Pilot Collaborative Water Monitoring Program, Northeastern British Columbia (NTS 094A, Parts of 093O, P, 094B, G, H): Year One Update

S.L. Lapp, British Columbia Oil and Gas Commission, Fort St. John, British Columbia, suzan.lapp@bcogc.ca

E.G. Johnson, British Columbia Ministry of Energy, Mines and Low Carbon Innovation, Victoria, British Columbia

D.L. Cottrell, Shell Canada Ltd., Calgary, Alberta

W.T. Van Dijk, Matrix Solutions Inc., Edmonton, Alberta

B.P. Shepherd, Matrix Solutions Inc., Grande Prairie, Alberta

R.L. Rolick, British Columbia Oil and Gas Commission, Fort St. John, British Columbia

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Program Background

In 2020 the Pilot Collaborative Water Monitoring Program came to fruition as the union of three distinct projects to address the needs brought forward through such programs as the Province of British Columbia's (BC) Northeast Water Strategy and Regional Strategic Environmental Assessment, and results of the *Scientific Review of Hydraulic Fracturing in British Columbia* (Scientific Hydraulic Fracturing Review Panel, 2019). The three projects include

1) Northeast BC Hydrometric Monitoring Project: an installation of four to six hydrometric stations to measure surface water quantity.
2) Co-ordinated Groundwater, Surface Water and Climate Monitoring Project, Northeast BC: co-location of supplemental monitoring to greatly expand collected knowledge at the monitoring sites, increase the opportunity for research and understanding into watershed processes, and increase the capacity and participation of local First Nations as a partner in water monitoring. Supplemental monitoring includes installation of groundwater monitoring wells for water quantity and quality where it is anticipated there will be groundwater–surface water interaction; surface water quality monitoring including benthic invertebrate sampling; installation or improvement of local climate stations to monitor factors that affect surface and groundwater, such as rainfall, snowfall, humidity, wind and solar radiation; and training of local First Nations to capture measurements and maintain equipment.
3) Traditional Knowledge Project: an innovative venture to bridge communication barriers through the gathering of Traditional Knowledge at each monitoring site at specific seasonal times with the hope of braiding Traditional Knowledge with Western-style scientific observations.

By co-locating groundwater monitoring stations near hydrometric stations, not only will project costs be reduced, but results of the research will hopefully answer several key questions using the datasets produced (groundwater quantity and quality, surface water quality, and climate data). This co-ordinated approach will also maximize the return on 'foundational science' through a more complete baseline monitoring program, which will augment the existing approved Surface Water Quantity Monitoring Program (Geoscience BC project number 2019-016), and the approved Traditional Knowledge Program (Geoscience BC project number 2019-018). The baseline data will allow for advanced analysis to support assessment of groundwater–surface water interaction, watershed water balance calculations, and meteorological data to support a variety of assessments.

Project Updates

This program was initiated with a virtual kick-off workshop on December 2, 2020, with members of the six Treaty 8 First Nations from within the boundary of the study area (Figure 1) in attendance, along with program partners from the BC Oil and Gas Commission (BCOGC), the BC Ministry of Energy, Mines and Low Carbon Innovation (EMLCI), Shell Canada Ltd. and Matrix Solutions Inc. (Matrix). The six First Nation communities included Blueberry River First Nations (BRFN), Doig River First Nation (DRFN), Halfway River First Nation (HRFN), McLeod

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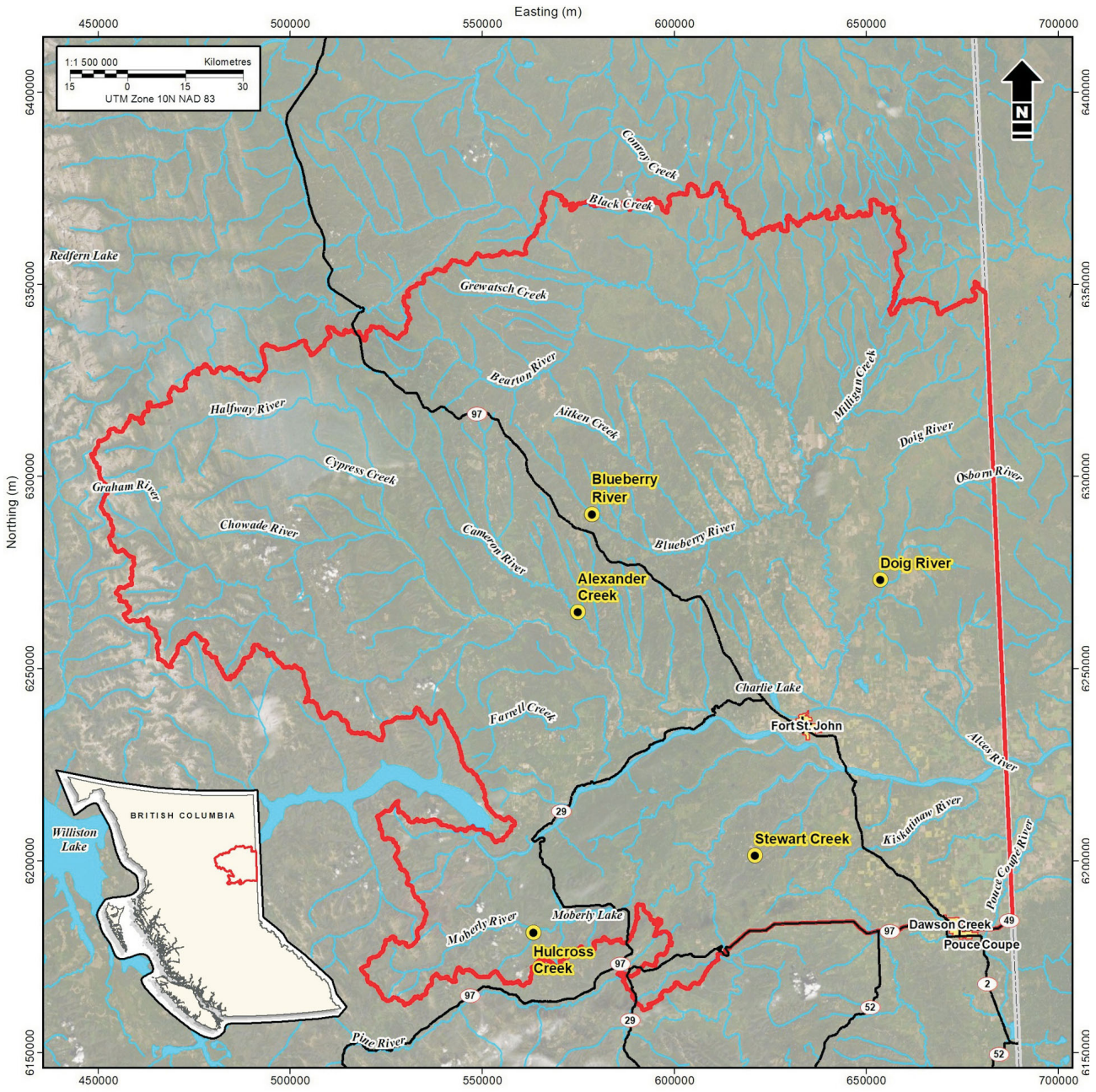

Figure 1. Location of study area (outlined in red) and water monitoring sites.

Lake Indian Band (MLIB), Saulteau First Nations (SFN), and West Moberly First Nations (WMFN). All First Nations expressed interest in participating in the research and monitoring partnership.

Site Criteria

Throughout the winter and spring of 2021 ongoing virtual meetings were conducted with each First Nation community within the study area to discuss co-locating water and climate monitoring sites based on specific site criteria and priorities and/or concerns expressed by each of the First Nations. Field reconnaissance was conducted in the early summer of 2021 with representatives of each First Nation community to confirm the site of the hydrometric station. Criteria for site selection was a mix of features, including

- vehicle accessibility to the monitoring site;
- watersheds with high cumulative disturbance on both water quantity and quality (Johnson, 2020; Sentlinger and Metherall, 2020), which is a monitoring criteria of primary interest to the local First Nation communities;
- whether the stream size was amenable to the type of hydrometric monitoring proposed (not too large or too small); and

- if the site could accommodate well drilling on Crown land.

To further refine the selection conditions, discipline-specific siting criteria were also considered, to meet standards for scientific data collection such as the desirable criteria for basic hydrometric stations, as outlined in the *Manual of British Columbia Hydrometric Standards* (Resources Information Standards Committee, 2018), and desirable class for sensor-siting classification for climate monitoring stations, as proposed in the *Manual of Surface Weather Observation Standards* (Environment and Climate Change Canada, 2019).

After potential sites were initially identified, they were further discussed with various subject matter experts from the BC Ministry of Forests, Lands and Natural Resource Operations and Rural Development (FLNRORD) and the BC Ministry of Environment and Climate Change Strategy, for considerations around benthic sampling (as part of the Canadian Aquatic Benthic Invertebrate Network); as potentially part of the Provincial Groundwater Observation Well Network; as a location to supply water quality data; and for considerations around surface water–groundwater interaction.

There is more flexibility in the location of climate monitoring stations, and the team is actively working with FLNRORD and BC Hydro to understand if certain infrastructure can be improved to serve multiple purposes instead of installing new stations. Figure 1 shows the location of the five chosen monitoring sites; Table 1 summarizes the hydrometric station site information; and Table 2 lists what monitoring was carried out at each site.

Table 1. Summary of the monitoring site locations and associated First Nation communities. All co-ordinates are in UTM Zone 10N, NAD 83. Abbreviations: BRFN, Blueberry River First Nations; DRFN, Doig River First Nation; HRFN, Halfway River First Nation; MLIB, McLeod Lake Indian Band; SFN, Saulteau First Nations; WMFN, West Moberly First Nations.

Location	First Nation	Easting	Northing
Blueberry River on Mile 98 Road	BRFN	578627	6290276
Doig River at Doig River First Nation	DRFN	653587	6273135
Alexander Creek on Mile 95 Road	HRFN	574248	6271384
Stewart Creek at Stewart Creek Road	MLIB	620969	6201392
Hulcross Creek on Moberly Forest Service Road	SFN/WMFN	563289	6181243

Proposed Monitoring

Hydrometric Stations

A total of five hydrometric stations were installed in the late summer and early fall of 2021; installation at each site took between two and three days. First Nation community members were invited to participate in the equipment installation and ongoing monitoring of the station associated with their community. Water Officers from FLNRORD based in Fort St. John also participated in the installation of the stations and will continue to collaborate with the BCOGC to monitor water quantity at these locations. At each hydrometric station the equipment consists of OTT HydroMet GmbH's OTT PLS sensors with Sutron XLink 100 loggers. The final visit to each of the stations for the 2021 field season was conducted in October to winterize them. Figure 2 shows the location of the hydrometric station installations.

Groundwater Wells

The purpose of water wells is to monitor the groundwater level in the shallow subsurface (unconfined aquifer), water quality in shallow groundwater, and ultimately—in coordination with the surface water monitoring—provide information about surface water–groundwater interaction. As such, wells were sited proximal to hydrometric stations. Some locations provided the added opportunity for testing the possible existence of a paleovalley at a slightly deeper horizon. Research on paleovalleys in this region has been supported by Geoscience BC with mapping, airborne and ground-based geophysical surveys, and drilling. Where possible, water wells will be installed to a depth sufficient to test any proposed paleovalley.

The sites selected for groundwater monitoring (Blueberry River, Alexander Creek, Stewart Creek and Hulcross Creek) were the most suitable, based on the objective of

Table 2. Summary of the proposed monitoring at each of the five chosen sites. An 'X' in a cell indicates that type of monitoring is being carried out at that site; an asterisk (*) indicates a site that is being discussed with the BC Ministry of Forests, Lands and Natural Resource Operations and Rural Development to assess suitability of use of wildfire stations at these sites as climate monitoring sites for this study. All sites are being assessed for suitability of benthic invertebrate sampling for use by the Canadian Aquatic Benthic Invertebrate Network (CABIN). Other abbreviations: BRFN, Blueberry River First Nations; DRFN, Doig River First Nation; HRFN, Halfway River First Nation; MLIB, McLeod Lake Indian Band; SFN, Saulteau First Nations; WMFN, West Moberly First Nations.

Location	First Nation	Hydrometric station	Groundwater well	Water quality	CABIN	Climate station
Blueberry River on Mile 98 Road	BRFN	X	X	X	X	Regional*
Doig River at Doig River First Nation	DRFN	X		X	X	Regional*
Alexander Creek on Mile 95 Road	HRFN	X	X	X	X	X
Stewart Creek at Stewart Creek Road	MLIB	X	X	X	X	X
Hulcross Creek on Moberly Forest Service Road	SFN/WMFN	X	X	X	X	Regional

Figure 2. Photos showing the hydrometric station equipment and data collection at **a)** Hulcross Creek, **b)** Blueberry River, **c)** Alexander Creek, **d)** Doig River and **e)** Stewart Creek.

monitoring interactions between surface water and groundwater in the Quaternary deposits overlying bedrock. Initial desktop analysis indicated that groundwater near the Doig River hydrometric site was deep and confined, and several existing wells in the vicinity gave no indication of shallow groundwater. Therefore, no well was proposed at the Doig River location. Geological and airborne geophysical surveys indicate the possibility of a paleovalley at the Alexander Creek and Blueberry River sites, therefore the wells at these sites will be drilled to a greater depth.

After the sites for water well installation were selected, applications were submitted to FLNRORD for permits to drill and install wells on Crown land, with the installations originally planned for September 2021. The drilling program was delayed due to permit requirements that included sign-off by all local First Nations. The monitoring wells have been designed to meet requirements for future inclusion in the Provincial Groundwater Observation Well Network. A pressure-logging instrument will be deployed in each monitoring well to record groundwater levels.

The monitoring wells are scheduled to be installed in late 2021 by Matrix and Anderson Water Services Ltd., a drilling contractor based in Fort St. John. The drilling and well construction details will be provided in a future report.

Water Quality

There is general consensus that insufficient water quality monitoring data exists in northeastern BC (Northeast Water Strategy, 2017, 2018). Sampling water quality in conjunction with stream volume helps identify any linked parameters, such as dissolved solids and dissolved oxygen. Sampling for water quality at monitoring sites was proposed for four specific time frames annually during the open-water season: once in spring, twice in summer, and once in fall. Surface water quality monitoring in 2021 was planned for all five monitoring locations during the four time frames, however, due to the time required earlier in the year to select and establish the monitoring sites and receive consensus among partners, sampling was carried out only twice at all but the Stewart Creek location: once in late summer and once in the fall. Details of the sampling completed at each site are given in 'Site Status', below.

Surface water quality monitoring for the program includes sampling both field and laboratory parameters. Routinely sampled field parameters include dissolved oxygen, temperature, pH and electrical conductivity, while sampled laboratory parameters include the same routine field parameters in addition to turbidity, major ions, total and dissolved metals, total organic carbon, coliforms and total plate count, biochemical and chemical oxygen demand, and hydrocarbons.

Additionally, sampling of benthic invertebrates was proposed at the start of the program for two monitoring sites; however, it was later determined that Matrix would investigate site suitability and benthic community diversity at as many sites as possible. The Canadian Aquatic Biomonitoring Network (CABIN) program assesses the aquatic health of streams through the collection of benthic invertebrate samples. Sampling for benthic invertebrates at the selected sites will be completed by a Matrix staff member certified by CABIN (Figure 3). Each site will be registered into the CABIN database by a Matrix staff member, which will identify any potential reference sites for evaluation of relative stream health. Determination of the necessity for future assessments will be made based on results of the 2021 assessments.

Climate Stations

Climate data will be used to assess the water balance at each of the monitoring sites. Climate data parameters include total accumulation of precipitation and snow, air temperature, wind speed and direction, barometric pressure, and relative

Figure 3. Examples of benthic invertebrate sampling at **a)** Alexander Creek and **b)** Blueberry River.

humidity. Climate stations do not need to be placed at the same exact location as the hydrometric sites and monitoring wells. Having the climate monitoring stations located in the vicinity of the other monitoring equipment is sufficient for research needs, and results are superior when the station is located away from road activity, in a sheltered spot where it is not unduly influenced by wind.

If there is not an existing climate station in proximity to the monitoring locations, a new climate station will be installed using a combination of provincial and federal government criteria for properly siting sensor equipment.

Site Status

Blueberry River at Mile 98 Road

This site is within 10 km of the community of Wonowon. The contributing watershed area is 312 km^2. The hydrometric station was installed between August 24 and 26, 2021.

Matrix completed sampling of surface water quality and benthic invertebrates on August 17, 2021, with two members from the Blueberry River First Nations. At that time, Matrix learned the BRFN had already established a monitoring site for benthic invertebrates at this location in 2019 and intend to continue sampling for CABIN at this site with First Nations members who have been trained by CABIN. Nevertheless, for the purpose of the co-ordinated program, Matrix collected benthic invertebrate samples at this site and will share the results of analyses with the BRFN.

Water quality was sampled a second time on October 20, 2021.

Climate data for the Blueberry River site will be sourced from regional climate monitoring stations. Matrix is in communication with the managers of FLNRORD Wildfire Management Branch's wildfire climate stations to see if the Geoscience BC program can support improvement of their Wonowon climate station to serve multiple purposes in 2022 and beyond.

A groundwater monitoring well will be installed on the west side of Blueberry River in late 2021. The site is within a mapped paleovalley associated with Blueberry River. The objectives of drilling a groundwater monitoring well at this site include confirming the presence of a paleovalley, identifying Quaternary aquifers, and monitoring groundwater quality and levels to assess interactions with Blueberry River.

Doig River at Doig River First Nation

Installation of the hydrometric station at this site was completed on August 18, 2021. The contributing watershed area is 2416 km^2. A community meeting was held on October 5, 2021, to discuss the hydrometric program and to conduct a field visit with DRFN members.

Matrix completed sampling of surface water quality and benthic invertebrates at Doig River on August 18, 2021, which coincided with the installation of the hydrometric station. Water quality was sampled a second time on October 20, 2021.

Climate data for the Doig River site will be sourced from regional climate monitoring stations. Matrix is in communication with the managers of FLNRORD Wildfire Management Branch's wildfire climate stations to see if the Geoscience BC program can support improvement of their Osborn climate station to serve multiple purposes in 2022 and beyond.

Alexander Creek at Mile 95 Road

The site is within 15 km of the Halfway River First Nation. The contributing watershed area is 134 km^2. Installation of a hydrometric station was completed at the site on August 19, 2021.

Matrix completed sampling of surface water quality and benthic invertebrates on August 17, 2021, which coincided with the installation of the hydrometric station. Three representatives from HRFN were present at the time of the site visit. Surface water quality was sampled a second time on October 20, 2021.

A new climate station was installed in early November 2021, approximately 1.5 km west of the Alexander Creek monitoring site. The climate station is equipped with sensors to record air temperature, year-round precipitation, snow-water equivalent, wind, relative humidity and barometric pressure.

A groundwater monitoring well will be installed on the west side of Alexander Creek. The site is located within a mapped paleovalley associated with Cameron River. The objectives of groundwater monitoring at this site include confirming the presence and characteristics of the paleovalley, and monitoring groundwater within the paleovalley to assess groundwater interactions with Alexander Creek.

Stewart Creek at Stewart Creek Road

The station is located within the McLeod Lake Indian Band's summer area and south of Stewart Lake. Installation of the hydrometric station was completed on October 15, 2021. The contributing watershed area is 24 km^2.

Matrix did not complete sampling of water quality during the month of August due to site selection and reaching consensus among participants taking longer than expected. However, water quality was sampled on October 21, 2021. Two members of the MLIB arrived on site at the end of the

sampling, but Matrix staff reviewed the sampling procedures they had completed with the First Nations members. No benthic invertebrate sampling was completed at this site in 2021.

A new climate station was installed approximately 0.5 km west of the Stewart Creek monitoring site in early November 2021. The climate station is equipped with sensors to record air temperature, year-round precipitation, snow-water equivalent, wind, relative humidity and barometric pressure.

A groundwater monitoring well will be installed at the Stewart Creek site. The objectives of groundwater monitoring at this site include characterizing the Quaternary geology, identifying Quaternary aquifers, and monitoring groundwater quality and levels to assess interactions with Stewart Creek.

Hulcross Creek at Moberly Forest Service Road

The Hulcross Creek site is located west of the West Moberly and Saulteau First Nations, within the Moberly Lake watershed. The contributing watershed area is 132 km^2. Installation of a hydrometric station at the site was completed on August 25, 2021.

Matrix completed sampling of surface water quality at Hulcross Creek on August 25, 2021. There were no representatives from WFMN or SRFN present at the time of the sampling. Water quality was sampled a second time on October 21, 2021.

Sampling for CABIN data was conducted by Matrix on August 17, 2021; however, due to a location error the work was completed at Dixie Creek, east of Hulcross Creek. Despite the location error, the results of the benthic invertebrate sampling will be shared with SFN and WMFN as it may be of value for other watershed studies.

Climate data for the Hulcross Creek monitoring site will be sourced from publicly available information from Environment and Climate Change Canada's climate monitoring station at the Chetwynd Municipal Airport.

A groundwater monitoring well will be installed at the Hulcross Creek location. The site is near the southern edge of a mapped paleovalley associated with Moberly River. The objectives of groundwater monitoring at this site include confirming the presence of the paleovalley, identifying Quaternary aquifers, and monitoring groundwater levels and quality to assess potential interactions with Hulcross Creek.

Traditional Knowledge

One of the objectives of this project is to include a holistic understanding of First Nation values and First Nations' relationship with water. Extensive conversations were carried out to construct a feasible plan for interacting with the local First Nations and to gather Traditional Knowledge related to water quantity. Special thanks to A. Garibaldi (EMLCI) for her assistance and insights.

Once the scope of this stage of the project was decided upon, a request for proposals was extended. Integral Ecology Group was the successful proponent to gather Traditional Knowledge from selected local First Nations.

At this initial stage, the plan is to visit the monitoring sites with First Nations members three times during the 2022 field season: at low water, high water, and at some point when water levels are moderate. First Nation attendees will be asked for their thoughts, input and stories about the site. Their responses will be gathered and collated into a summary report. The results of this element of the project will be available in late 2022 or early 2023.

The information gained from this pilot project will help form the foundation for understanding how First Nations think about water quantity in northeastern BC. The information may also be used to develop relevant indicators and thresholds for assessing water quantity specifically and water health more generally.

Summary and Next Steps

Work on the program moved forward successfully in 2021 following a one-year setback resulting from the COVID-19 outbreak. The project team was able to successfully engage with all six First Nation communities within the study area, and identified five monitoring locations in collaboration with the First Nation communities.

Hydrometric Study

Hydrometric equipment was installed at each location and is ready to capture spring freshet in 2022.

During the winter of 2021–2022 the data will be assessed for quality assurance and quality control as outlined in the *Manual of British Columbia Hydrometric Standards* (Resources Information Standards Committee, 2018). Data collection at the hydrometric stations will be reinstated in the spring to capture a full open-water season of data, including freshet. As water quantity information becomes available it will be posted for the public to access through the BC Water Portal (www.waterportal.geoweb.bcogc.ca) and the provincial database Aquarius (https://aqrt.nrs.gov.bc.ca).

Groundwater Study

Groundwater monitoring wells will be installed at four locations in late 2021 and equipped with pressure transducers. In 2022, groundwater monitoring will include measuring static water levels, downloading pressure transducer results, and collecting groundwater samples.

Water Quality Study

Water quality was sampled twice during 2021 at most sites (once at Stewart Creek). Water quality will be sampled at each site four times during the open-water season of 2022. The 2022 sampling schedule for benthic invertebrates for the Canadian Aquatic Benthic Invertebrate Network will be determined based on the results of the 2021 suitability assessment and analytical results.

Climate Study

Two climate stations were installed in 2021: at the Alexander Creek and Stewart Creek sites. Publicly available climate data will be downloaded from a climate station located near the Hulcross Creek site. At the Doig River and Blueberry River sites, climate data will be collected by installing new stations in 2022 or upgrading existing wildfire stations.

First Nations Training

Training of First Nations' community members is planned for 2022, to develop skills and facilitate ongoing participation in the program. The training will consist of a classroom-based training session, as well as field-based training during field monitoring. The training will cover hydrometric monitoring, climate station monitoring and maintenance, groundwater monitoring and water quality sampling.

The program team is also exploring future funding options to ensure the monitoring continues past the March 2023 expiration of the Geoscience BC funding.

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References

Environment and Climate Change Canada (2019): Manual of Surface Weather Observation Standards, (MANOBS), Eighth Edition; Monitoring and Data Services Directorate, Meteorological Service of Canada, 187 p., URL <https://www.canada.ca/en/environment-climate-change/services/weather-manuals-documentation/manobs-surface-observations.html> [October 2021].

Johnson, E.J. (2020): Cumulative watershed disturbance model for surface water quality and quantity; report prepared for Regional Stratigraphic Environmental Assessment WATER Working Group for Northeast BC, 32 p., URL <https://doi.org/10.13140/RG.2.2.31708.3164>.

Northeast Water Strategy (2017): A disturbance-sensitivity based approach to prioritizing water monitoring in northeast B.C., Part 1: Report; BC Ministry of Environment and Climate Change Strategy, 119 p., URL <https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/northeast-water-strategy/disturbance_sensitivity_based_approach.pdf> [October 2020].

Northeast Water Strategy (2018): Surface water quality data summary for northeast British Columbia; BC Ministry of Environment and Climate Change Strategy, 59 p. URL <https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/northeast-water-strategy/news_ne_wq_summary_2018.pdf> [October 2020].

Resources Information Standards Committee (2018): Manual of British Columbia Hydrometric Standards, Version 2.0, December 2018; BC Ministry of Environment and Climate Change Strategy, Knowledge Management Branch, 160 p., URL <https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nr-laws-policy/risc/man_bc_hydrometric_stand_v2.pdf> [September 2021].

Scientific Hydraulic Fracturing Review Panel (2019): Scientific review of hydraulic fracturing in British Columbia; BC Ministry of Energy, Mines and Low Carbon Innovation, 220 p., URL <https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-gas-oil/responsible-oil-gas-development/scientific_hydraulic_fracturing_review_panel_final_report.pdf> [October 2020].

Sentlinger, G.I. and Metherall, C. (2020): RSEA hydrology and allocation baseline, rev. 0.9.5; unpublished report prepared for Regional Stratigraphic Environment Assessment, 157 p.