future industrial use.
 - 2 Detention Pond - Construction of new storm water detention pond. Run-off directed to existing discharge point.
 - 3 Site Access - Installation of new left turn lane on Whispering Pines Lane to access site.
 - 4 Open space for special-status plant species.
 - 5 Open space for Wolf Creek and 100 foot setback.
 - 6 Potable water extension - Extension of NID potable water pipeline to service East Bennett Road residential area.
- Area of fill excavation planned
 - Undisturbed ground
 - Current / original ground surface
 - Final Ground Surface
 - Centennial Industrial Site - Boundary

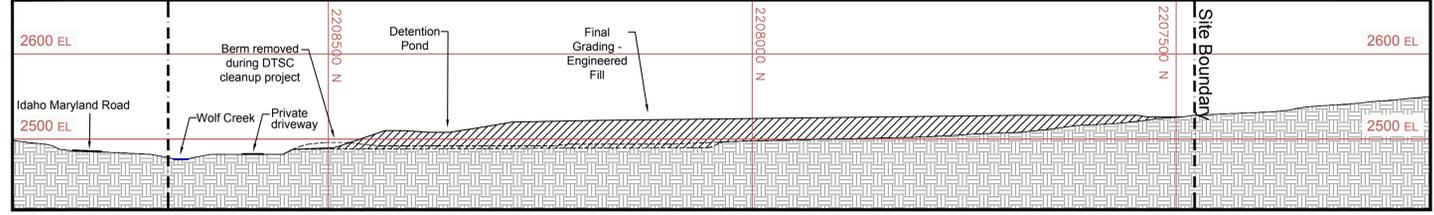
SECTION A-A' - Looking East - Final Grading SCALE 1" = 100'



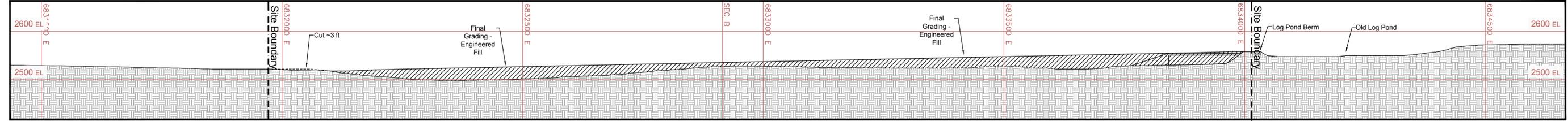
SECTION B-B' - Looking East - Final Grading SCALE 1" = 100'



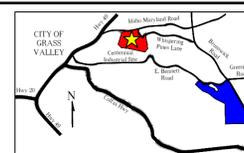
SECTION C-C' - Looking East - Final Grading SCALE 1" = 100'



SECTION D-D' - Looking North - Final Grading SCALE 1" = 100'

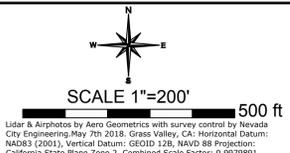


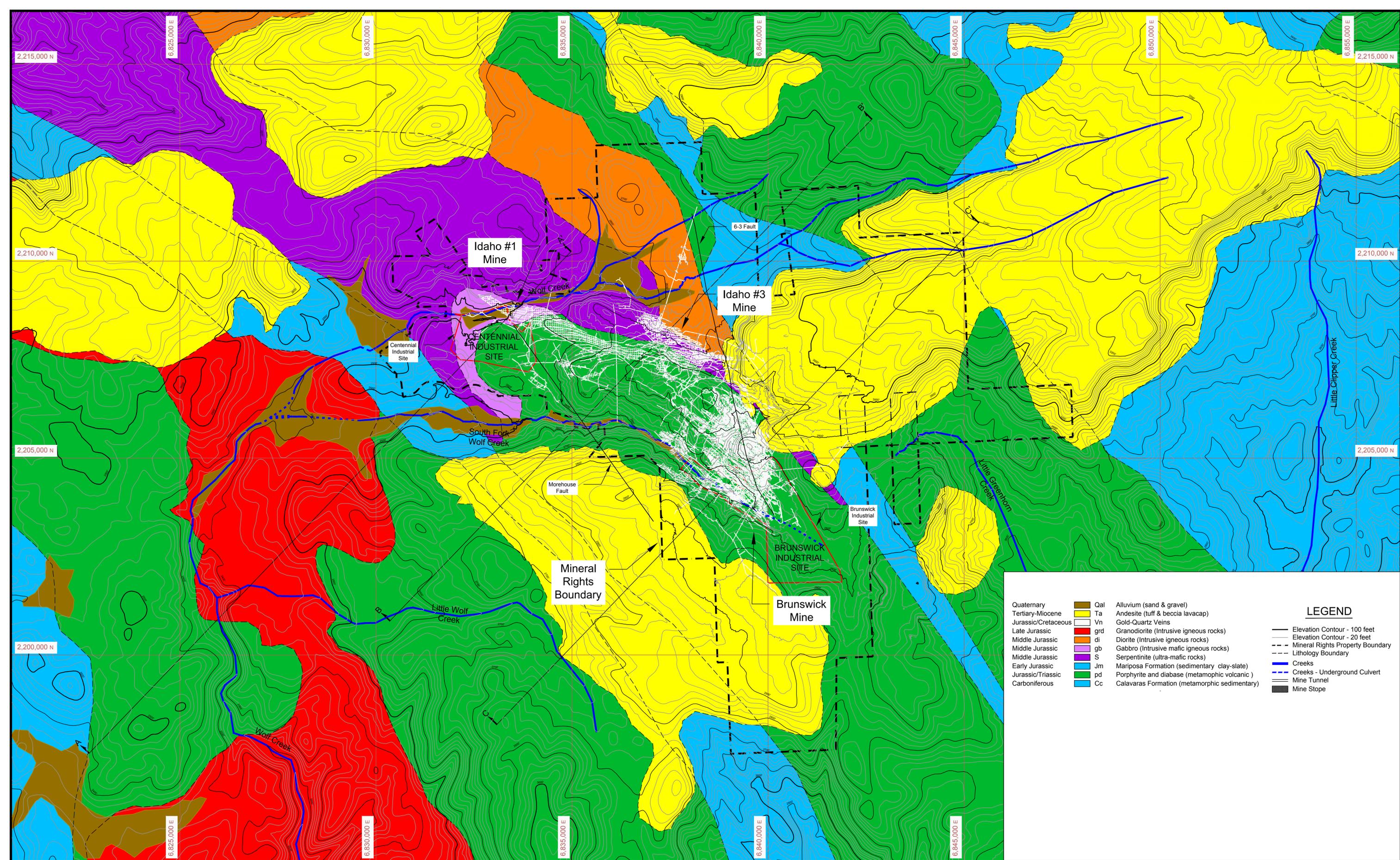
Idaho-Maryland Mine Project
 Rise Grass Valley Inc.
 PO Box 271
 Grass Valley, California, USA 95945



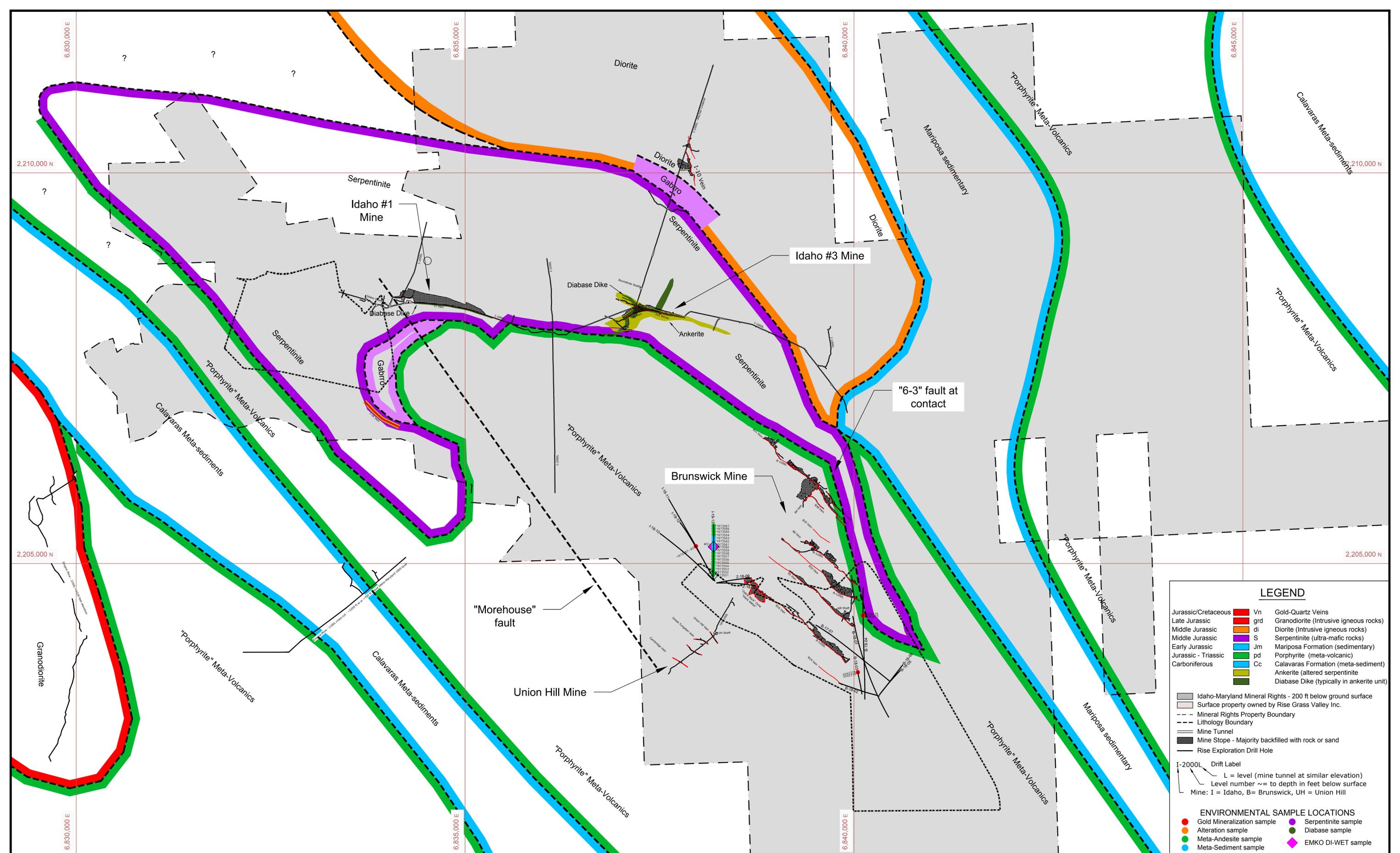
Centennial Industrial Site
 Nevada County, SEC. 26, T.16N, R.8E., M.D.M
 Total Area = 56.41 Acres
 Assessor Parcel Numbers:
 09-550-32, 09-550-37, 09-550-38, 09-550-39,
 09-550-40, 09-560-36
 Current Zoning M1 / Proposed Zoning M1

Domestic water source: Nevada Irrigation District
 Industrial water source: N/A
 Sewage disposal: N/A
 Orphir Hill Fire Protection District
 Electrical power: N/A
 Final grading topography based on:
 Preliminary Grading Plan prepared by Nevada City Engineering Inc.





LEGEND	
Quaternary	Qal Alluvium (sand & gravel)
Tertiary-Miocene	Ta Andesite (tuff & beccia lavacap)
Jurassic/Cretaceous	Vn Gold-Quartz Veins
Late Jurassic	grd Granodiorite (Intrusive igneous rocks)
Middle Jurassic	di Diorite (Intrusive igneous rocks)
Middle Jurassic	gb Gabbro (Intrusive mafic igneous rocks)
Middle Jurassic	S Serpentinite (ultra-mafic rocks)
Early Jurassic	Jm Mariposa Formation (sedimentary clay-slate)
Jurassic/Triassic	pd Porphyrite and diabase (metamorphic volcanic)
Carboniferous	Cc Calaveras Formation (metamorphic sedimentary)
	— Elevation Contour - 100 feet
	- - - Elevation Contour - 20 feet
	- - - Mineral Rights Property Boundary
	- - - Lithology Boundary
	— Creeks
	- - - Creeks - Underground Culvert
	— Mine Tunnel
	▨ Mine Stope



LEGEND

Jurassic/Cretaceous	Vn	Gold-Quartz Veins
Late Jurassic	grd	Granodiorite (Intrusive igneous rocks)
Middle Jurassic	di	Diorite (Intrusive igneous rocks)
Middle Jurassic	S	Serpentinite (ultra-mafic rocks)
Early Jurassic	Jm	Mariposa Formation (sedimentary)
Jurassic - Triassic	pd	Porphyrite (meta-volcanic)
Carboniferous	Cc	Calaveras Formation (meta-sediment)
		Ankerite (altered serpentinite)
		Diabase Dike (typically in ankerite unit)

	Idaho-Maryland Mineral Rights - 200 ft below ground surface
	Surface property owned by Rise Grass Valley Inc.
	Mineral Rights Property Boundary
	Lithology Boundary
	Mine Tunnel
	Mine Stope - Majority backfilled with rock or sand
	Rise Exploration Drill Hole

I-2000L Drift Label
 L = level (mine tunnel at similar elevation)
 Level number ~ = to depth in feet below surface
 Mine: I = Idaho, B = Brunswick, UH = Union Hill

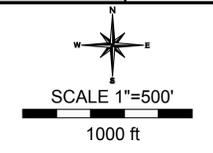
ENVIRONMENTAL SAMPLE LOCATIONS

	Gold Mineralization sample		Serpentinite sample
	Alteration sample		Diabase sample
	Meta-Andesite sample		EMKO DI-WET sample
	Meta-Sediment sample		

R Idaho-Maryland Gold Project
 Rise Grass Valley Inc.
 PO Box 271
 Grass Valley, California, USA 95945

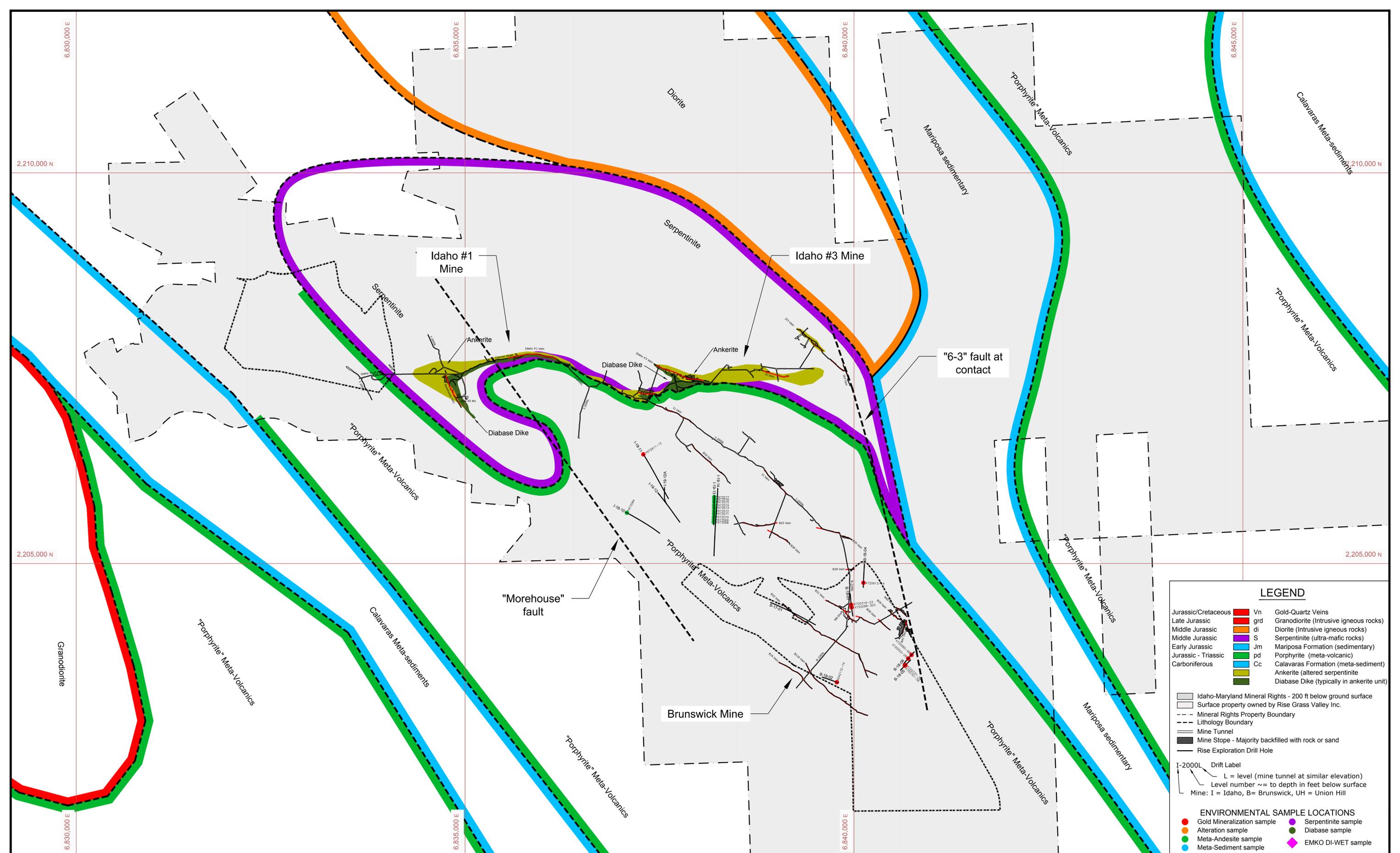
Generalized Geological Mapping Compilation
 Based on USGS mapping - 1940, Johnston
 and internal maps from Idaho-Maryland Mine

Idaho-Maryland Mineral Rights
 Total Area = 2585 Acres
 Mineral rights contiguous at 200 feet
 below ground surface



Sheet 5
Mine Geology 1000L
 Overview showing mine workings and geology at 1000 level
 elevation ~1570 feet

Drawnby : Rise Grass Valley - Feb 1 / 20



LEGEND

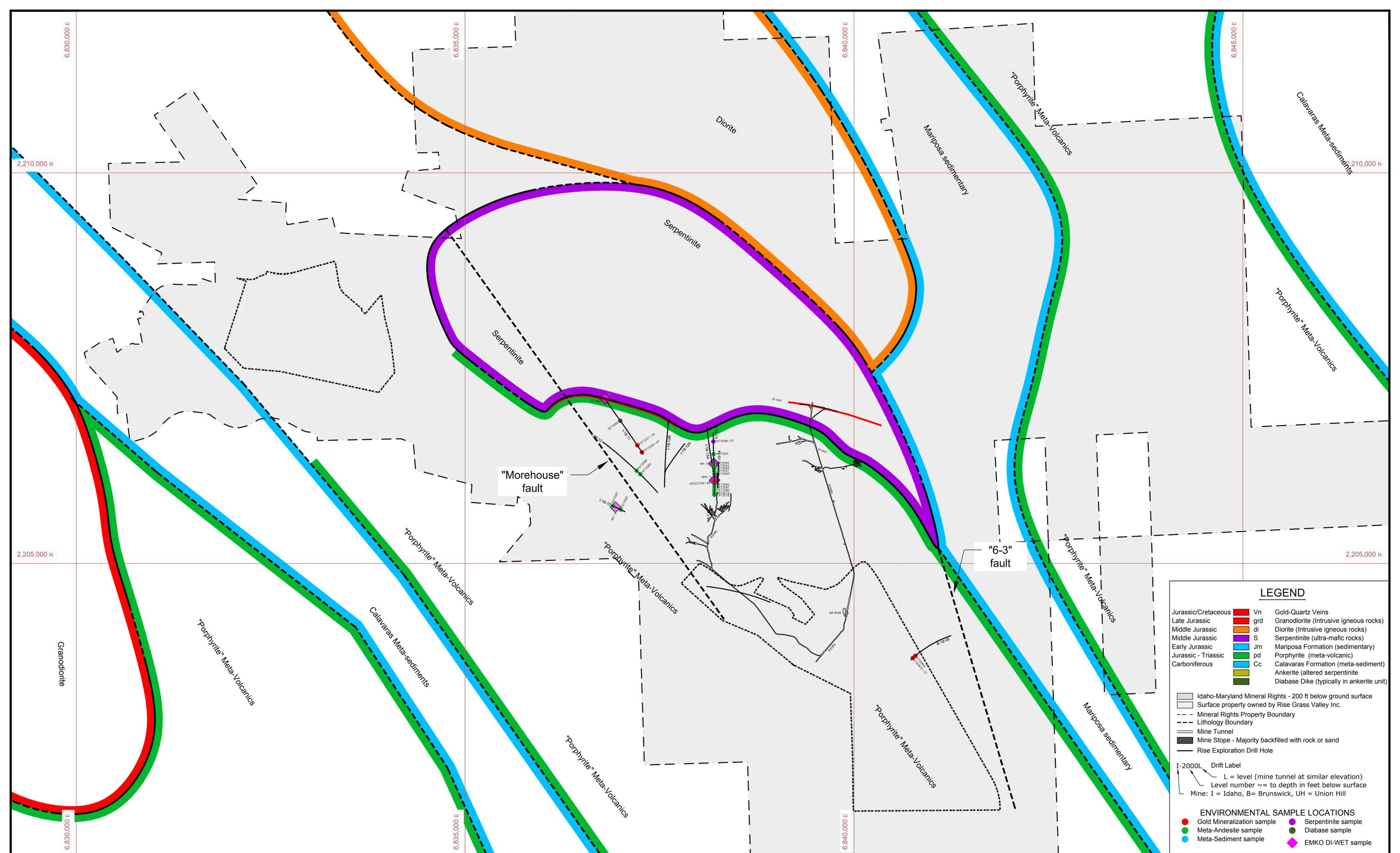
Jurassic/Cretaceous	Vn	Gold-Quartz Veins
Late Jurassic	grd	Granodiorite (Intrusive igneous rocks)
Middle Jurassic	di	Diorite (Intrusive igneous rocks)
Middle Jurassic	S	Serpentinite (ultra-mafic rocks)
Early Jurassic	Jm	Mariposa Formation (sedimentary)
Jurassic - Triassic	pd	Porphyrite (meta-volcanic)
Carboniferous	Cc	Calaveras Formation (meta-sediment)
		Ankerite (altered serpentinite)
		Diabase Dike (typically in ankerite unit)

	Idaho-Maryland Mineral Rights - 200 ft below ground surface
	Surface property owned by Rise Grass Valley Inc.
	Mineral Rights Property Boundary
	Lithology Boundary
	Mine Tunnel
	Mine Stope - Majority backfilled with rock or sand
	Rise Exploration Drill Hole

I-2000L	Drift Label
L = level	L = level (mine tunnel at similar elevation)
Level number ~ =	to depth in feet below surface
Mine: I = Idaho, B = Brunswick, UH = Union Hill	

ENVIRONMENTAL SAMPLE LOCATIONS

	Gold Mineralization sample		Serpentinite sample
	Alteration sample		Diabase sample
	Meta-Andesite sample		EMKO DI-WET sample
	Meta-Sediment sample		



LEGEND

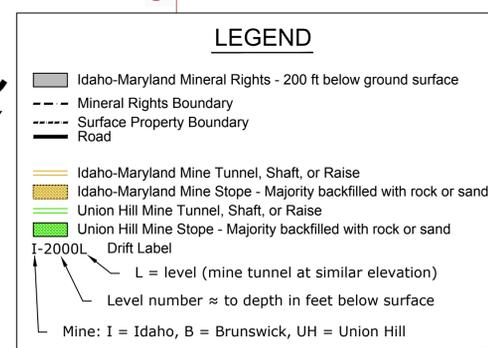
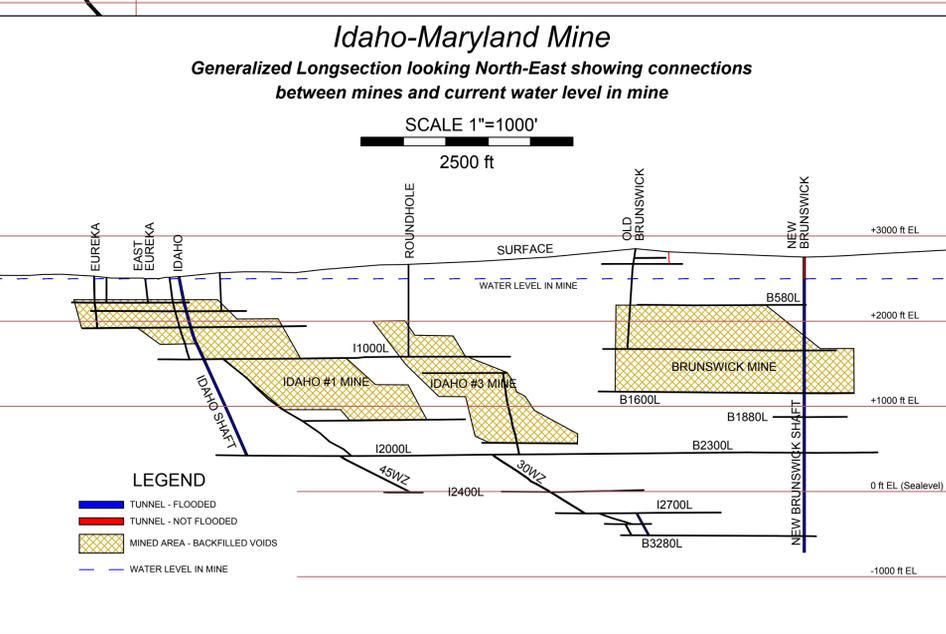
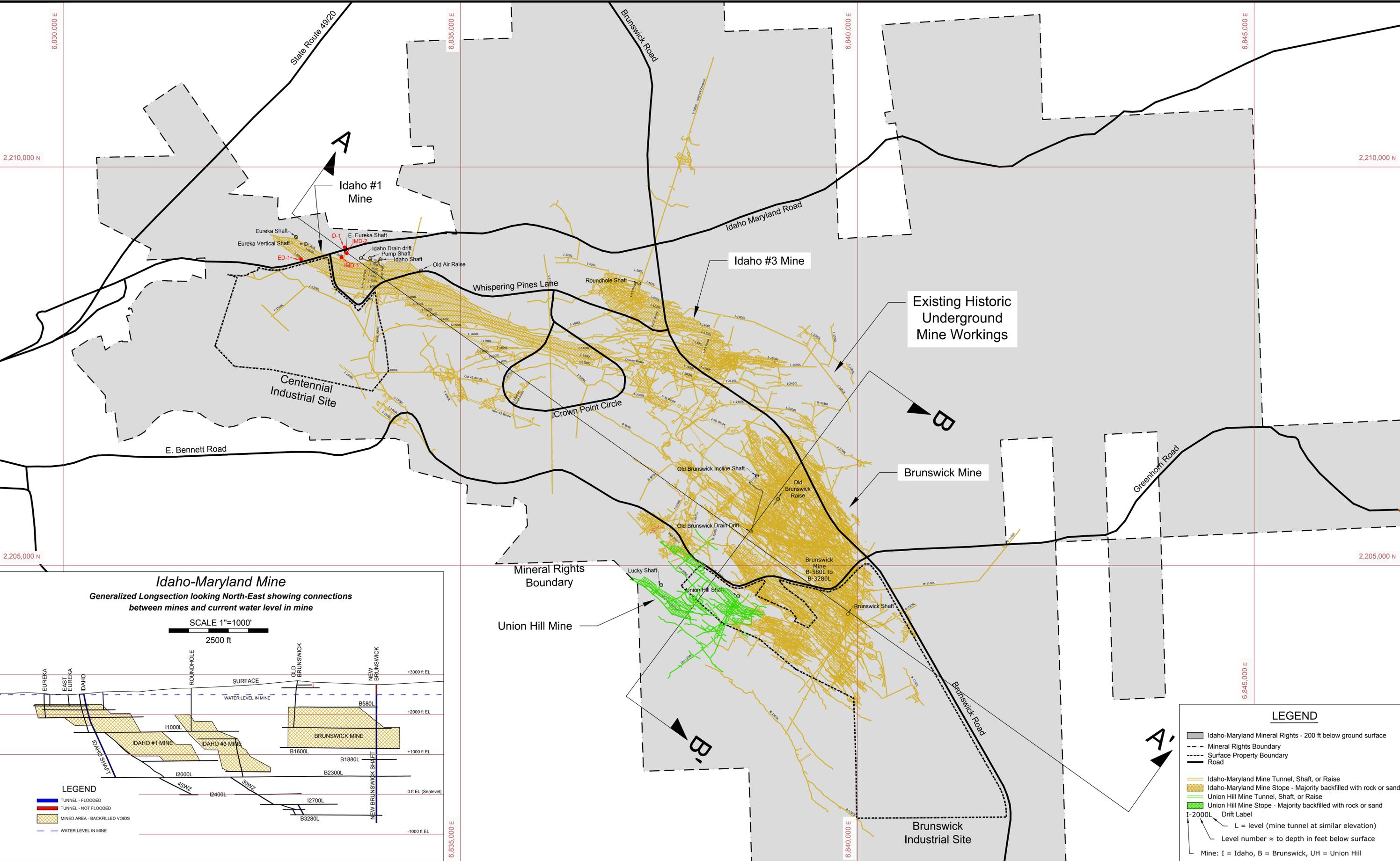
Jurassic/Cretaceous	Vn	Gold-Quartz Veins
Late Jurassic	grd	Granodiorite (Intrusive igneous rocks)
Middle Jurassic	di	Diorite (Intrusive igneous rocks)
Middle Jurassic	S	Serpentine (ultra-mafic rocks)
Early Jurassic	Jm	Mariposa Formation (sedimentary)
Jurassic - Triassic	pd	Porphyrite (meta-volcanic)
Carboniferous	Cc	Calaveras Formation (meta-sediment)
		Ankerite (altered serpentinite)
		Diabase Dike (typically in ankerite unit)

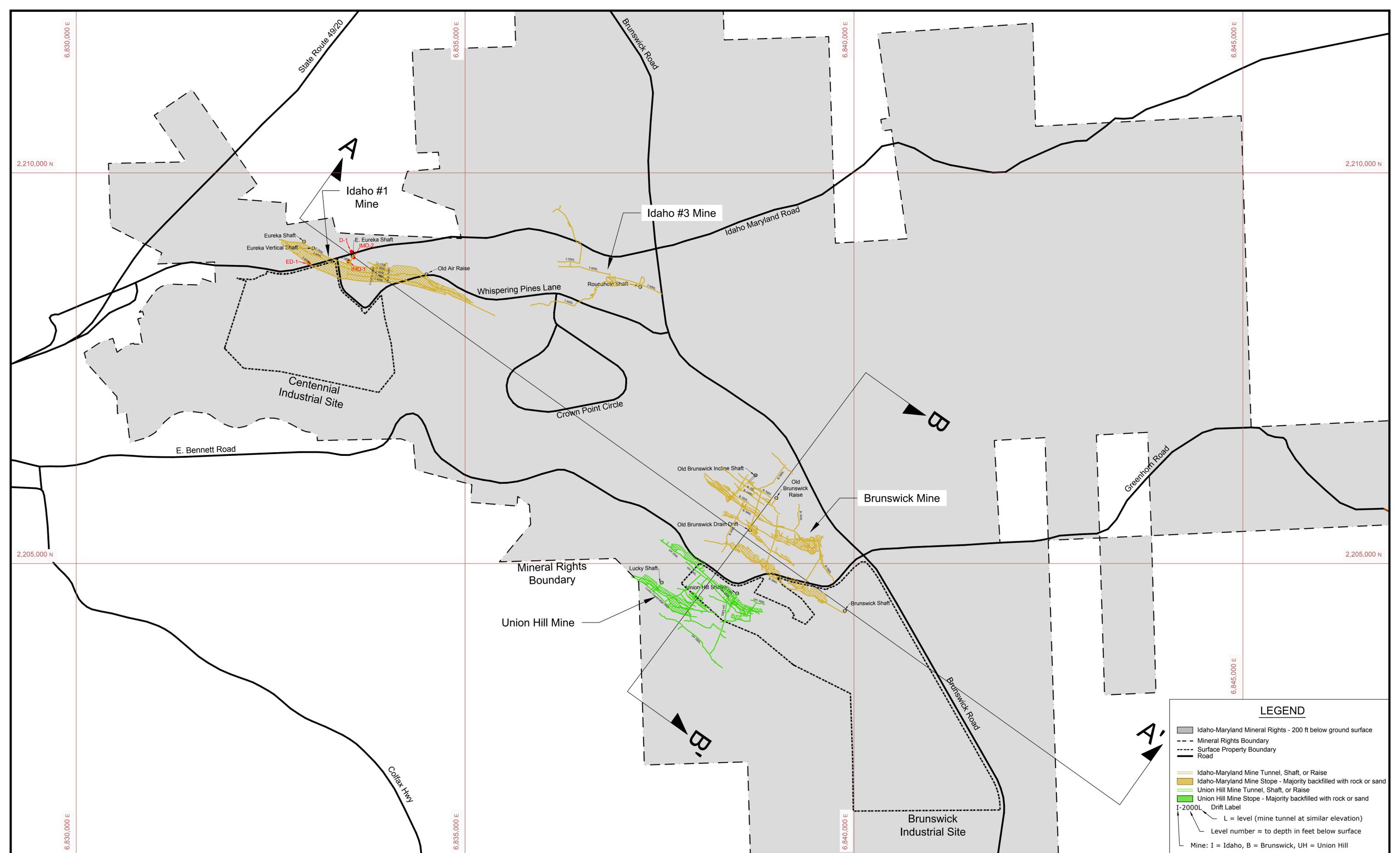
	Idaho-Maryland Mineral Rights - 200 ft below ground surface
	Surface property owned by Rise Grass Valley Inc.
	Mineral Rights Property Boundary
	Lithology Boundary
	Mine Tunnel
	Mine Stope - Majority backfilled with rock or sand
	Rise Exploration Drill Hole

I-2000L Drift Label
 L = level (mine tunnel at similar elevation)
 Level number ~ = to depth in feet below surface
 Mine: I = Idaho, B = Brunswick, UH = Union Hill

ENVIRONMENTAL SAMPLE LOCATIONS

	Gold Mineralization sample		Serpentine sample
	Meta-Andesite sample		Diabase sample
	Meta-Sediment sample		EMKO DI-WET sample

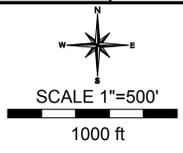




LEGEND

- Idaho-Maryland Mineral Rights - 200 ft below ground surface
- Mineral Rights Boundary
- Surface Property Boundary
- Road
- Idaho-Maryland Mine Tunnel, Shaft, or Raise
- Idaho-Maryland Mine Stope - Majority backfilled with rock or sand
- Union Hill Mine Tunnel, Shaft, or Raise
- Union Hill Mine Stope - Majority backfilled with rock or sand
- I-2000L Drift Label
- L = level (mine tunnel at similar elevation)
- Level number ≈ to depth in feet below surface
- Mine: I = Idaho, B = Brunswick, UH = Union Hill

Idaho-Maryland Mineral Rights
 Total Area = 2585 Acres
 Mineral rights contiguous at 200 feet
 below ground surface



Sheet 9
Existing Historic Underground Mine Workings
 Showing Workings less than ~600 feet bgs
 Spatial Relationship to major roads and site boundaries

Drawnby : Rise Grass Valley - Feb 1 / 20

Idaho-Maryland Mine Project
 Rise Grass Valley Inc.
 PO Box 271
 Grass Valley, California, USA 95945

 ZOH
SCALE: 1" = 200'
CONTOUR INTERVAL: 2'



REVISION:	DATE:	DESCRIPTION:
1	2/5/2020	TERMINOLOGY UPDATE

BRUNSWICK SITE
RISE GRASS VALLEY INC.
SEC. 31, T.16N., R.9E., M.D.M.
NEVADA COUNTY , CALIFORNIA

HYDROLOGY MAP
PRE-DEVELOPMENT

LEGEND:

-  DRAINAGE SUBAREA BOUNDARY
-  EXISTING CONTOUR W/ ELEVATION
-  PROPERTY LINE
-  DRAINAGE SUBAREA DESIGNATION
ACREAGE OF SUBAREA

TERMINOLOGY PER POND PACK PROGRAM

-  CATCHMENT AREA (SAME AS DRAINAGE SUBAREA ABOVE)
-  POND #
-  OUTLET #
-  COMPOSITE OUTLET STRUCTURE #
-  OUTLET CULVERT #

SHEET 10

H-3



REVISION:	DATE:	DESCRIPTION:
1	2/5/2020	TERMINOLOGY UPDATE

CENTENNIAL SITE

RISE GRASS VALLEY INC.

SEC. 26, T.16N., R.8E., M.D.M.

NEVADA COUNTY, CALIFORNIA

HYDROLOGY MAP
PRE-DEVELOPMENT

H-1



SCALE: 1" = 200'
CONTOUR INTERVAL: 2'

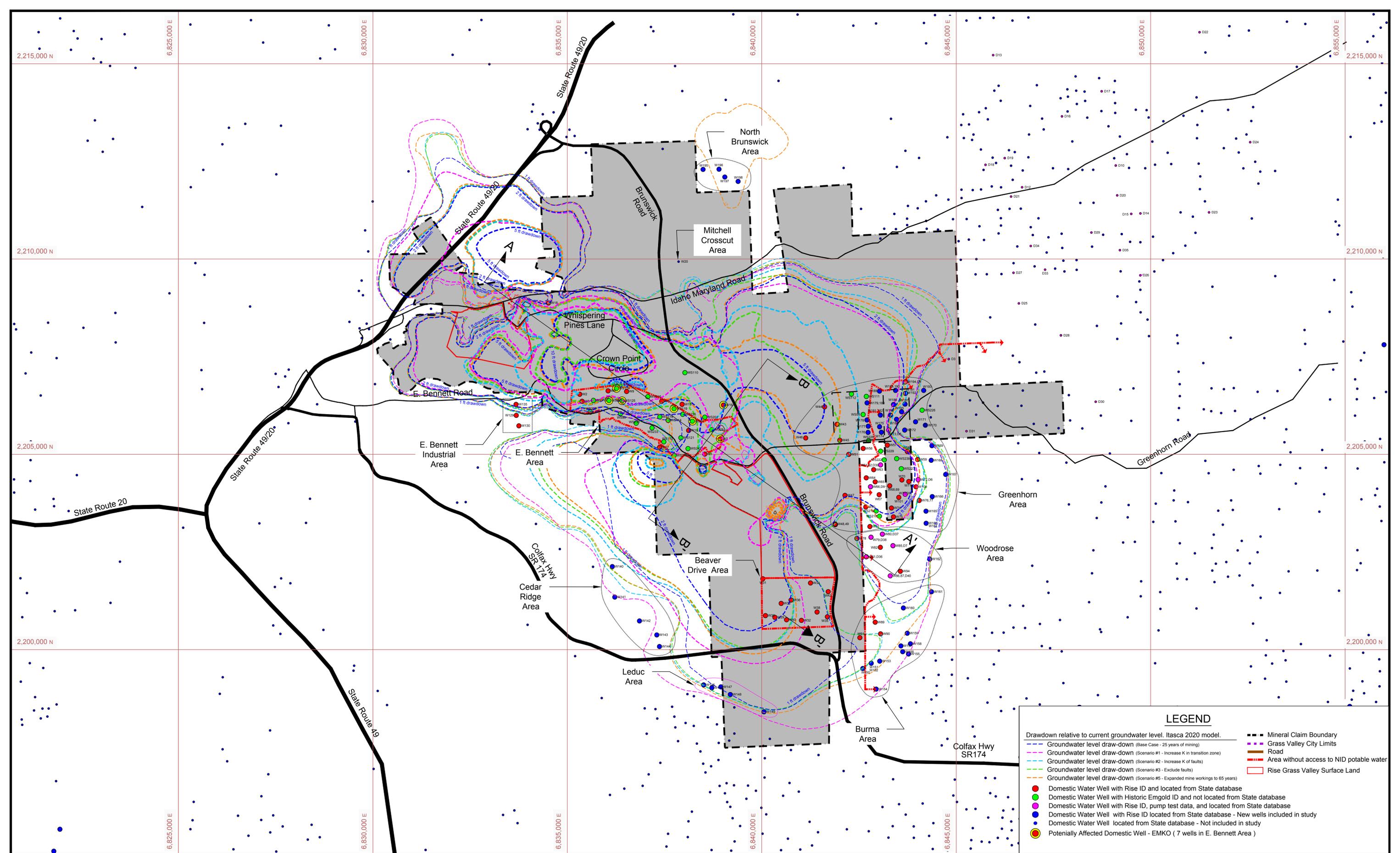
LEGEND:

- DRAINAGE SUBAREA BOUNDARY
- EXISTING CONTOUR W/ ELEVATION
- PROPERTY LINE
- DRAINAGE SUBAREA DESIGNATION
ACREAGE OF SUBAREA

TERMINOLOGY PER POND PACK PROGRAM

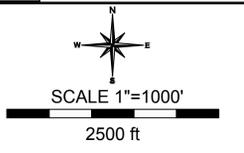
- CATCHMENT AREA (SAME AS DRAINAGE SUBAREA ABOVE)
- POND #
- OUTLET #
- COMPOSITE OUTLET STRUCTURE #
- OUTLET CULVERT #

SHEET 11



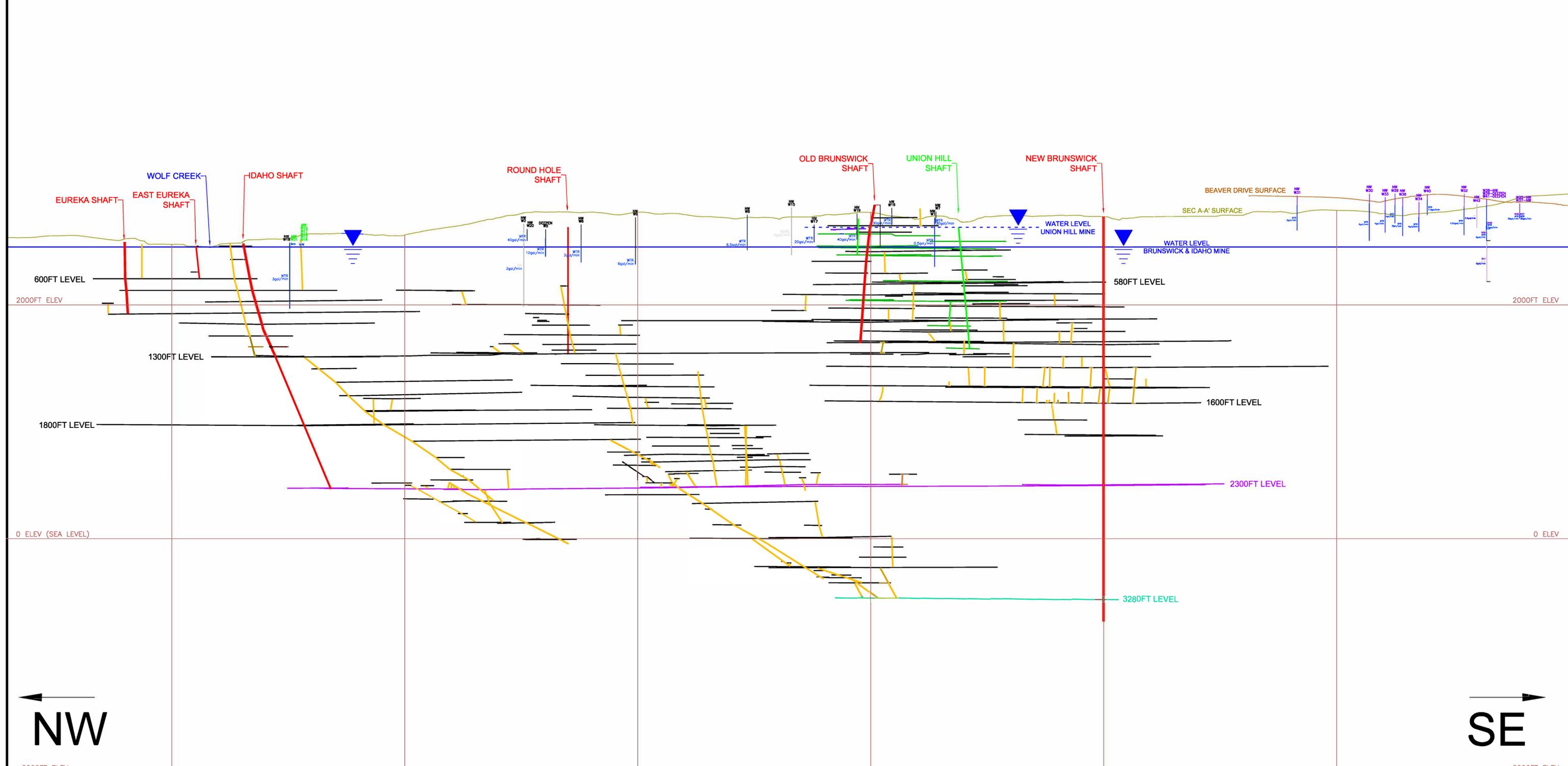
LEGEND

<ul style="list-style-type: none"> --- Drawdown relative to current groundwater level. Itasca 2020 model. --- Groundwater level draw-down (Base Case - 25 years of mining) --- Groundwater level draw-down (Scenario #1 - Increase K in transition zone) --- Groundwater level draw-down (Scenario #2 - Increase K of faults) --- Groundwater level draw-down (Scenario #3 - Exclude faults) --- Groundwater level draw-down (Scenario #5 - Expanded mine workings to 65 years) 	<ul style="list-style-type: none"> --- Mineral Claim Boundary --- Grass Valley City Limits --- Road --- Area without access to NID potable water --- Rise Grass Valley Surface Land
<ul style="list-style-type: none"> ● Domestic Water Well with Rise ID and located from State database ● Domestic Water Well with Historic Emgold ID and not located from State database ● Domestic Water Well with Rise ID, pump test data, and located from State database ● Domestic Water Well with Rise ID located from State database - New wells included in study ● Domestic Water Well located from State database - Not included in study ● Potentially Affected Domestic Well - EMKO (7 wells in E. Bennett Area) 	



LONGSECTION: SECTION A-A'

SECTION LOOKING NORTHEAST
ALL MINE WORKINGS PROJECTED ON LONGSECTION



NW

SE

SHEET 13



LEGEND

WELLS

W#	WELL ID
W#	BEAVER DRIVE WELL - WELL ID
NW	NEW WELL
WTR	WELL WATER LEVEL
NA	WATER LEVEL DATA NOT AVAILABLE
NONE	NO WATER IN WELL
gal/min	WELL TEST DATA

MINE WORKINGS

	BRUNSWICK / IDAHO MINE LATERAL DRIFTS
	SHAFT
	RAISE / WINZE
	UNION HILL MINE LATERAL DRIFTS
	UNION HILL SHAFT / RAISE

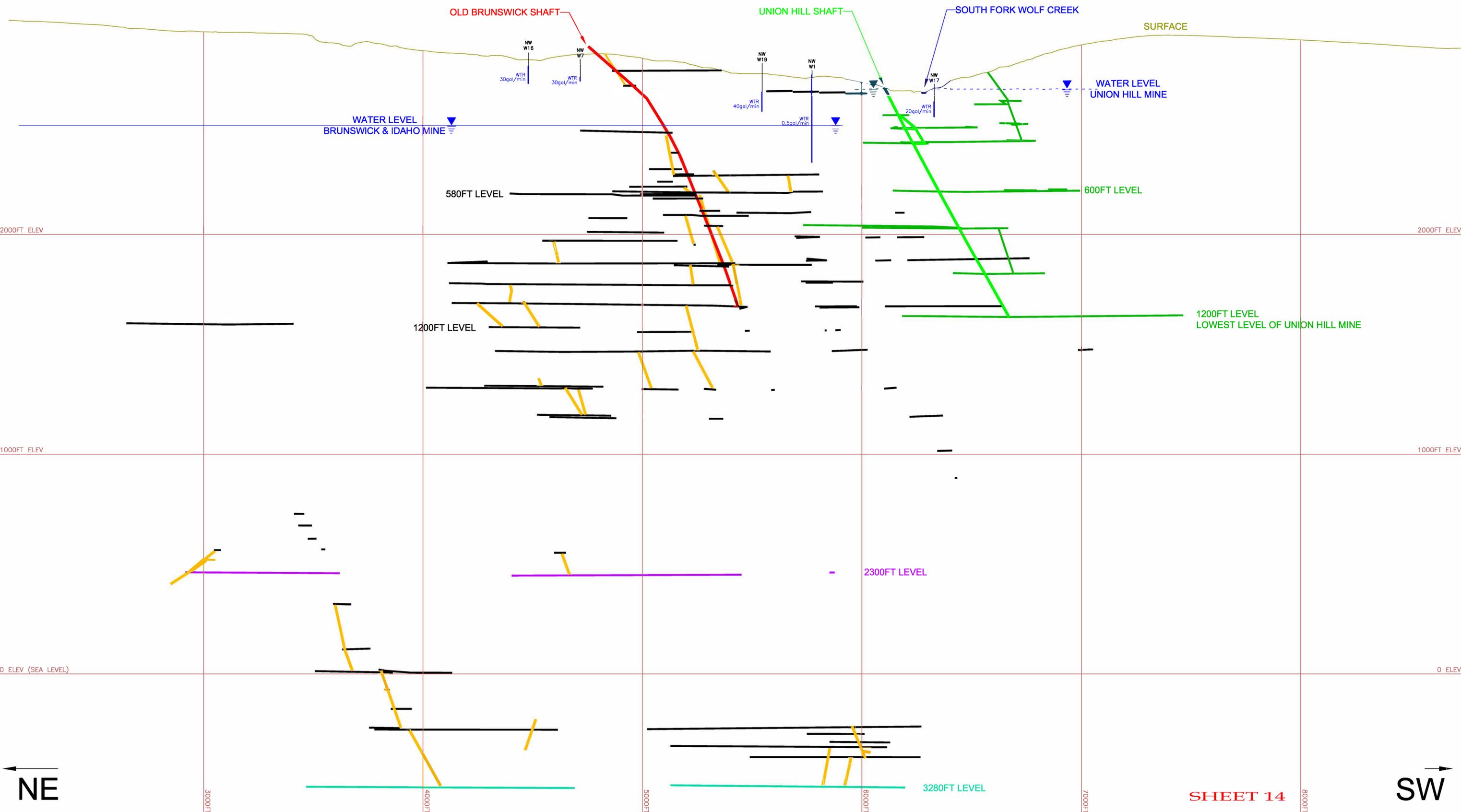
WATER LEVELS

	APPROX. WATER LEVEL IN BRUNSWICK & IDAHO MINE
	APPROX. WATER LEVEL IN UNION HILL MINE

- NOTES:**
- DOMESTIC WELLS ALONG EAST BENNETT RD CORRIDOR AND WITHIN BEAVER DRIVE SUBDIVISION SHOWN ON LONGSECTION.
 - ALL MINE DRIFTS AND SHAFTS PROJECTED ON TO LONGSECTION.
 - SURFACE PROFILE SHOWN CORRESPONDS TO SURFACE PROFILE ALONG SECTION A-A'. SEE PLAN LAYOUT FOR BEAVER DRIVE SURFACE PROFILE LOCATION.
 - BRUNSWICK AND IDAHO MINES ARE CONNECTED ON 2300FT LEVEL & 3280FT LEVEL.
 - WELL WATER DATA IS STATIC WATER LEVEL. DEPTH TO FIRST WATER IS SHOWN WHEN NO STATIC WATER LEVEL DATA AVAILABLE.

TITLE: DOMESTIC WATER WELLS - SEC A-A'			
Idaho-Maryland Mine Property			
SHOWING ALL MINE DRIFTS & SHAFTS PROJECTED ON SEC A-A'			
Drawn by: RISE	Scale: 1"=400'	Approval:	Date:
Date: 2020/01/15			
File:			

CROSS-SECTION: SECTION B-B'
SECTION LOOKING SOUTHEAST
INCLUDES 1000FT PROJECTION SE & NW



NE

SW

WELLS

W#	WELL ID
NW	NEW WELL
WTR	WELL WATER LEVEL
NA	WATER LEVEL DATA NOT AVAILABLE
NONE	NO WATER IN WELL
gal/min	WELL TEST DATA

MINE WORKINGS

—	BRUNSWICK / IDAHO MINE LATERAL DRIFTS
—	SHAFT
—	RAISE / WINZE
—	UNION HILL MINE LATERAL DRIFTS
—	UNION HILL SHAFT / RAISE

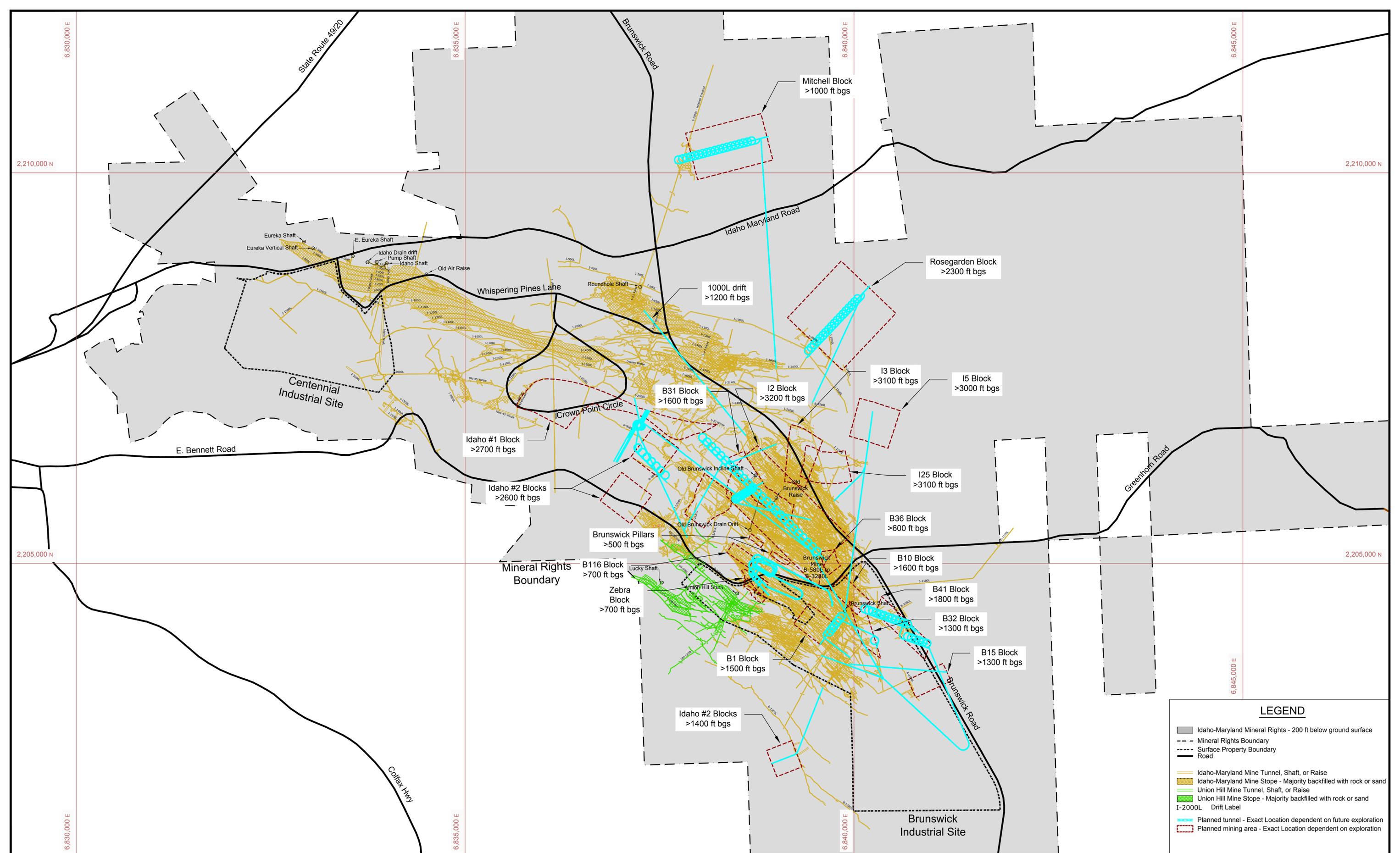
WATER LEVELS

—	APPROX. WATER LEVEL IN BRUNSWICK & IDAHO MINE
—	APPROX. WATER LEVEL IN UNION HILL MINE

- NOTES:**
1. ALL MINE DRIFTS AND SHAFTS WITHIN 1000FT OF SECTION PROJECTED ON TO SECTION B-B'.
 2. SURFACE PROFILE SHOWN CORRESPONDS TO SURFACE PROFILE ALONG SECTION B-B'; SEE PLAN LAYOUT.
 3. BRUNSWICK AND IDAHO MINES ARE CONNECTED ON 2300FT LEVEL & 3280FT LEVEL.
 4. WELL WATER DATA IS STATIC WATER LEVEL. DEPTH TO FIRST WATER IS SHOWN WHEN NO STATIC WATER LEVEL DATA AVAILABLE.

TITLE: DOMESTIC WATER WELLS - SEC B-B'	
Idaho-Maryland Mine Property	
CROSS-SECTION THROUGH UNION HILL MINE	
Drawn by: RISE	Scale: 1"=200'
Date: 2020/01/15	Approval: _____ Date: _____
File:	

SHEET 14

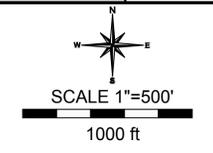


LEGEND

- Idaho-Maryland Mineral Rights - 200 ft below ground surface
- Mineral Rights Boundary
- Surface Property Boundary
- Road
- Idaho-Maryland Mine Tunnel, Shaft, or Raise
- Idaho-Maryland Mine Stope - Majority backfilled with rock or sand
- Union Hill Mine Tunnel, Shaft, or Raise
- Union Hill Mine Stope - Majority backfilled with rock or sand
- I-2000L Drift Label
- Planned tunnel - Exact Location dependent on future exploration
- Planned mining area - Exact Location dependent on exploration

R Idaho-Maryland Mine Project
 Rise Grass Valley Inc.
 PO Box 271
 Grass Valley, California, USA 95945

Idaho-Maryland Mineral Rights
 Total Area = 2585 Acres
 Mineral rights contiguous at 200 feet
 below ground surface



Sheet 15
Base Case - 25 years mining
Planned Underground Mine Workings
(Locations will vary dependant on exploration)

Drawnby : Rise Grass Valley - Feb 1 / 20