PRELIMINARY HYDROGEOLOGICAL SITE CHARATERIZATION FOR SALTAIR GROUNDWATER SOURCE, INCLUDING COST ESTIMATE (CVRD NO. ES-031-16)

Submitted to:

COWICHAN VALLEY REGIONAL DISTRICT
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Submitted by:

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Nanaimo, British Columbia
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EXECUTIVE SUMMARY

Waterline Resources Inc. (Waterline) is pleased to provide our report for Preliminary Hydrogeological Site Characterization for the Saltair Groundwater Source Project. The Project represents the first phase of a multi-phase study and involves conducting a desktop-based assessment with site reconnaissance to identify the most promising aquifer locations and to determine the feasibility of supplying groundwater to the CVRD water system.

In order to secure a reliable long-term source of safe groundwater, the CVRD are seeking to identify the location(s) and relevant parameters of any aquifers in Saltair. The suitability of aquifers for use as drinking water supply may also be dependent on their location relative to the service area infrastructure, anticipated yield, water quality, infrastructure costs and maintenance/operations costs, and environmental impacts of groundwater extraction including potential impact on nearby surface water.

To meet the objectives of the study, Waterline used our in-house geodatabase system (EWS^{TM}) to complete the Project. The system allowed our staff to immediately focus on planning and addressing groundwater issues, mapping and targeting suitable aquifers in relation to land and infrastructure information. Based on this preliminary work the alluvial fan at the confluence of North and West Banon Creeks (CVRD Site 1) was identified as the preferred target for further groundwater exploration.

Waterline visited the site in March and April of 2017 to conduct confirmatory field mapping in the vicinity of the Banon Creek alluvial fan, confirm the location of water utility networks, and determine site accessibility for Phase 2 exploration. In consultation with Waterline, the CVRD contracted Frontier Geosciences in April to complete the seismic refraction survey in order to better define the subsurface structure and to help select the test drilling locations. The seismic survey indicates the presence of a thick sequence of coarse unconsolidated sediment adjacent to Banon Creek and the main logging access road. The data indicate the existence of a relatively continuous layer of saturated sand and gravel which has been selected for testing as part of the recommended Phase 2 drilling program. CVRD is currently completing consultation and permitting requirements in order to proceed with the test drilling program.

1.0 INTRODUCTION

1.1 Background

The Saltair Water System is located on the east coast of Vancouver Island, south of the Town of Ladysmith. Waterline understands that the CVRD assumed responsibility from Saltair Waterworks District in 1986 and supplies water from Stocking Lake to approximately 850 residences, businesses, and a portion of the lands within the Town of Ladysmith. As a surface water source, the system must meet requirements for Provincial Drinking Water Standards and regulatory compliance for the 4-3-2-1 multi-barrier drinking water treatment objective. Recently the CVRD commissioned a study to confirm appropriate technology with Class C cost analysis to assist in developing the necessary infrastructure to improve public health and safety of this community. Due to the high cost the of multi-barrier treatment, the CVRD is exploring the potential for a groundwater supply including a number of previously identified sites within the area as potential groundwater sources, as well as the sites capacities to service the community.

1.2 Objectives

The objective of this desktop-based study was to compile and review pertinent geologic and hydrogeologic reports, maps and cross sections related to the study area, identify the most promising aquifer(s) in the area, and provide drilling targets. In addition, Waterline considered regulatory and licensing, water quality, and environmental issues that may require further study. The main criteria for aquifer target selection was that it must have a high enough yield and be of good water quality. In addition, it must be accessible so that infrastructure costs such as piping, storage, and water treatment can be minimized. The water quality will help determine whether treatment prior to consumption is required.

2.0 SCOPE OF WORK AND METHODOLOGY

2.1 Scope of Work

To accomplish the objectives of the study, Waterline has completed the following scope of work:

- Review regional physiography and geologic mapping of the Saltair Study Area;
- Review publicly available water well records from the Ministry of Environment (MOE) water well database, and hydrogeologic and engineering reports provided by the CVRD;
- Evaluate the groundwater potential within the two site areas identified by the CVRD and selected the potentially favorable drilling locations; and
- Prepare a report summarizing the background review and providing recommendations for pursuing an alternate new groundwater supply.

For the purposes of this assessment, the Study Area is identified as the extent of the map sheet presented on Figure 1. The CVRD's three areas of interest are identified as follows:

- Stocking Lake: Surface water reservoir and water supply for the Village of Saltair.
- CVRD Site 1: Located at the confluence of North and West Banon Creeks.
- CVRD Site 2: Located along Old Victoria Road within the Village of Saltair.

CVRD Site 1 was previously identified as a potential aquifer target in a 1965 report by BC Hydro where the Banon Creek alluvial fan was identified during a field reconnaissance program by J.C. Foweraker. The CVRD Site 2 location was identified based on a preliminary well test at the time of drilling in 1977 indicating high potential yield in this area.

2.2 Methodology

2.2.1 EWS Geodatabase

Waterline used the Environmental Web Services (EWS^{TM}) database system to complete the Saltair groundwater study. EWS was created by Waterline to specifically deal with water-related projects across Western Canada. Access to environmental data allows our staff to immediately focus on planning and addressing groundwater issues, mapping and targeting suitable aquifers in relation to land and infrastructure information.

2.2.2 Conceptual Hydrogeological Model Development

The information compiled by Waterline was used to assess the groundwater flow regime within the Study Area, including the extent of shallow overburden aquifers, bedrock aquifers, and probable groundwater yield. The data was used to develop a conceptual hydrogeological model to identify favorable drilling locations within the Saltair Study Area.

3.0 RESULTS AND DISCUSSION

3.1 Project Kick-Off Meeting

In mid-December 2016, Waterline attended a meeting at the CVRD office in Duncan to present our approach for the Saltair groundwater study. The objective of the meeting was to assist the CVRD team in their consultant selection process. During the meeting, Waterline completed a review of the existing information contained in the EWS Geodatabase system and was able to demonstrate the utility of our database tool and essentially narrow the site selection to one preferred site located within the Banon Creek alluvial fan system (CVRD Site 1, Figure 1).

The CVRD Site 2 along Old Victoria Road was evaluated in a 1986 report prepared for the CVRD by R.C. Le Noury and long-term pump testing of the well drilled in 1977 indicated that the well depleted rapidly. Based on this initial meeting, the CVRD eliminated the Site 2 location as a viable option given the historical aquifer yield data and its proximity to the CVRD water distribution system. Therefore, although Waterline does evaluate the regional hydrogeology, the enclosed report was focused on the Banon Creek alluvial fan system for possible Phase 2 exploration and development for groundwater supply.

3.2 Regional Geology and Aquifer Mapping

Using the EWS mapping system, Waterline was able to assemble and present the regional hydrogeological model to help further evaluate the groundwater development potential surrounding the Village of Saltair. Figure 2 shows the approximate outline of mapped aquifers developed by the MOE. Waterline sorted water well data to show wells based on whether the screened inteval was completed in overburden or bedrock (yellow points in overburden, pink points in bedrock). As can be seen, most water wells have been drilled within the Saltair Town boundary and relate to either a mapped overburden aquifer (Aquifer 169) or a bedrock aquifer (Aquifer 170) located at Panorama Ridge just west of Highway 1.

Figure 3 shows the mapped overburden geology in the region along with water wells sorted by completion interval at the well screen. In addition, mapped fault lines are shown which relate to structual breaks in the underlying bedrock formations which may also provide controls on drainage systems in the area. These major fault features are likely important conduits for groundwater flow in both the overburden and bedrock. Overburden deposits and aquifers tend to align with these major structural deformities which may also provide regional hydraulic connections for recharge from the mountain block located inland.

Figure 4 shows a map of the bedrock geology, including major fault lines and water wells sorted by material at the well screen. Figure 5 shows the same except wells have been sorted by well yield indicated at the time of drilling. Numerous water supply wells drilled at Panorama ridge have been completed in volcanic bedrock of the Sicker Group - Nitinat Formation near the geologic contact with the Cretaceos-age Nanaimo Group sedimentary bedrock and in close proximity to a map fault line situated to the west. Figure 5 shows that the Panorama Ridge wells range in yield from less than 50 m^3/day (9 US gpm) to 545 m^3/day (100 US gpm). The higher well yield is most likely related to increased fracture permeability associated with major faulting in the area.

3.3 Banon Creek Alluvial Fan Assessment

As indicated previously, Figure 3 shows that other than the mapped geology information, no water well information is available along the Banon Creek drainage. However, the available information shows that an alluvial fan system appears to be well developed at the confluence of North and West Banon creeks. The sub-watershed outlines indicate that the catchment areas above the confluence is relatively large which could be very important for aquifer recharge from surface drainage.

The alluvial deposits appear to extend along Banon Creek to the southeast. Of significance is the fact that Banon Creek is aligned with the regional structural deformities and appears to coincide with a fault line that extends the length of the creek to the North-West arm confluence. This structural control on sediment deposition may also be important to enhance bedrock permeability and for mountain block recharge emanating from the underlying bedrock. Further evaluation of this hypothesis can only be investigated and confirmed during Phase 2 drilling and testing.

Figure 6 shows a close-up air photo of the CVRD Site 1 location with the surficial geology and watershed boundary overlay. The CVRD water distribution pipeline is also shown and one can see that the target drilling site is within the center of the mapped Alluvial fan, within the larger main stem of Banon Creek, and in close proximity to the mapped fault. This area is the focus of the field reconnaissance program to determine site access for exploration drilling and testing equipment.

3.4 Impact Assessment and Regulatory Considerations

Shallow sand and gravel aquifers in the coastal environment tend to be partially confined or unconfined and therefore may have limited protection from surface activities that release potential contaminants (i.e., spills) adversely impacting groundwater quality. The interaction between an aquifer and surrounding surface water was considered in terms of limitations on the available groundwater and its potential vulnerability (i.e., GARP), in addition to the potential long-term use effects of the aquifer on surface water levels. Figure 7 shows information from the MOE contaminated site registry. All historical contaminated sites are situated near or within the Saltair Town Limits which further supports the elimination of CVRD Site 2, and the focus on the Banon Creek Alluvial Fan system (CVRD Site 1).

As of February 29, 2016, British Columbia's new Water Sustainability Act requires that Municipal groundwater users license water supply wells. The following apply:

- Water Sustainability Act (WSA), February 2016;
- Water Sustainability Regulation (*B.C. Reg*. *36*/*2016* O.C. 110/2016);

The Groundwater Licence Application requirements include information regarding water works infrastructure and hydrogeological setting such as aquifer description, well details, estimated yield, etc. Waterline will consider application requirements for submission to the BC Ministry of Forests, Lands and Natural Resource Operations (FLNRO) as part of the current project.

Other regulations, and guidance documents may also apply but will only be considered once an exploration well has been drilled and tested:

- Groundwater Protection Regulation (*B.C. Reg*. *39*/*2016* O.C. 113/2016);
- Drinking Water Protection Regulation *(B.C. Reg. 87/2011);*
- Drinking Water Treatment Objectives (Microbiological) for Ground Water Supplies in British Columbia, Version 1, November 2015.
- British Columbia Guidance (Microbiological) on the Best Management Practice of Secondary Disinfection for the Purpose of Maintaining Water Quality Within Distribution Systems, Version 1, April 2016.
- Disinfection for the Purpose of Maintaining Water Quality within Distribution Systems, Version 1, April 2016.
- Guidance Document for Determining Ground Water at Risk of Containing Pathogens (GARP), Version 2, November 2015.

The Phase 2 exploration and testing program described below incorporates the requirements of the various regulations and guidance documents.

3.5 Field Visit of Preferred Exploration Drilling Site

Waterline visited the Banon Creek site on March 1 and April 3, 2017 to conduct confirmatory field mapping in the vicinity of the Banon Creek Alluvial fan, confirm the location of water utility networks, and determine site accessibility for Phase 2 exploration. An initial site visit in March confirmed that ground geophysics would be a suitable option based on the site layout and access. A second site visit in April allowed Waterline to map out and select the preferred geophysical seismic lines. Field notes and photos were collected using an iPad with GIS software and uploaded to Waterline's EWS system for further evaluation.

4.0 PHASE 2 GROUNDWATER EXPLORATION PROGRAM

Based on the results of the hydrogeological site characterization, Waterline proposed a phase 2 groundwater exploration program, which includes the following:

- Ground geophysics;
- Test well drilling;
- Aquifer testing; and
- Water quality assessment and GARP assessment.

If the phase 2 program is successful in identifying a suitable aquifer with high quality groundwater, the program could move to phase 3 which would include drilling a larger diameter production well and additional testing to support a new groundwater license under the WSA.

4.1 Ground Geophysics

Due to the limited subsurface geology information within the Banon Creek alluvial fan deposit, a geophysical survey was completed to define potential permeable zones and to help select the best possible location for test well drilling. Based on Waterline's recommendation, the CVRD contracted Frontier Geosciences Inc. (Frontier) from North Vancouver to conduct a seismic refraction survey which was completed between April 21-22, 2017. Frontier's geophysical report is provided for reference in Appendix A and Figure 8 shows the surface trace of lines completed.

Based on the results of the ground geophysics program, potential drilling targets were identified based on interpreted sediment thickness and permeable zones (Figure 8). The geophysical profiles indicate a channel of thick unconsolidated sediments appears to exist on the north side of Banon Creek in close proximity to the logging access road. The channel feature may contain alluvial deposits of saturated sand and gravel which is the target of the phase 2 test drilling program.

4.2 Test Well Drilling

Waterline recommends drilling adjacent to the access road at the Test Well 1A location shown on Figure 8. Drilling will determine the aquifer characteristics, water quality, and well yield. Drilling should be completed using an air-rotary rig, which is capable of simultaneously drilling and advancing casing through the surficial deposits, sealing off shallow zones and isolating the return of drill cuttings and formation water from the drill bit. The hydrogeologist will collect formation samples during the drilling operation and the lithology will be continuously logged to assess textural and lithological characteristics and aquifer potential. Selected aquifer samples will be further processed by sieve analysis conducted in the field to determine the grain size distribution for use in well screen design. Air-lift testing will be used to estimate the potential production rates at various depths along the wellbore. Water quality field parameters, including pH, electrical conductivity, and temperature will be monitored during air-lift testing. Once the total drilled depth is achieved, the most favorable production interval will be selected for well screen placement based on lithology, particle size distribution, and air-lift test results.

Test holes can be completed as either 152 mm (6-inch) diameter, or 203 mm (8-inch) diameter wells. There is an estimated 50-100% increase in the construction costs associated with the larger diameter 203 mm test wells. The well diameter will determine the pump size and the maximum production limit of the well. On sites, which have not been proven by previous test drilling, a common approach is to complete exploration drilling as 152 mm diameter. Waterline recommends first drilling a 152 mm diameter test well and if this proves successful, the well can be used as an observation well or backup well and a larger diameter (twin) well can be constructed on the same site if required. If we find that the 1A location doesn't deliver the required water volume, then the CVRD should consider a broader exploration program using a track mounted drill rig to test the other target locations.

4.3 Aquifer Testing

Waterline recommends a short-term 24-hr aquifer test is performed on the test well once it has been installed. The test will be performed at a constant-rate followed by residual drawdown (recovery) monitoring. The aquifer's response to pumping will be assessed to determine the transmissivity of the aquifer material and the suitability of using the aquifer as a long-term water source for the CVRD. Surface water levels will be monitored during the test to determine if there is a direct hydraulic connection between the aquifer and surface water. Water quality field parameters, including pH, electrical conductivity, and temperature will be monitored during pumping. A groundwater sample will be collected from the test well near the end of the test and submitted to an accredited laboratory for analysis.

4.4 Water Quality Evaluation and GARP Assessment

Water quality will be assessed to determine if the aquifer has high quality groundwater suitable for human consumption. VIHA's recommended water quality analysis includes the following parameters:

- Major Anions and Cations;
- Total and Dissolved Metals;
- Physical (Colour, Turbidity, TDS); and
- Microbiological (Total Coliform, E.coli, HPC).

4.5 Phase 3 Production Well Installation and WSA Licensing

If the Phase 2 groundwater exploration program is successful, Waterline recommends following up with the installation of a larger diameter (203 mm) production well and 48-hour aquifer test. The 152 mm diameter well will be required as an observation wells and the aquifer test will follow the new BC Guidance document for Technical Assessment in Support of an Application for Groundwater Use (2016). The guidance document outlines the technical information required by the Province to approve new groundwater sources under the WSA. The requirements include the following:

- Assessing adequacy of supply using a longer duration pumping test and observation well;
- Assessing the likelihood of hydraulic connection to streams and other aquifers;
- Assessing potential impacts on nearby groundwater users and the environment; and
- Identifying issues related to land, public safety, and the environment.

The CVRD can review technical requirements using the following weblink:
http://a100.gov.bc.ca/appsdata/acat/documents/r50847/TechAssess_1473197338159_3194880156.pdf

4.6 Estimated Costs for Phase 2 & 3

Table 1 provides estimated costs for the recommended Phase 2 and 3 programs. The estimated costs are intended to be used for planning purposes, with more detailed quotes provided following the ground geophysics and test well drilling.

Table 1: Estimated Costs for Phase 2 & 3 Drilling and Testing

Phased Approach	Task	Cost ($)*
Phase 2 Groundwater Exploration	Geophysics (Frontier Geosciences)	10,000
	Drilling 6-inch Test Well	15,000
	Aquifer Test 24-hr	5,000
	Hydrogeological Support	24,000
	Total Phase 2 (excluding taxes)	**54,000**
Phase 3 Production Well Drilling and Licensing	Drilling 8-inch Production Well	25,000
	Aquifer Test 48-hr	10,000
	Hydrogeological Support	32,000
	Total Phase 3 (excluding taxes)	**67,000**

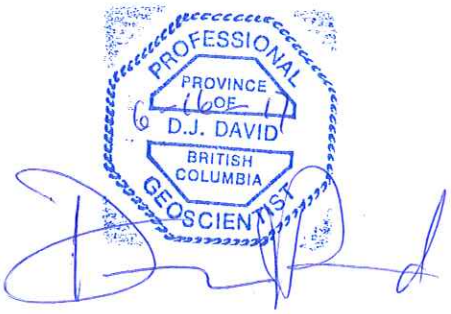
Notes: * all cost estimates are “ballpark” and expected to be within +/- 30%, costs also assume sub-contractors would be directly billed to CVRD otherwise a 10% handling fee would be applied.

5.0 CLOSURE

Waterline is pleased to provide the enclosed summary report on the groundwater supply investigation for the Cowichan Valley Regional District. We trust that the information provided provides sufficient detail for decision making by the CVRD to guide the Phase 2 exploration drilling and testing program. Should you require more information or have any questions or concerns, please do not hesitate to contact Darren David at 1-844-585-0800.

Respectfully submitted,

Waterline Resources Inc.



Darren David, M.Sc., P.Geo.
VP of Operations and Principal Hydrogeologist

Dalton Pajak, B.Sc., P.Geo.
Intermediate Hydrogeologist

FIGURES

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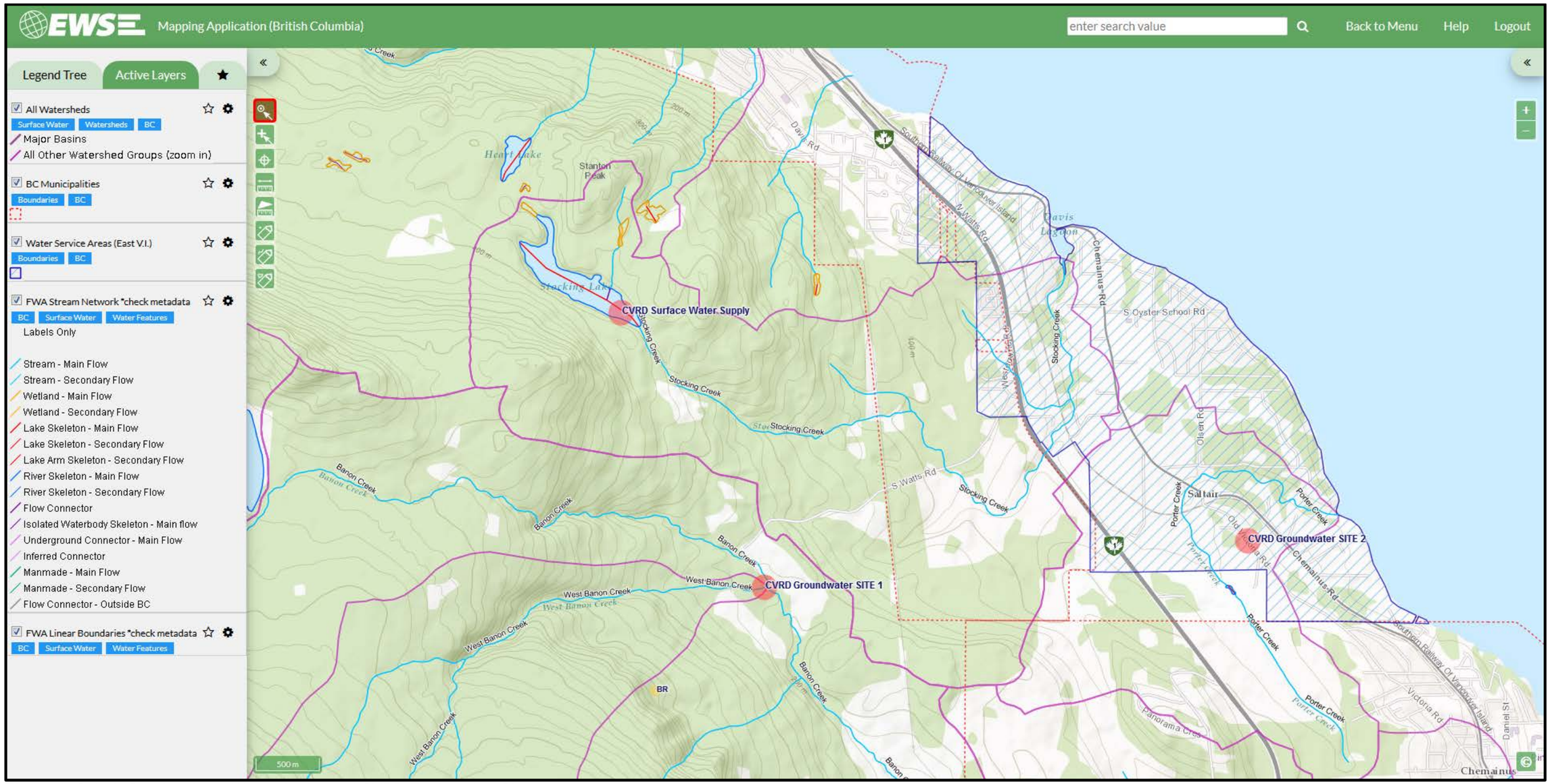

Figure 1: Saltair Service Area, Watersheds, and CVRD Exploration Sites

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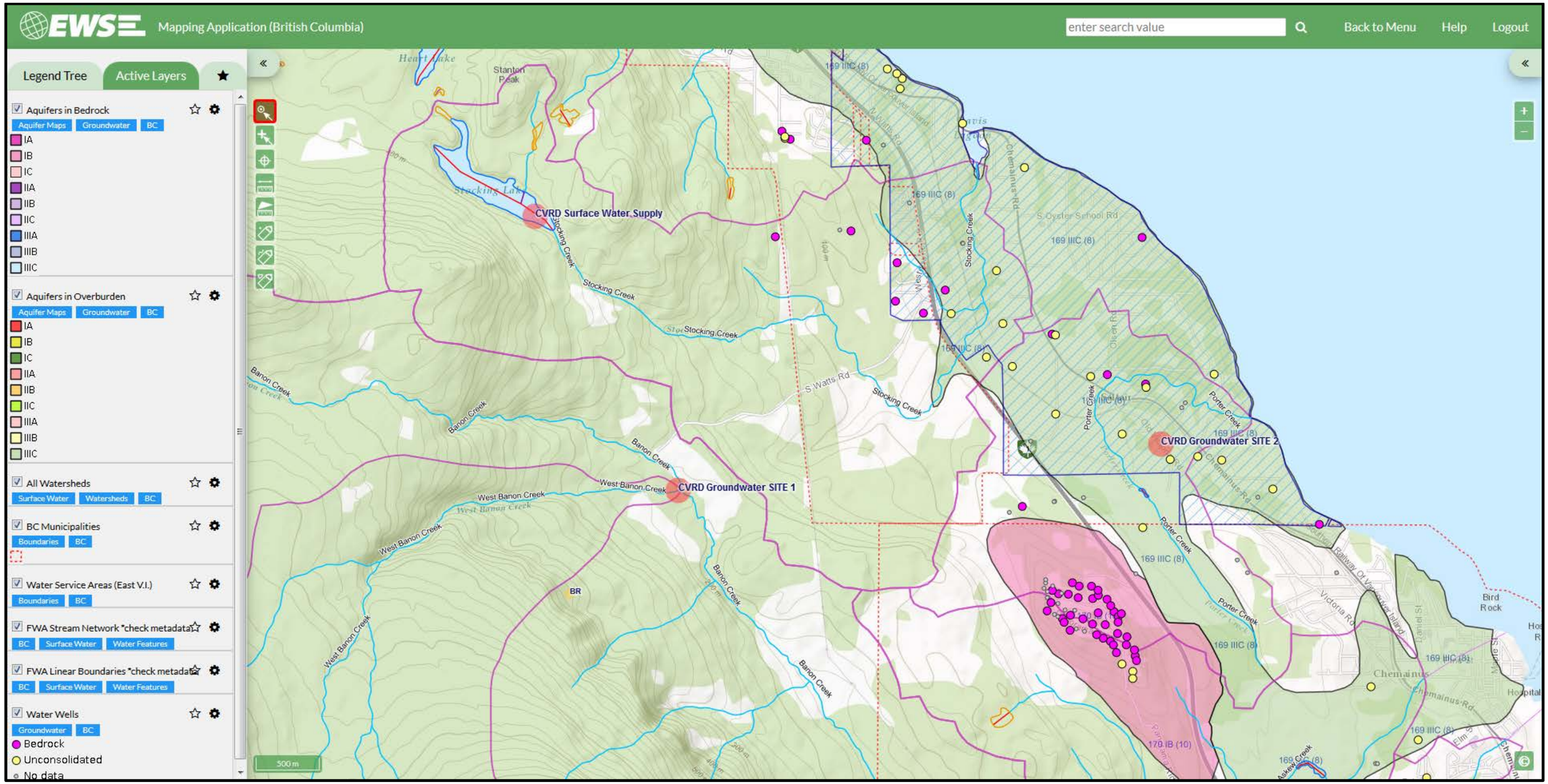

Figure 2: Mapped Aquifers and Water Wells Sorted by Material at Screen

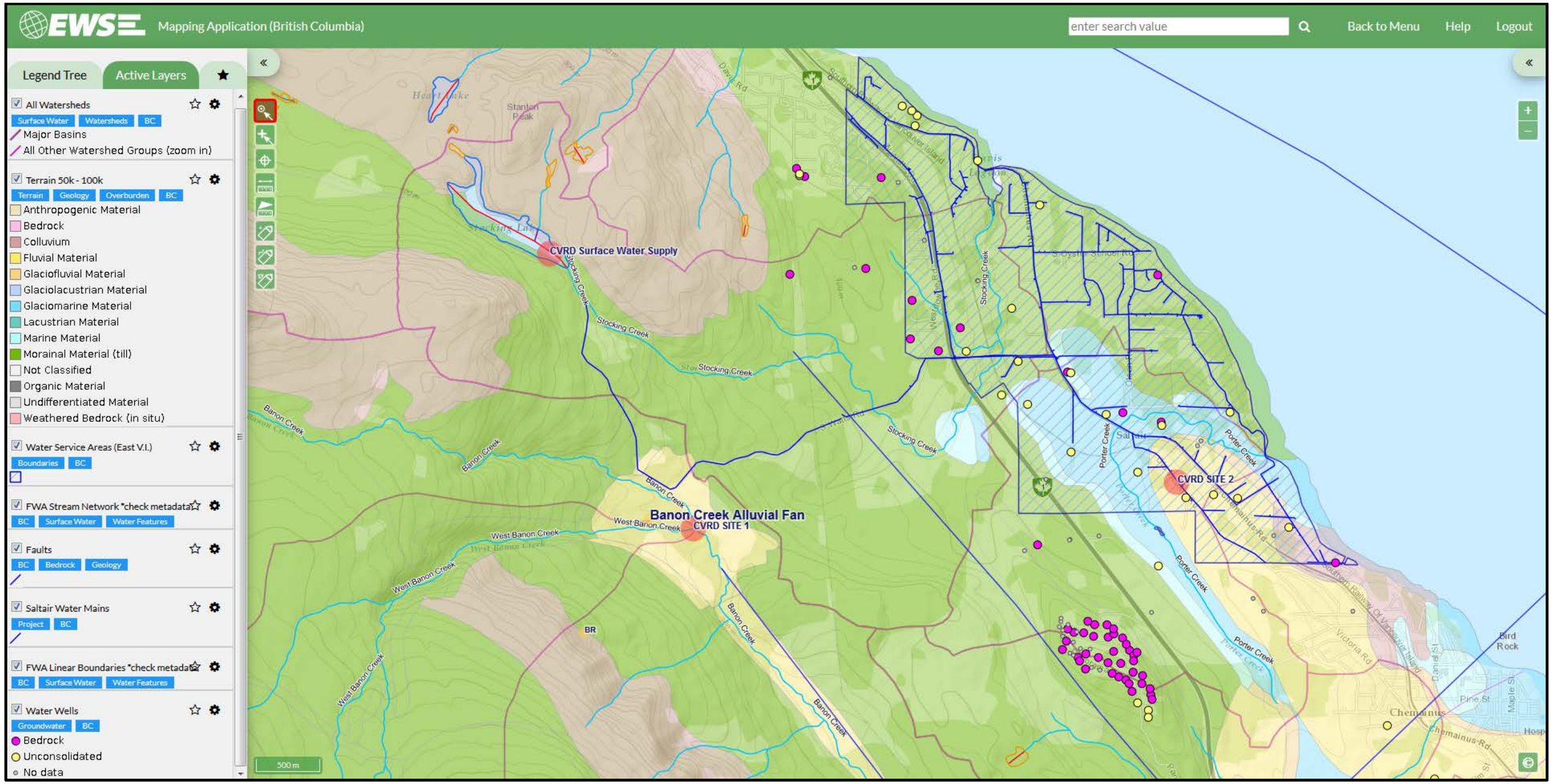

Figure 3: Overburden Geology, Faults and Water Wells Sorted by Material at Screen

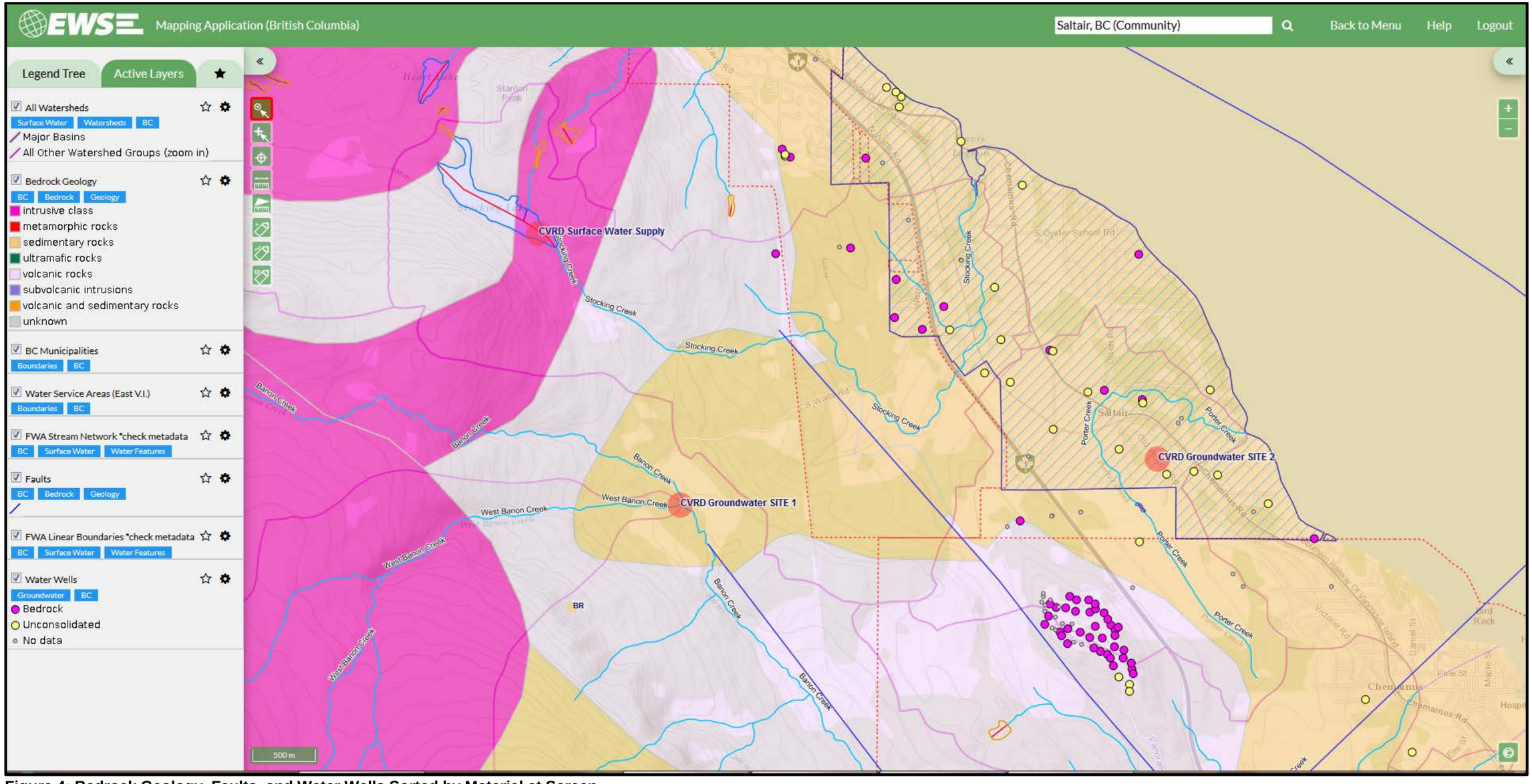

Figure 4: Bedrock Geology, Faults, and Water Wells Sorted by Material at Screen

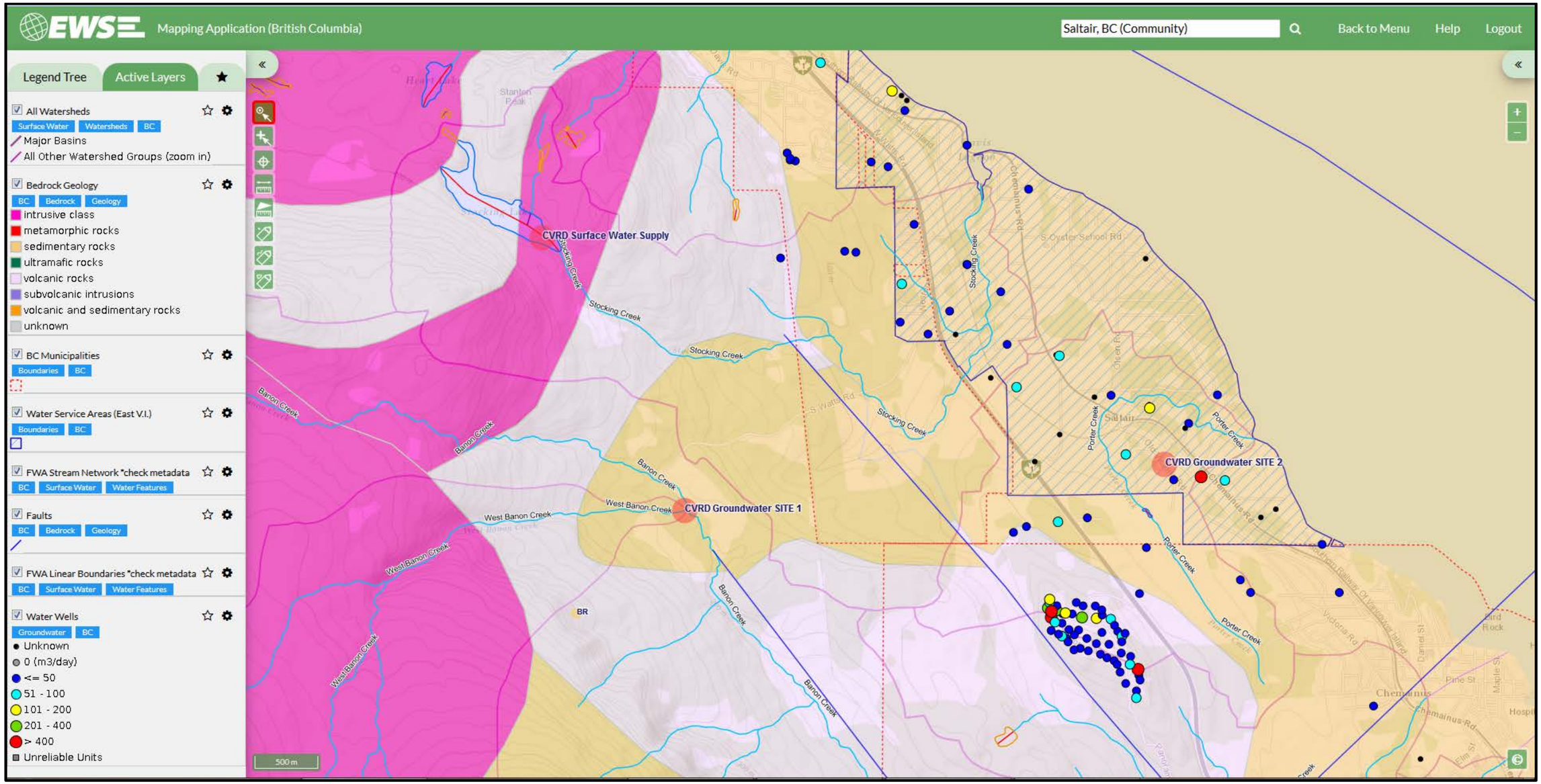

Figure 5: Bedrock Geology, Faults, and Water Wells Sorted by Well Yield

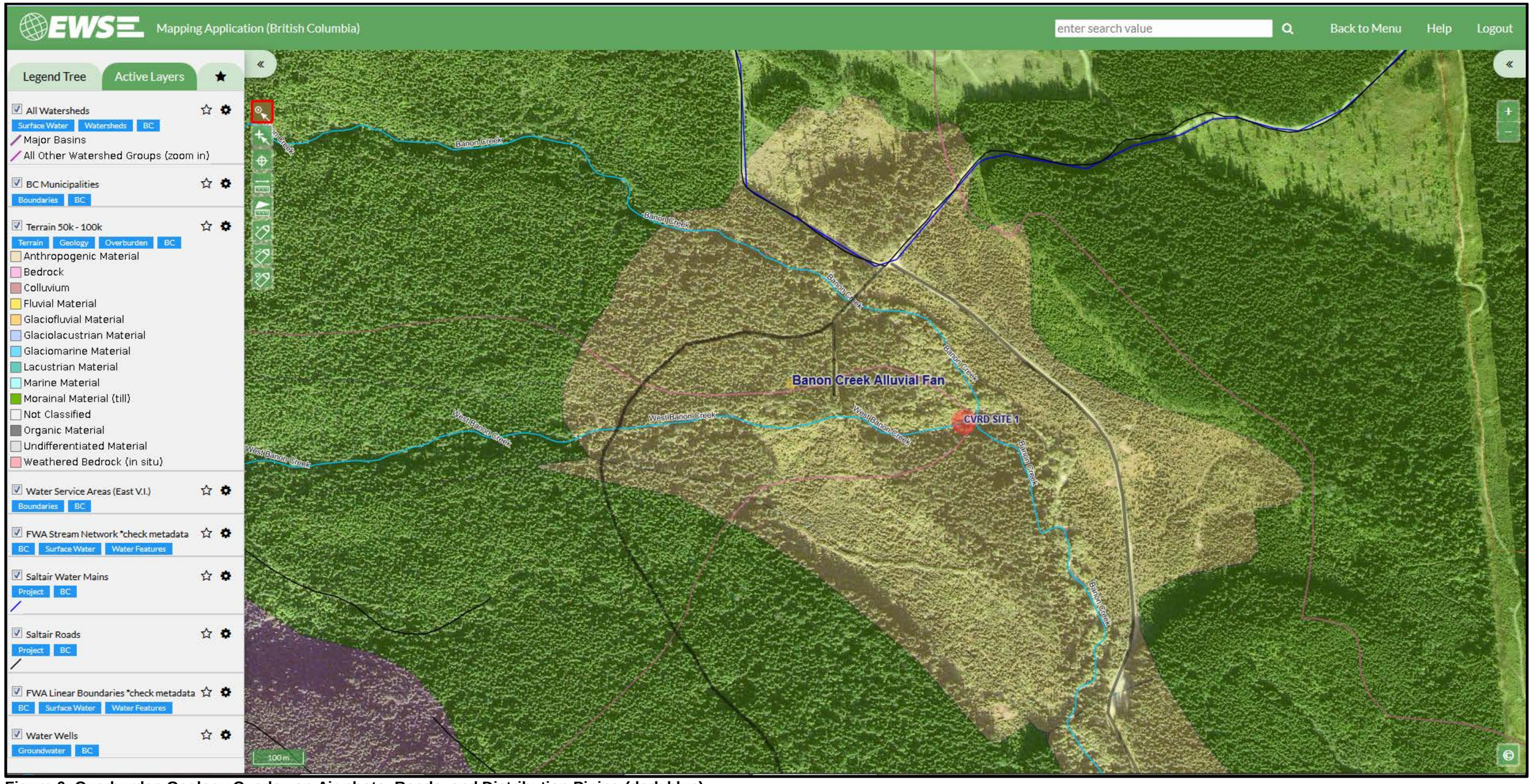

Figure 6: Overburden Geology Overlay on Air photo, Roads, and Distribution Piping (dark blue)

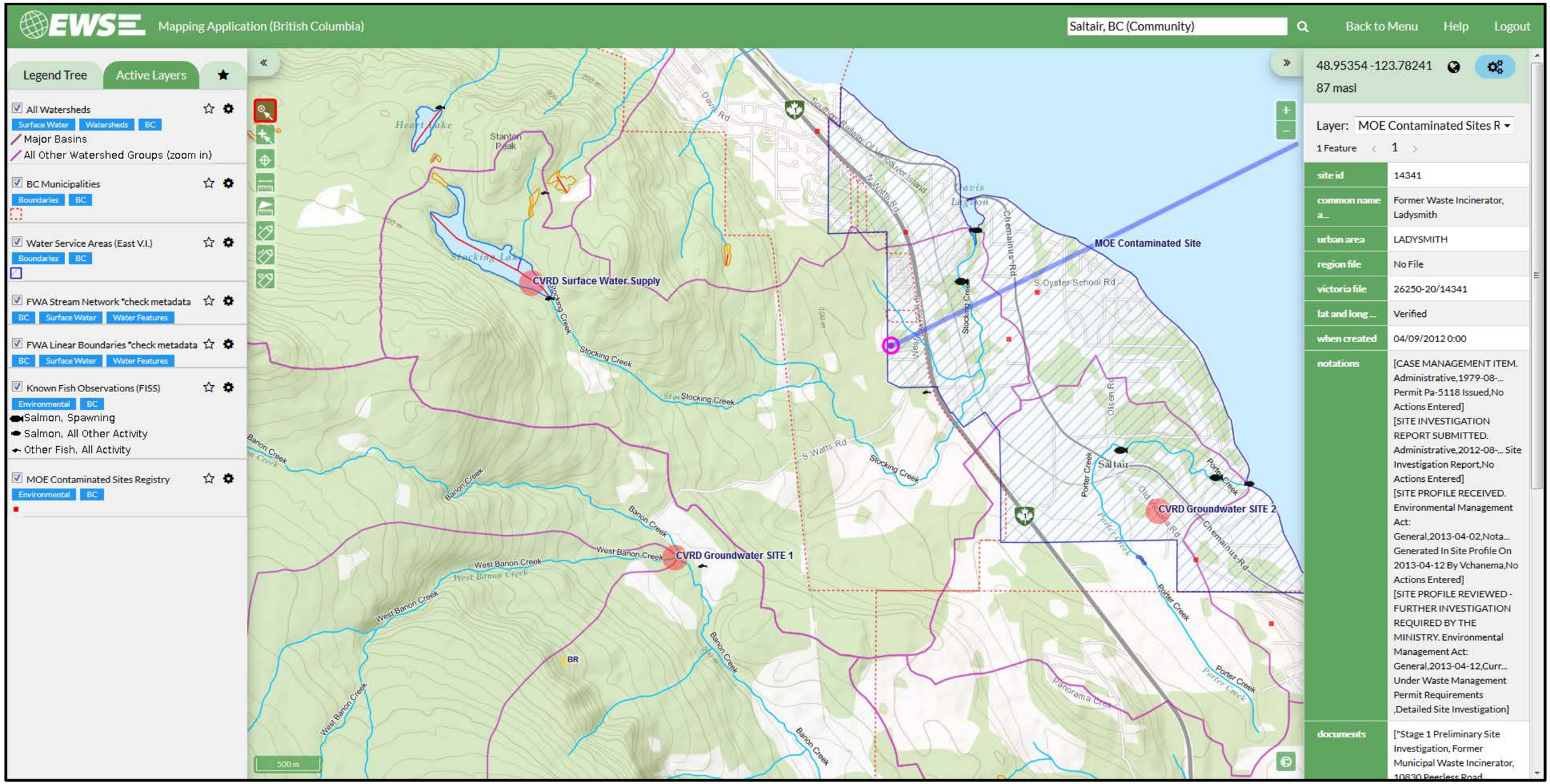

Figure 7: Fish Occurrence and MOE Contaminated Site File

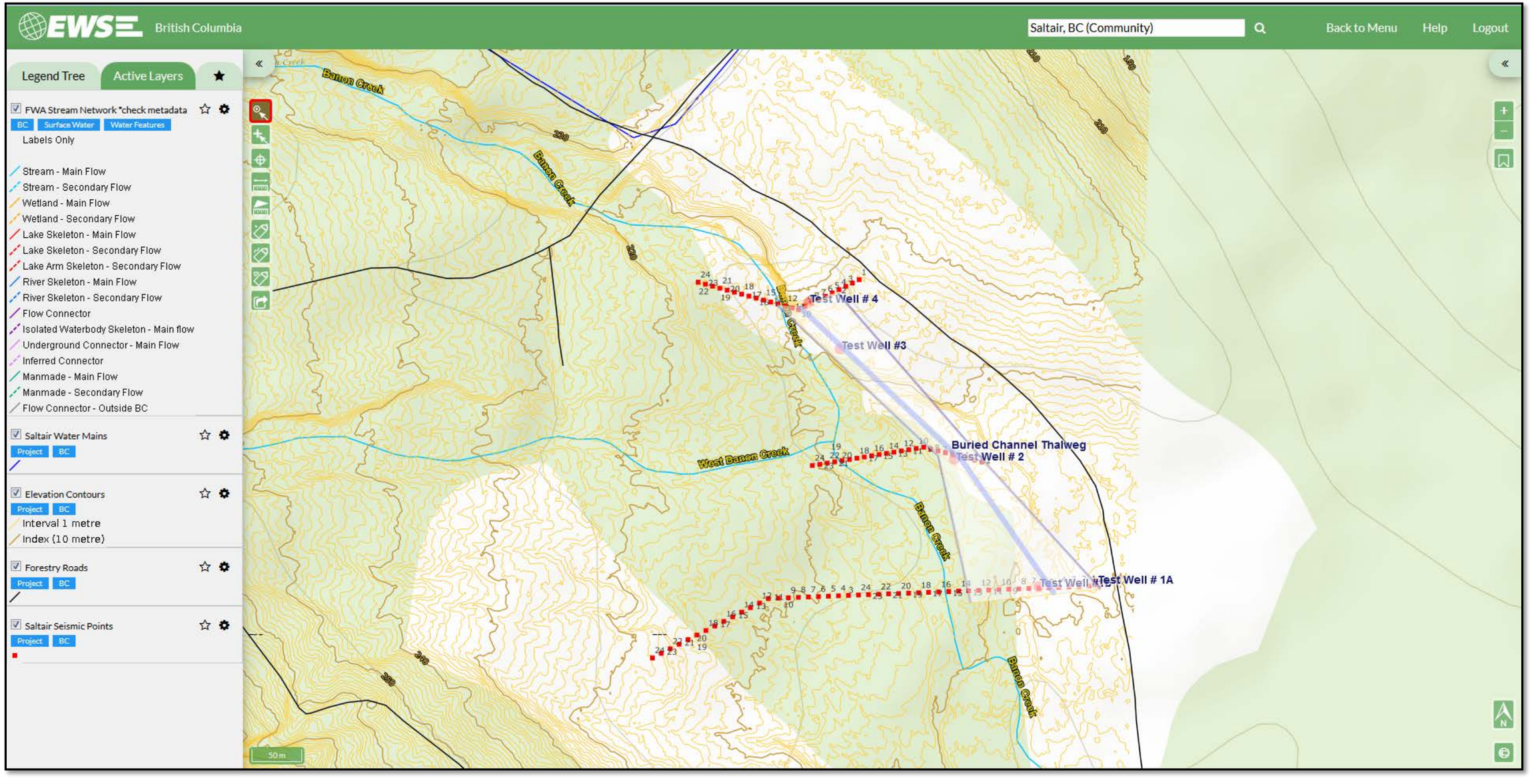

Figure 8: Seismic Profiles and Proposed Test Well Locations

APPENDIX A

Frontier Geosciences Seismic Refraction Report