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Fort Nelson Aquifer Mapping and Hydrostratigraphic Characterization

Tibor Lengyel, Judit Deri-Takacs, and Andrew Hinnell

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Author's Affiliation:
Tibor Lengyel, M.Sc., P.Geo.
Hydrogeologist

Judit Deri-Takacs, Ph.D.
Water Scientist

and

Andrew Hinnell, Ph.D., P.Geo.
Principal Hydrogeologist

Worley Consulting (Worley Canada Services Ltd.)
Suite 200 – 2930 Virtual Way
Vancouver, British Columbia V5M 0A5 Canada

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The Province of B.C. 2018. An aerial view of the Fort Nelson River, looking north. Photo taken by A. White.

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EXECUTIVE SUMMARY

The Province of British Columbia retained Worley Canada Services Ltd., operating as Worley Consulting, to conduct aquifer mapping near Fort Nelson (the Study Area). The purpose of the aquifer mapping study was to review and update the mapped aquifer boundaries and identify previously unmapped aquifers to support the management of groundwater resources.

To meet these goals, a database of available information was compiled. The database includes water well records, bedrock and surficial geology maps, topography information, surface water bodies, and spring locations. Geology data were captured using key lithology terms to support subsurface interpretation. A map illustrating updated aquifer mapping locations and one geological cross-section were prepared for the Study Area. Interpretation relied on the conceptual model developed by Levson et al. (2018).

Previously, four aquifers were identified within or near the Study Area. The extents of three aquifers were adjusted by expanding them to interpreted physical and hydraulic boundaries (1034, 1040, and 1041). The study also identified an additional bedrock aquifer (1291) and three additional overburden aquifers (1288, 1289, and 1290). Overburden Aquifer 1035 was retired and superseded by Aquifer 1041. Aquifer updates used regional-scale physical and hydraulic boundaries (e.g., groundwater divides, streamlines, and surface water bodies) to delineate aquifers and to support water management efforts. Mapped aquifers may extend beyond areas where registered wells currently exist; therefore, there is uncertainty in aquifer boundaries and properties, particularly at distance from areas of development.

The vulnerability of the mapped aquifers has been assessed as high (1041, 1288, 1289, and 1290), moderate/high (1034, 1291), and low (1040; Table A).

Aquifers 1034, 1041, 1289, 1290, and 1291 likely extend beyond the Study Area, while Aquifer 1040 likely extends beyond its current limits. The descriptions provided here are based on information reviewed within the Study Area. Worley Consulting recommends that the aquifer mapping be extended to allow for a more rigorous mapping of these new aquifers beyond the Study Area.

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1. BACKGROUND

1.1 Water Management

Water for domestic purposes in northeast British Columbia (B.C.) is primarily sourced from surface water. While surface water resources are available in northeast B.C., water allocation notations (e.g., fully reserved) already exist in the region (e.g., for Colins Creek, a tributary to Pouce Creek, which is, in turn, a tributary to Muskwa River). The region is subject to the Bilateral Water Management Agreement between B.C. and the Northwest Territories, stipulating better understanding of groundwater resources in the area. Levson et al. (2018) completed a regional, fundamental assessment of the transboundary groundwater resources. As various industrial uses and interests may also influence groundwater quality and quantity (including geothermal energy [e.g., Associated Engineering 2019] and hydrocarbon production, which may be a source of methane in groundwater [e.g., Cahill et al. 2017; Bondu et al. 2021]), a more detailed local review of the aquifers in the Fort Nelson area was deemed necessary.

An aquifer, as defined by the Water Sustainability Act (WSA), is a geological formation, a group of geological formations, or part of one or more geological formations that is groundwater-bearing and capable of storing, transmitting, and yielding groundwater. Aquifers have been previously mapped in northeast B.C. (Kohut 2013). Groundwater studies carried out in the region since Kohut's 2013 aquifer mapping study (e.g., Baye et al. 2022, and Levson et al. 2018) provide additional information for interpreting groundwater conditions in the region. As part of a hydrogeologic interpretation and aquifer mapping series in northeast B.C., Worley Consulting completed mapping in the Peace-Beatton (Lengyel et al. 2022) and Peace-Kiskatinaw (Lengyel et al. 2023) study areas. The current study is part of the same aquifer mapping series. Mapping aquifers and improving understanding of the groundwater system (including connection to surface water) are important in the context of managing trans-boundary water resources.

1.2 Scope of Study

Worley Canada Services Ltd. (operating as Worley Consulting) was retained by the Province of British Columbia to conduct a desktop regional aquifer mapping study near Fort Nelson in northeast B.C. for six British Columbia Geographic System (BCGS) 1:20,000 map sheets (the Fort Nelson Study Area; Figure 1):

- 094J057, 094J067, 094J077, 094J086, 094J087, and 094J088.

2. METHODS

2.1 Data Sources

The key studies and spatial data sources reviewed/used to facilitate hydrogeologic interpretations include Berardinucci and Ronneseth (2002), Cui et al. (2019), Levson and Fournier (2012), and Levson et al. (2018). The conceptual model developed by Levson et al. (2018) was adopted for this study.

2.2 Data Processing

Within this study, the lithology presented in the Provincial Groundwater Wells database (GWELLS) was standardized as described below. The updated lithology was used to revise the depth to bedrock, which in turn was used to update the classification of the screened interval (i.e., bedrock vs. unconsolidated sediments). The processed geological data were visualized on a cross-section.

Aquifer mapping in the Study Area was updated utilizing the processed geological data and the conceptual model developed by Levson et al. (2018).

2.2.1 Well Depth

Well depths reported in GWELLS in the Study Area range from 10.7 to 144.8 metres below ground surface (mbgs), with an average well depth of 61.3 mbgs. Reported depths for wells assigned to overburden aquifers in the current study range from 10.7 to 138.6 mbgs, and depths for wells assigned to bedrock aquifers range from 22.9 to 144.8 mbgs.

2.2.2 Lithology Standardization

GWELLS includes lithological descriptions of the subsurface sediments encountered during water well drilling. Lithological descriptions are presented over a series of intervals penetrated during drilling and may include both lithologies (e.g., clay, shale, till) and sediment physical properties (e.g., blue, hard, silty). The quality of information and the status of data in GWELLS have not been field-verified. Quality of lithologic information is variable and typically based on the drilling method, the type of samples collected, the experience of field personnel, and the purpose of drilling. The quality of the lithological logs may limit detailed geologic interpretation of subsurface conditions.

Semi-automated methods were used to standardize lithologic units. Data preparation included the removal of lithologic data for wells with interval errors, text cleaning (e.g., correcting spelling errors and using consistent terminology), and standardization of lithologic units based on material classification. Material descriptions may not be standardized for all entries due to ambiguous terminology (e.g., “rock”), lack of material descriptors (e.g., only colour is described), or the use of material descriptors that are unlikely to be correct (e.g., ash). GWELLS does not include elevation data for many wells. In the absence of available Light Detection and Ranging (LiDAR) data, each well was assigned a ground surface elevation based on the Terrain Resource Information Management (TRIM) digital elevation model (DEM, 25 m resolution) to convert interval data from depth to elevation values.

Standardized lithologic units were based on the size and composition of sediment particles using the American Association for Testing and Materials (ASTM) modified Unified Soil Classification System (USCS). However, the units are generally more simplified (e.g., one category for silt) and include additions such as till and bedrock and consider boulder and cobble grain sizes. This level of detail in the classification scheme was deemed appropriate given the reliance on water well records and the regional nature of the study. Standardized lithologic units were manually reviewed and edited based on a review of bedrock depth, screen material, and water levels.

2.2.3 Bedrock Depth

Bedrock depth was calculated by taking the minimum depth of material classified as bedrock within a borehole to ensure consistency with processed lithology data.

2.2.4 Screen Interval Lithology

Screened interval lithology (overburden or bedrock) was determined from standardized lithologic units that overlap with screen interval data. Screened interval lithology determined this way was used to quality-control the aquifer lithology code available from GWELLS during data processing. Manual review and edits to standardize lithologic units or screen material were made based on quality assurance/quality control checks.

If screen interval data were not available in GWELLS, the well screen was assumed to be at the bottom of the well and assigned to the corresponding lithology.

2.2.5 Geologic Cross-Section

One cross-section was prepared to improve understanding of the subsurface geology in the Study Area. The cross-section location was selected to understand potential buried paleo-valley and vertical aquifer extents and to investigate potential surface water/groundwater interactions.

Standardized lithologic units were grouped and included in the cross-section to interpret hydrogeologic units (HGUs). HGUs were identified based on inferred permeability and depositional environment (e.g., fluvial, glaciofluvial, glacial, glacial [sand and gravel]).

2.2.6 Aquifer Mapping Approach

Aquifers were delineated using physical and hydraulic boundaries where possible (e.g., geologic contacts, major surface water bodies, and groundwater divides or streamlines). Mapped aquifers may extend beyond, or include areas, where there are no registered wells. Aquifers may also exist outside of mapping extents where information is limited. Therefore, there is some uncertainty in aquifer boundaries and properties, particularly for confined and bedrock aquifers.

Geological boundaries as potential aquifer boundaries were reviewed; however, consistent with Berardinucci and Ronneseth (2002), they were not used to delineate boundaries due to observations indicating that secondary, fracture-generated porosity and permeability is dominant in the Study Area, which included:

- No apparent correlations between geological units and well yields (e.g., the following wells installed in the shale of the Buckinghorse Formation have a higher yield than expected in shale: 2.6 L/s at Well Tag Number [WTN] 102692, 2.3 L/s at WTN 95424 in); and
- Large variation of well yields over short distances (e.g., relatively large variation in yield between WTN 95427 and WTN 95424 [0.8 and 2.3 L/s, respectively] over a short lateral distance [approximately 160 m]). While well yields are also a function of well construction (e.g., diameter, depth, screened length), normalizing well yield for these factors was beyond the scope of the current study.

Mapping of bedrock aquifers was primarily based on hydraulic boundaries. As such, surface water licensing watershed boundaries and inferred groundwater divides were used as aquifer boundaries. Major geographical features (e.g., the Fort Nelson and Muskwa rivers) were also used to separate flow systems.

Overburden aquifers were delineated based on an understanding of the glacial history of the area as well as topography, surficial geology mapping, and water licensing watershed boundaries. Water licensing watershed boundaries were used as an approximation of groundwater flow system boundaries. Groundwater in aquifers separated by water licensing watershed boundaries are part of the same geological unit and thus are expected to be hydraulically connected but have different natural flow directions. Production of large volumes of water near the boundaries of the mapped aquifer may result in hydraulic influence to the adjacent (connected) aquifer. These boundaries are considered uncertain. The overburden aquifers are typically associated with heterogeneous glacial deposits with uncertainty in the lateral and vertical extent of permeable units and recent alluvial sediments comprised of alluvial floodplain, blanket, fan, and fluvial terrace deposits.

Existing aquifer mapping reports have been reviewed, with relevant information incorporated into mapping report templates provided by the Province.

Aquifer attributes were assigned using statistics calculated for wells correlated to an aquifer based on location and screen material. Wells with no lithology information or unknown screen material were not assigned to a specific aquifer. Wells with lithologic information may not be correlated to mapped aquifers due to interval errors, a lack of screen information, or material descriptions that could not be standardized using automated methods or during manual reviews as part of quality assurance/quality control. This may result in some wells that were previously assigned to an aquifer not being assigned to the current mapped aquifers due to missing information in the well records. Wells with no lithology information that had an available aquifer designation from the licence (i.e., bedrock or unconsolidated) were assigned to new aquifers following the aquifer material identified in the licence.

Vulnerability of aquifers to surface contamination was assessed based on the thickness and extent of geologic materials above the aquifer, their depth to the water table (or top of the confined aquifer), and the type of aquifer material.

3. GEOLOGY

A basic summary of the expected geological model is presented based on the geological model presented by Lengyel et al. (2023) for northeast B.C., updated with local information from Levson et al. (2018), Levson and Fournier (2012), Trommelen et al. (2005), and Trommelen and Levson (2011). The reader is referred to these references for a more detailed review of the geology of the Study Area.

3.1 Bedrock Geology

The Fort Nelson Study Area is located about 60 km northeast of the Rocky Mountain Foothills in the Interior Plains physiographic region. The Interior Plains in B.C. form the western edge of the Western Canada Sedimentary Basin (WCSB) and include some of the thickest (over 3 km) Phanerozoic sedimentary rocks within the basin (Wright et al. 1994).

The Lower Cretaceous Sikanni and Buckinghorse formations of the Fort St. John Group form bedrock in the Study Area. The Buckinghorse Formation consists of silty shales with minor sandstone (Cui et al. 2019; Trommelen et al. 2005). The Sikanni Formation overlies the Buckinghorse Formation and consists of up to eleven sandstone units separated by silty shales (Cui et al. 2019; Trommelen et al. 2005).

No major faults are reported in bedrock within the Study Area. However, major faults are present within the Rocky Mountain Foothills nearby; thus, bedrock in the Study Area, which has been uplifted since deposition, is likely fractured. Fractured bedrock has been described in several wells.

3.2 Quaternary Geology

The Study Area can be divided into three distinct regions based on the observed elevations (Figure 1) and surficial deposits (Levson and Fournier 2012):

- Uplands (approximately above 400 m) often associated with till blankets (few to several metres thick);
- A broad, flat-lying valley (in the range of 350 to 400 m) along the Muskwa and the lower reaches of the Fort Nelson rivers often associated with undifferentiated glaciolacustrine and organic deposits; and
- Incised river valleys (approximately below 350 m) of the Muskwa, Fort Nelson, and Prophet rivers covered by recent alluvial sediments of various types.

Overburden thickness is expected to be the lowest in the uplands and higher in the broad valley along the Muskwa and the Fort Nelson rivers and in the incised river valleys. Levson et al. (2017) have identified multiple buried sand bodies and have also described potential paleo-valleys, which would be expected to correspond to thick overburden deposits. Buried valley floors are expected to contain fluvial gravels. Buried valleys elsewhere in northeast B.C. have been dated to the Middle Wisconsinan (ca. 30,000-50,000 years; Hartman et al. 2018) and older.

The Quaternary geology of the Fort Nelson Study Area, similar to the Peace-Kiskatinaw Study Area discussed in Lengyel et al. (2023), is a product of glaciation originating both east (Laurentide Ice Sheet) and west (Cordilleran Ice Sheet and Rocky Mountain glaciers) of the area (Trommelen et al. 2005). The general Quaternary sediment sequence is expected to be similar to the stratigraphy compiled elsewhere in northeast B.C. (Lengyel et al. 2022 and 2023) with slight variation in the name and the age of the units. The Quaternary sediment is generally expected, based on regional geology, to be comprised, from oldest to youngest, of the following units:

1) Early Wisconsinan (>50,000 years old) or older fluvial gravel overlain by glaciolacustrine/overbank silt and sand
2) Early Wisconsinan or older glacial sediments:
    a. Ice-advance glaciofluvial gravels within paleo-valleys;
    b. Till deposited in front of and beneath advancing glaciers; and
    c. Ice-retreat glaciolacustrine sediments within paleo-valleys.
3) Middle Wisconsinan (non-glacial, ca. ~30,000-50,000 years old) fluvial gravel and overbank deposits (“lower paleovalley sediments”)
4) Late Wisconsinan (ca. 11,000-~30,000 years old) glacial sediments:
    a. Ice-advance, mainly fine-grained glaciolacustrine, deposits within paleo-valleys, associated with glacial lakes, which were impounded by the Laurentide Ice Sheet. Ice-advance sediments comprise laminated and bedded clay, silt, and sand. Locally, glaciodeltaic sediments, consisting of fine- to coarse- grained sand and gravel, occur near the top of the ice-advance glaciolacustrine sequence.
    b. Till deposited beneath Rocky Mountain glaciers and the Cordilleran Ice Sheet in the west and the Laurentide Ice Sheet in the east. Interbeds of sand and gravel may be present within till.
    c. Late-glacial glaciolacustrine deposits consisting of stratified and massive clay, silt, and sand associated with Late Wisconsinan glacial lakes. These sediments were deposited near the end of the Pleistocene Epoch, before the present river system became established.
    d. Glaciofluvial and deltaic gravels deposited on river terraces near the end of the Pleistocene.
5) Holocene or postglacial (ca. 11,000 years old to present):
    a. Fluvial gravel and sand associated with the channels and floodplains of rivers;
    b. Colluvium (landslide deposits, talus, slope deposits).

Glacial sediments are overlain by alluvial, colluvial, eolian, and organic sediments deposited during the Holocene.

4. HYDROGEOLOGY

4.1 Conceptual Model of Hydrogeology

The conceptual model described by Levson et al. (2018) and Lengyel et al. (2023) was adopted for the current study. Based on recent aquifer mapping studies in northeast B.C. (Lengyel et al. 2022 and 2023), regionally significant aquifers are expected to be generally associated with the following units:

- the fractured bedrock (e.g., Lower Cretaceous Sikanni and Buckinghorse formations);
- the Middle to Late Wisconsinan fluvial gravel deposits;
- glaciofluvial and deltaic gravels deposited on river terraces near the end of the Pleistocene; and
- fluvial gravel and sand associated with modern rivers.

Regionally, smaller-scale aquifers have also been observed in hydraulic connection with the above units, including the Early Wisconsinan or older fluvial sand and gravel deposit and the fine to medium grained sand at the base of the Late Wisconsinan ice-advance glaciolacustrine sediments. Smaller-scale aquifers separated from the regionally significant aquifers, like discontinuous sand lenses within the till or glaciolacustrine sediments, have also been observed.

4.2 Bedrock Aquifers

Bedrock Aquifer 1034 in the Study Area has been previously delineated based on areas of well development, topography, and drainage features.

Bedrock aquifer extents have been revised in the current study by extending the aquifer beyond areas with known well installations based on mapped and interpreted geological and hydrogeological conditions. Aquifer boundaries delineated within the Fort St. John Group (Sikanni and Buckinghorse formations) follow major water bodies (deemed significant enough to impact bedrock groundwater flow) and watershed boundaries (based on inferred alignments between surface water and groundwater flow systems). No geological boundaries preventing flow between the Sikanni and Buckinghorse formations are known; connectivity between these units should be expected.

The extents of the existing Cridland Creek Bedrock Aquifer (1034)[1] were revised as part of the current study, and a new bedrock aquifer, the Pouce Creek Bedrock Aquifer (1291), was mapped.

Details for each aquifer are provided in aquifer mapping reports (Appendix A).

The extent of Aquifer 1034 was adjusted based on inferred groundwater flow systems (represented by water licensing watershed boundaries) and surface water bodies (Figure 1). Aquifer 1034 encompasses the northern portion of the previously delineated Aquifer 1034. Aquifer 1034 extends to Cridland Creek in the north, the Fort Nelson River in the east, and the water licensing watershed boundary in the west and south.

Aquifer 1291 is a newly delineated aquifer. It encompasses the southern portion of the previously delineated Aquifer 1034, and the two mapped aquifers are separated by an assumed groundwater flow divide. Connectivity between the aquifers is expected. Aquifer 1291 is bound by watershed boundaries in the north, the Muskwa River in the east, and Pouce Creek in the south and west.

There is one active bedrock provincial observation well within the Study Area:

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[1] Aquifer was not previously named. Aquifer names are assigned in this study for ease of reference and may not be reflective of initial location.

- OW 496 (WTN 126680) – aquifer 1034.

Water levels in OW 496 have stayed between approximately 23 and 24 mbgs since well installation in 2021, displaying only limited variability. Water type at the well is sodium-bicarbonate (Na-HCO_3). The lack of chloride in the groundwater samples suggests relative short flow paths in the bedrock fractures (Baye et al. 2022).

4.3 Overburden Sediment Aquifers

A geologic cross-section (Figure 2) was prepared to assist with reviewing and delineating overburden aquifers. The location of the cross-section is illustrated in Figure 1.

Previously, three overburden aquifers were mapped in the Study Area:

- Fort Nelson River Confined Aquifer (1035)[1];
- Muskwa – Fort Nelson Buried Valley Aquifer (1040); and
- Fort Nelson River Alluvial Aquifer (1041).

Three new unconsolidated aquifers were mapped for the Study Area:

- Muskwa-Fort Nelson Glaciofluvial Aquifer (1288);
- Muskwa River Alluvial Aquifer (1289); and
- Prophet River Alluvial Aquifer (1290).

The extents of Aquifer 1040 were revised based on the extent of coarse-grained paleo-valley sediments identified in boreholes (Figure 2). Aquifer 1040 consists of sand and gravel and is associated with Middle Wisconsinan (65,000 – 35,000 years ago) buried-channel fluvial sediments. The boundary of the aquifer is shown as uncertain, as the extent of the aquifer is likely to continue beyond the current aquifer boundaries.

Aquifers 1041, 1289, and 1290 comprise alluvial sediments, including alluvial floodplain, blanket, fan, and fluvial terrace deposits (silt, clay, fine- to coarse-grained sand, gravel). Their extents were revised based on the extents of the alluvial deposits along the Fort Nelson (Aquifer 1041), Muskwa (Aquifer 1289), and Prophet (Aquifer 1290) rivers, respectively (Levson and Fournier 2012 and Trommelen and Levson 2011), and water licensing watershed boundaries. The aquifer boundaries are uncertain where they correspond to alluvial deposit boundaries, as digitization of the surficial geological maps may have introduced inaccuracies. Aquifer boundaries are also uncertain where they correspond to watershed boundaries (see Section 2.2.6).

Aquifers 1041, 1289, and 1290 are within the same geological unit and are separated based on their different flow regimes. Thus, they are expected to be in hydraulic connection with each other where they were delineated by water licensing watershed boundaries and with adjacent surface water bodies, such as the Fort Nelson, Muskwa, and Prophet rivers, respectively, and their tributaries (where alluvial sediments are present).

Aquifer 1035 has been incorporated into Aquifer 1041, and Aquifer 1035 has been retired.

Aquifer 1288 consists of sand and gravel associated with the Late Wisconsinan (35,000 – 10,000 years ago) glaciofluvial depositional environment. The extent of Aquifer 1288 was determined based on the presence of glaciofluvial terrace sediments (Levson and Fournier 2012) and topography. There is no apparent hydraulic connection between Aquifer 1288 and the underlying buried channel (Aquifer 1040; Figure 2) consistent with the observations by Yin (Yin, Jun 2023. pers. comm.).

Based on the conceptual model, coarse-grained sediments associated with tributaries of the Fort Nelson and Muskwa rivers (e.g., McConachie Creek and Donaldson Creek in the north-central part of the Study Area) may also act as aquifers (see Levson et al. 2018). However, insufficient data were available to delineate aquifers in these areas.

Wells with high well yields (WTN 109974 with 7.6 L/s and WTN 109973 with 4.6 L/s) were reported in GWELLS near the western boundary of the Study Area. Based on the borehole lithology, both wells are screened in confined unconsolidated materials consisting of sand and gravel. The available data from the area, however, were not sufficient to delineate a regionally significant aquifer. Further study is required to assess the extent (i.e., local or regional) of the aquifer.

There are two active overburden provincial observation wells within the Study Area:

- OW 481 (WTN 118702) – Aquifer 1041, and
- OW 482 (WTN 118701) – Aquifer 1040.

Water levels in OW 481 displayed seasonal variability, with depth to water ranging between 5 and 8 mbgs since 2021, suggesting a potential connection between Aquifer 1041 and the Fort Nelson River. Water levels at OW 482 displayed only limited variability (0.6 m), with depth to water ranging between 8.2 and 8.8 mbgs since 2018.

4.4 Vulnerability

Aquifer vulnerability has been qualitatively assessed as part of the review of aquifer extents based on the methods described by Berardinucci and Ronneseth (2002). Factors considered in assessing aquifer vulnerability included:

- Depth of the aquifer;
- Depth of the water table;
- Presence or absence of low-permeability confining layers above an aquifer;
- Integrity of the overlying confining units (i.e., if fractured or not); and
- Velocity of expected seepage (including porosity).

The vulnerability of the mapped aquifers has been assessed as high (1041, 1288, 1289, 1290), moderate/high (1034, 1291), and low (1040; Table A).

Table A: Aquifer vulnerability assessment.

Aquifer Number	Aquifer Name	Subtype	Depth of the Water Table	Permeability of Overlying Material	Confining Unit	Vulnerability
1034	Cridland Creek Bedrock Aquifer	5a	Shallow to moderately deep	Low	Present with variable thickness (≥1.5 m)	Moderate/High
1040	Muskwa-Fort Nelson Buried Valley	4b	Moderately deep to deep	Low	Present (thickness is >90 m)	Low
1041	Fort Nelson River Alluvial Aquifer	1a	Shallow to moderately deep	Medium/Low (where present), partially confined	The unit is at surface but is comprised of interspersed coarse-grained and fine-grained materials; where the fine-grained materials (up to 1.5 m thick) are at surface, locally the coarse-grained materials may be confined.	High
1288	Muskwa-Fort Nelson Glaciofluvial Aquifer	4a	Shallow	Medium (where present)	Silt may be present with variable thickness (<3 m)	High
1289	Muskwa River Alluvial Aquifer	1a	Shallow	Medium/Low (where present), partially confined	The unit is at surface but is comprised of interspersed coarse-grained and fine-grained materials; where the fine-grained materials (up to 11.6 m thick) are at surface, locally the coarse-grained materials may be confined.	High
1290	Prophet River Alluvial Aquifer	1a	Not available[1]	Medium/Low (where present), partially confined	The unit is at surface but is comprised of interspersed coarse-grained and fine-grained materials; where the fine-grained materials are at surface, locally the coarse-grained materials may be confined.	High
1291	Pouce Creek Bedrock Aquifer	5a	Shallow to deep	Low	Present with variable thickness (≥2 m)	Moderate/High

Notes:

[1]Not available – no wells were installed in Aquifer 1290. Water level assumed to be shallow similar to Aquifers 1041 and 1289.
A more detailed data table summarizing aquifer properties is presented in Appendix B.

5. DATA GAPS AND UNCERTAINTY

Mapped aquifers extend beyond areas with registered wells; therefore, there is uncertainty in aquifer boundaries, properties, and interpreted water levels. Specific areas of uncertainty are highlighted in the individual aquifer mapping reports (Appendix A). Areas with uncertainties due to data gaps include:

- The horizontal extent of Aquifer 1040.
- The horizontal and vertical extent of coarse-grained material (sand and gravel) in Aquifers 1041, 1289, and 1290, as alluvial deposits comprise of fine-grained sediments, such as silt and clay interspersed with coarse-grained material.
- Potential aquifers in alluvial sediments of the tributaries of the Fort Nelson, Muskwa, and Prophet rivers.
- Potential confined unconsolidated aquifer northwest of Fort Nelson in the northern central part of the Study Area indicated by presence of intra-till coarse-grained units in the lithology (e.g., WTN 102689).
- Potential confined unconsolidated aquifer near the western boundary of the Study Area indicated by presence of wells with high yield and coarse-grained units in lithology (e.g., WTN 109973, WTN 109974, and WTN 109978).
- Potential bedrock aquifer in the southern part of the Study Area. The bedrock in the southern Study Area is expected to contain additional aquifer(s); however, due to insufficient data, further aquifers in the area could not be delineated. Further study is required to assess the presence and extent of aquifers in this area.

Uncertainties in surface water/groundwater interactions follow from limited information on local variations in the hydraulic conductivity of streambed sediments and underlying geology.

6. CONCLUSIONS AND RECOMMENDATIONS

Seven aquifers were mapped in the Fort Nelson Study Area (two bedrock and five overburden aquifers). One aquifer (1035) was retired. Mapped aquifers are summarized in Table B below.

Table B: Summary of mapped aquifers.

Aquifer Name	Recommended Action
1034	Revised extent
1035	Retired aquifer
1040	Revised extent, updated description
1041	Revised extent
1288	Introduced as new aquifer
1289	Introduced as new aquifer
1290	Introduced as new aquifer
1291	Introduced as new aquifer

As various observations (see Section 2.2.6) indicated that secondary fracture generated porosity and permeability is dominant in the Study Area, aquifers in the Fort St. John Group (Sikanni and Buckinghorse formations [1034 and 1291]) were inferred to be part of the same geological/hydrostratigraphical unit. These aquifers were separated along groundwater divides.

Current provincial systems do not allow for the handling of aquifer management units representing portions of a large continuous aquifer, only separate aquifers. As the development of groundwater resources near groundwater divides may require an assessment of groundwater resources on both sides of a divide, it is recommended that current provincial systems be revised for handling aquifer management units within aquifers.

Aquifers 1034, 1041, 1289, 1290, and 1291 extend beyond the Study Area. It is recommended that data outside of the Study Area boundary be reviewed to assess the full extent of these aquifers.

The vulnerability of the mapped aquifers has been assessed as low (1040), moderate/high (1034 and 1291), and high (1041, 1288, 1289, and 1290).

There are three active bedrock provincial observation wells within the Study Area, one in Aquifer 1034, one in Aquifer 1040, and one in Aquifer 1041.

Recommendations to advance understanding of hydrogeological conditions in the Study Area include the following:

- Refine the extent of Aquifer 1041, 1289, and 1290 by conducting aquifer mapping studies north, south, and west of the Study Area.
- Conduct detailed geological mapping to delineate the extent of paleo valleys in the Study Area.
- Expand the provincial observation monitoring well network to determine the presence/extent of potential bedrock aquifers in the southern Study Area.
- Expand the provincial observation monitoring well network in the northern central part of the Study Area to determine the extent of a potential unconsolidated aquifer near Fort Nelson.
- Expand the provincial observation monitoring well network in areas of high-productivity wells with coarse-grained units in lithology to determine the extent of potential unconsolidated aquifers near the western boundary of the Study Area.
- Expand the provincial observation monitoring well network to include nested/clustered wells in the bedrock to facilitate understanding regional groundwater flow.
- Update the extent of alluvial aquifers upon completing digitization of surficial geological information for the study area.

REFERENCES

ASSOCIATED ENGINEERING 2019. Clarke Lake Geothermal Pre-Feasibility Study. August 2019. https://www.geosciencebc.com/wp-content/uploads/2019/11/Clarke-Lake-Geothermal-Final-Report.pdf. [Last accessed 17 July 2023].

BAYE, A., YIN, J, BRYSON, S., AND WICK, J. 2022. Exploratory drilling, pumping test, Groundwater sampling and Provincial Groundwater Observation wells network expansion in the Liard-Petitot subbasins-Fort Nelson Area. September 2022, Victoria, B.C. https://a100.gov.bc.ca/pub/acat/documents/r59882/FortNelsonPGWON_Expansion_1663715430377_411A25FB2C.pdf . [Last accessed: 17 July 2023].

BERARDINUCCI, J.F. & RONNESETH, K.D. 2002. Guide to Using the BC Aquifer Classification Maps for the Protection and Management of Groundwater, Government of British Columbia, British Columbia. Ministry of Water, Land Air Protection, Water Air and Climate Change Branch, Water Protection Section.

BONDU, R., KLOPPMANN, W., NAUMENKO-DÈZES, M.O., HUMEZ, P. AND MAYER B.K. 2021. Potential Impacts of Shale Gas Development on Inorganic Groundwater Chemistry: Implications for Environmental Baseline Assessment in Shallow Aquifers. Environmental Science & Technology 2021 55 (14), 9657-9671. DOI: 10.1021/acs.est.1c01172

CAHILL, A.G., STEELMAN, C.M., FORDE, O., KULOYO, O., RUFF, S.E., MAYER, B.K., MAYER, U., STROUS, M., RYAN, M.C., CHERRY, J.A., AND PARKER, B.L. 2017. Mobility and persistence of methane in groundwater in a controlled-release field experiment. Nature Geosciences, 10, 289–294. https://doi.org/10.1038/ngeo2919

CUI, Y., MILLER, D., SCHIARIZZA, P. & DIAKOW, L J. 2019. British Columbia Digital Geology. BC Ministry of Energy, Mines and Petroleum Resources, BC Geological Survey Open File 2017-8, 9p. Data Version 2019-12-19.

HARTMAN, G.M.D., CLAGUE, J.J., BARENDREGT, R.W. & REYES, A.V. 2018. Late Wisconsinan Cordilleran and Laurentide glaciation of the Peace River Valley east of the Rocky Mountains, British Columbia. Canadian Journal of Earth Sciences, 55 (12), pp. 1324-1338. https://doi.org/10.1139/cjes-2018-0015.

KOHUT, A.P. 2013. Aquifer Classification and Ranking of Aquifer #s 1040, 1041, 1034 and 1035, BC Ministry of Environment, well logs.

LENGYEL, T., HINNELL, A.C., & CLAGUE, J. J. 2022. Peace-Beatton Aquifer Mapping and Hydrostratigraphic Characterization, Water Science Series, WSS2022-04. Province of British Columbia, Victoria.

LENGYEL, T., J. DERI-TAKACS, A.C. HINNELL, AND J.J CLAGUE 2023. Kiskatinaw-Peace Aquifer Mapping and Hydrostratigraphic Characterization, Water Science Series, WSS2023-04. Province of British Columbia, Victoria.

LEVSON, V.M., AND FOURNIER, M. 2012. Surficial geology, Fort Nelson (NTS 94J/NE), British Columbia. Geological Survey of Canada, Open File 7041; British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Geoscience Map 2011-06, 1:100,000 scale.

LEVSON, V.M., H. BLYTH, T. JOHNSEN AND M. FOURNIER. 2018. Liard and Petitot Sub Basins Transboundary Groundwater Resources Assessment. Water Science Series, WSS2018-01. Prov. B.C., Victoria B.C.

PROVINCE OF B.C. 2023. Groundwater Wells and Aquifers (GWELLS). https://apps.nrs.gov.bc.ca/gwells/ [Last Accessed: 2023 December 22].

TROMMELEN, M.S., LEVSON, V.M., HICKIN, A., AND T. FERBEY. 2005. Quaternary geology of Fort Nelson (NTS 094J/SE) and Fontas River (NTS 094I/SW), northeastern British Columbia. *In:* Summary of Activities 2005, BC Ministry of Energy and Mines, pages 96-112.

TROMMELEN, M., AND LEVSON, V. 2011. Surficial geology, Adsett Creek (NTS 94J/SE), British Columbia; British Columbia Ministry of Energy and Mines, BCGS Open File 2011-05; Geological Survey of Canada, Open File 6832, scale 1:100 000. DOI: 10.4095/288643.

WRIGHT, G.N., MCMECHAN, M.E., POTTER, D.E.G. & HOLTER, M.E. 1994. Chapter 3: Structure and Architecture of the Western Canada Sedimentary Basin. In Geological Atlas of the Western Canada Sedimentary Basin, G.D. Mossop and I. Shetsen (comp.), Canadian Society of Petroleum Geologists and Alberta Research Council, URL https://ags.aer.ca/atlas-the-western-canada-sedimentary-basin/chapter-28-geological-history-the-peace-river-arch, [Date last accessed: 15-February-2023].

YIN, JUN 2023. Regional Hydrogeologist, Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Prince George, BC, Personal Communication August 31, 2023.

AUTHORSHIP

Prepared by:

Original Signed and Sealed

Tibor Lengyel, M.Sc., P.Geo.
Hydrogeologist

Original Signed

Judit Deri-Takacs, Ph.D.
Water Scientist

Original Signed and Sealed

Andrew Hinnell, Ph.D., P.Geo.
Principal Hydrogeologist

Worley Consulting (Worley Canada Services Ltd.)

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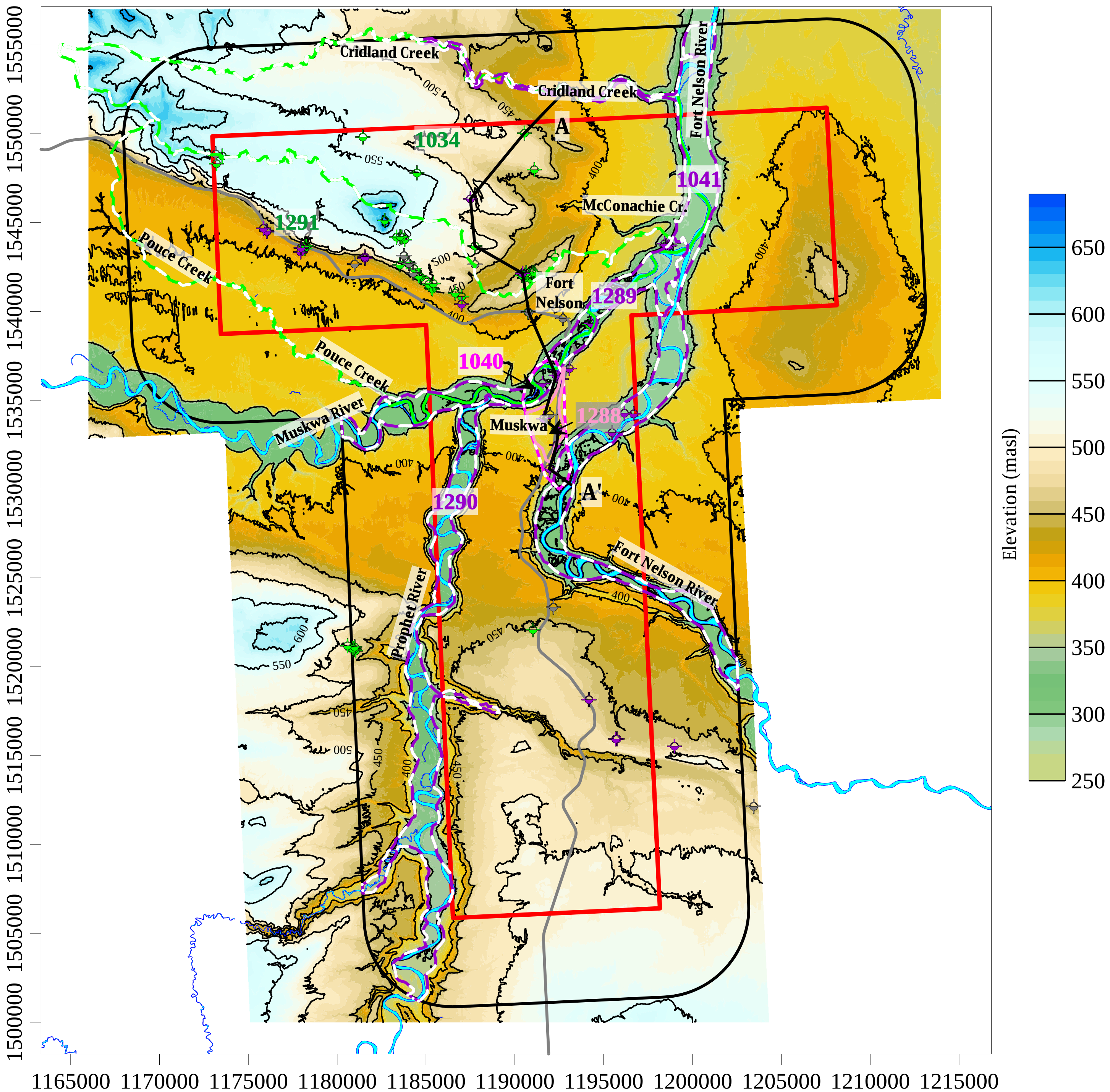
FIGURES (FOLLOWING TEXT)



1041 Overburden Aquifers (1a)

1288 Overburden Aquifers (4a)

1040 Overburden Aquifers (4b)

1034 Bedrock Aquifers (5a)

Study Area

A Cross-Section Line

97 Highway 97 (Alaska Highway)

Uncertain Aquifer Boundary (Overburden, 1a)

Uncertain Aquifer Boundary (Overburden, 4b)

Uncertain Aquifer Boundary (Bedrock, 5a)

Bedrock Well

Overburden Well

Undifferentiated Well

0 2 4 6 8

Kilometres

1:325,000

N

BC Albers, NAD 83 Projection

BRITISH COLUMBIA MINISTRY OF WATER, LAND AND RESOURCE STEWARDSHIP

HYDROGEOLOGIC INTERPRETATION & AQUIFER MAPPING

FORT NELSON AREA

LOCATION MAP AND MAPPED AQUIFERS

Date: 01-Mar-2024	Drawn by: J. D-T.	Edited by: T.L.	App'd by: T.L.

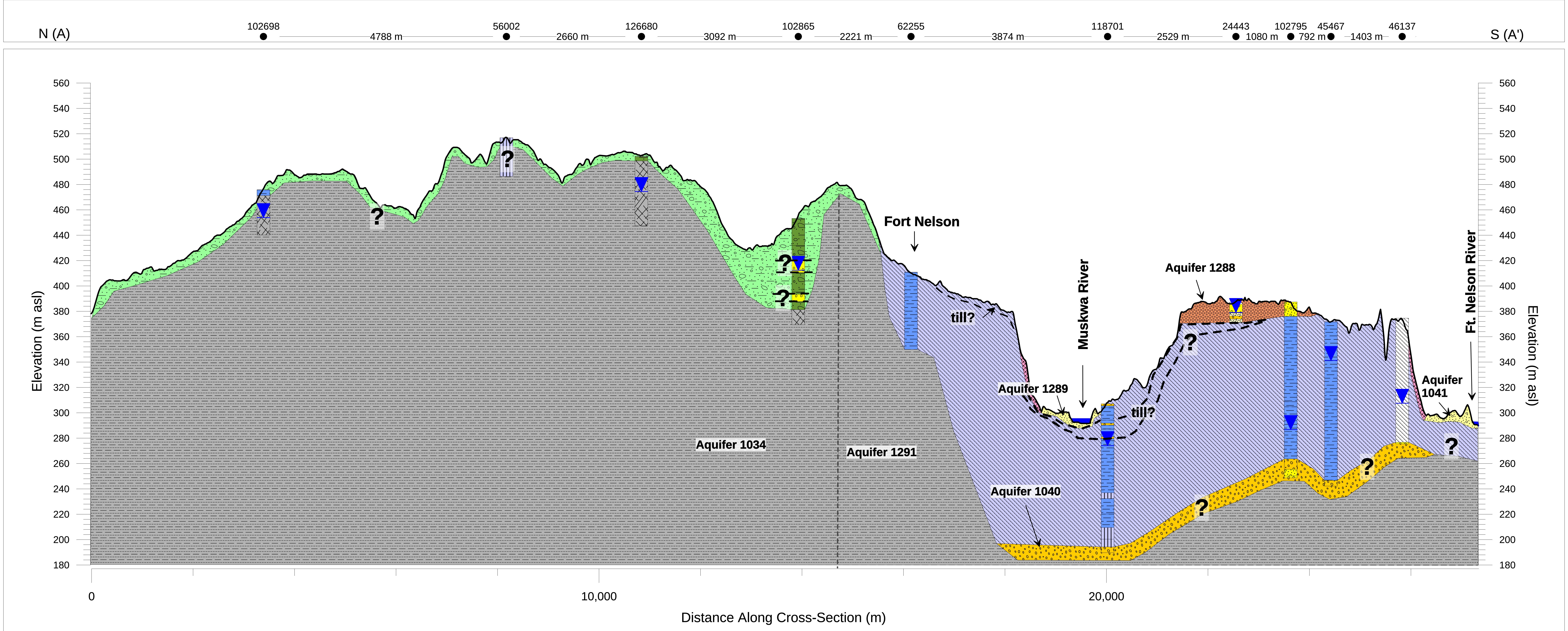
BRITISH COLUMBIA

worley DELIVERING SUSTAINABLE CHANGE

Worley Project No. 317085-50500

FIG No 1

REV 0



Borehole Legend

- bedrock
- clay
- gravel
- sand & fines
- sand & gravel (clean)
- sand coarse
- sand medium
- silt
- till
- unknown

Stratigraphy

- Post-Glacial (Alluvial)
- Post-Glacial Colluvium)
- Late Wisconsinan Ice-Retreat Glaciolacustrine
- Late Wisconsinan Ice-Retreat Glaciofluvial
- Late Wisconsinan Till
- Middle Wisconsinan Fluvial
- Fort St. John Group

? Uncertain Geological Boundary
▼ Water Level

The distribution of bedrock units is based on Cui et al. (2017)
This cross-section shows interpreted geology based on data from discrete locations and professional judgement. Deviations in the type and location of material are expected.

Vertical Exaggeration: 25x
Projection: NAD83 BC Albers

BRITISH COLUMBIA MINISTRY OF WATER, LAND AND RESOURCE STEWARDSHIP HYDROGEOLOGIC INTERPRETATION & AQUIFER MAPPING FORT NELSON AREA				
CROSS-SECTION A-A'				
Prepared for: British Columbia	Date: 01-Mar-24	Drawn by: J. D-T.	Edited by: T.L.	App'd by: T.L.
	worley DELIVERING SUSTAINABLE CHANGE		Worley Project No. 317085-50500	
			FIG No 2	REV 0

"This drawing is prepared for the use of our customer as specified in the accompanying report. Worley Canada Services Ltd. assumes no liability to any other party for any representations contained in this drawing."

APPENDIX A: AQUIFER MAPPING REPORTS

1034 CRIDLAND CREEK BEDROCK AQUIFER

1040 MUSKWA-FORT NELSON BURIED VALLEY

1041 FORT NELSON RIVER ALLUVIAL AQUIFER

1288 MUSKWA-FORT NELSON GLACIOFLUVIAL AQUIFER

1289 MUSKWA RIVER ALLUVIAL AQUIFER

1290 PROPHET RIVER ALLUVIAL AQUIFER

1291 POUCE CREEK BEDROCK AQUIFER

Aquifer Name: Cridland Creek Bedrock Aquifer

Aquifer Number: 1034

Date of Mapping: October 30, 2023

Authors: Tibor Lengyel, M.Sc., P.Geo., Judit Deri-Takacs, Ph.D., and Andrew Hinnell, Ph.D., P.Geo.

A. AQUIFER DESCRIPTION FOR AQUIFER 1034

A.1 CONCEPTUAL UNDERSTANDING OF HYDROSTRATIGRAPHY

A.1.1 AQUIFER EXTENTS

The aquifer is located west of the Fort Nelson River and south of Cridland Creek. It was delineated based on water licensing watershed boundaries and surface water bodies. Aquifer 1034 extends to Cridland Creek in the north, the Fort Nelson River in the east, and a water licensing watershed boundary in the west and south.

The aquifer boundary is uncertain in the west and south, where it follows the watershed boundary and along Cridland Creek.

Water licensing watershed boundaries were used as an approximation of groundwater flow system boundaries. Where water licensing watershed boundaries are used, aquifer boundaries are uncertain, and groundwater resources may be hydraulically continuous across the boundary.

A.1.2 GEOLOGIC FORMATION (OVERLYING MATERIALS)

The aquifer is overlain by till, clay, and organic deposits (Levson and Fournier 2012). Twelve out of the 18 wells associated with the aquifer reported fine-grained material (clay, till) on the surface, two wells reported overburden without further clarification of the type of material, one well reported organic material, and three wells had unknown lithology at surface. The thickness of the overlying material ranges from 1.5 to 71.9 m.

A.1.3 GEOLOGIC FORMATION (AQUIFER)

The bedrock aquifer is comprised of sediments of the Sikanni and Buckinghorse formations of the Cretaceous Fort St. John Group. The Buckinghorse Formation consists of fine-grained deposits of mudstone, siltstone, and shale. The Buckinghorse Formation is overlain by the Sikanni Formation, which is dominated by sandstone (Massey et al. 2005). Permeability may be associated with both the primary and secondary porosity (through fracturing) of the Sikanni Formation, as well as of the Buckinghorse Formation (Lengyel et al. 2024). This aquifer is interpreted to be confined.

A.1.4 VULNERABILITY

Depth to groundwater varies from shallow to moderately deep (3.5 to 43.3 metres below top of casing [mbtoc][1]).

Surficial mapping by Levson and Fournier (2012) and borehole logs indicate that the bedrock aquifer is covered by fine-grained materials (dominantly clayey till) of variable thickness and (generally silty and clayey) till blanket. Thus, the permeability of the overlying material is low. The overall vulnerability of the aquifer to surface contamination has been qualitatively assessed to be moderate, except where overlain by silty or clayey till blankets, where, due to the lower thickness, the vulnerability is expected to be high.

A.2 CONCEPTUAL UNDERSTANDING OF FLOW DYNAMICS

A.2.1 GROUNDWATER LEVELS AND FLOW DIRECTION

Static water levels recorded in the provincial groundwater wells database (GWELLS) range from shallow (3.5 mbtoc) to moderately deep (43.3 mbtoc). Groundwater flow direction in the bedrock was not determined; however, the groundwater surface is assumed to be a subdued representation of the topography based on the static water levels recorded in the GWELLS database (Lengyel et al. 2024; Figure 2). Groundwater is interpreted to flow from topographic highs towards topographic lows, primarily towards the Fort Nelson River and its tributaries. There is one active provincial observation well (OW-496, Well Tag Number [WTN] 126680) and one artesian well (WTN 102516) reported in the aquifer.

A.2.2 RECHARGE

Recharge to the aquifer could occur via distributed infiltration of precipitation and snowmelt, particularly where the aquifer is in a topographically elevated position and in areas where the overburden is thin. Much of the recharge is expected to occur in the spring, associated with snowmelt. The spatial and temporal understanding of the recharge mechanism, however, is unknown, and further investigation is required to confirm this hydraulic connection.

A.2.3 POTENTIAL FOR HYDRAULIC CONNECTION

Groundwater in the aquifer is in direct hydraulic connection with its neighbouring bedrock Aquifer 1291 and with Aquifer 1041, where the intervening sediments have high conductivity and/or absent. Hydraulic connection may exist between Aquifer 1034 and overlying tributaries and wetlands where the unconsolidated material above the bedrock is thin; however, further investigation is required to evaluate this hydraulic connection.

[1] Default water level unit in GWELLS: feet below top of casing (ft btoc). Water levels converted to m btoc, with no corrections made based on the presence or absence of reported stick-up values.

A.3 WATER MANAGEMENT

A.3.1 ADDITIONAL INFORMATION ON WATER USE AND MANAGEMENT

Stated yields in the well records range from 0.19 to 4.55 L/s, with a geometric mean of 0.72 L/s indicating moderate productivity with localized zones of low and high productivity. Groundwater use was reported for domestic purposes at 14 wells and for unknown purposes at four wells.

A.3.2 ADDITIONAL ASSESSMENTS OR MANAGEMENT ACTIONS

Hydrochemical information was reported at three wells in the provincial groundwater wells (GWELLS) database, reporting total dissolved solids (TDS) values between 910 and 1150 mg/L, iron concentrations between 2.4 and 4.8 mg/L, hardness between 61 and 79 mg/L, and pH between 7.6 and 7.8.

A.4 AQUIFER REFERENCES

Lengyel, T., J. Deri-Takacs, and A.C. Hinnell, 2024. Fort Nelson Aquifer Mapping and Hydrostratigraphic Characterization, Water Science Series, WSS2024-02. Province of British Columbia, Victoria.

Levson, V., Fournier, M. 2012. Surficial geology, Fort Nelson (NTS 94 J/NE), British Columbia, Geological Survey of Canada, Open File 7041, British Columbia Ministry of Energy and Mines, BCGS Geoscience Map 2011-06, scale 1:100,000, doi: 10.4095/291399

Massey, N.W.D., MacIntyre, D.G., Desjardins, P.J. & Cooney, R.T. 2005. Geology of British Columbia. Ministry of Energy and Mines, BC Geological Survey, Geoscience Map 2005-3.

A.5 REVISION HISTORY

Date	Version	Revision Class	Comments	Author
2013	1	Major	Initial mapping of aquifer	Kohut, A.P.
2023	2	Major	Remapping of aquifer	Tibor Lengyel, M.SC., P.Geo. Judit Deri-Takacs, Ph.D. Andrew Hinnell, Ph.D., P.Geo.

Aquifer Name: Muskwa-Fort Nelson Buried Valley

Aquifer Number: 1040

Date of Mapping: October 30, 2023

Authors: Tibor Lengyel, M.Sc., P.Geo., Judit Deri-Takacs, Ph.D., and Andrew Hinnell, Ph.D., P.Geo.

A. AQUIFER DESCRIPTION FOR AQUIFER 1040

A.1 CONCEPTUAL UNDERSTANDING OF HYDROSTRATIGRAPHY

A.1.1 AQUIFER EXTENTS

The aquifer is located between the Muskwa and Fort Nelson rivers, east of the Prophet River. It was delineated based on the presence of Middle Wisconsinan fluvial deposits identified in the boreholes (provincial groundwater wells database [GWELLS]; Lengyel et al. 2024). The boundaries of the aquifer are indicated as uncertain, as the extent of the buried valley could not be determined based on the available data.

A.1.2 GEOLOGIC FORMATION (OVERLYING MATERIALS)

The aquifer is overlain by fine-grained (clay) sediments of glaciolacustrine deposits and by coarse-grained sediments (sand, gravel) of glaciofluvial and alluvial deposits. Within the glaciolacustrine deposits, clayey till-like sediments (i.e., consisting of a mixture of clay, sand, and gravel) were observed in some of the boreholes (Lengyel et al. 2024; Figure 2). Two of the five wells assigned to the aquifer reported unknown material above the aquifer. The thickness of the overlying materials ranges from 98 to 125 m.

A.1.3 GEOLOGIC FORMATION (AQUIFER) – 4B CONFINED GLACIOFLUVIAL

The aquifer consists of fine- to medium-grained sand and gravel interpreted to be Middle Wisconsinan fluvial deposits (Lengyel et al. 2024; Figure 2). The aquifer is interpreted to be a confined aquifer. The aquifer thickness is highly uncertain. No wells have reached the bedrock below the aquifer, as demonstrated in Cross Section A-A’ of Lengyel et al. 2024.

A.1.4 VULNERABILITY

Depth to groundwater varies from moderately deep to deep. The borehole logs indicate that the aquifer is overlain by thick, fine-grained glaciolacustrine sediments with a thickness of 97 to 125 m. The permeability of the overlying material is low. The overall vulnerability of the aquifer to surface contamination has been qualitatively assessed to be low.

A.2 CONCEPTUAL UNDERSTANDING OF FLOW DYNAMICS

A.2.1 GROUNDWATER LEVELS AND FLOW DIRECTION

The groundwater flow direction could not be determined due to the limited availability of data. Static water levels recorded in GWELLS range from moderately deep (30.5 metres below top of casing [mbtoc][1]) to deep (100.6 mbtoc). One active provincial observation well (OW-482, Well Tag Number [WTN] 118701) is installed in the aquifer.

A.2.2 RECHARGE

The aquifer may be partially recharged from underlying bedrock (e.g., Aquifer 1291); the recharge mechanism of the aquifer, however, is unknown, and further investigation is required to evaluate hydraulic connections.

A.2.3 POTENTIAL FOR HYDRAULIC CONNECTION

Groundwater may be hydraulically connected with the underlying bedrock aquifer (Aquifer 1291) where it is fractured and the intervening sediments (if any) are permeable; however, further investigation is required to confirm this hydraulic connection.

A.3 WATER MANAGEMENT

A.3.1 ADDITIONAL INFORMATION ON WATER USE AND MANAGEMENT

Stated yields in the well records range from 0.8 to 11.4 L/s, with a geometric mean of 2.9 L/s indicating high productivity with localized zones of moderate productivity. Groundwater is used for domestic purposes (two of five wells), based on the GWELLS database. Three wells recorded groundwater use for unknown purposes.

A.3.2 ADDITIONAL ASSESSMENTS OR MANAGEMENT ACTIONS

No water availability or water budget studies have been completed in the area.

A.4 AQUIFER REFERENCES

Lengyel, T., J. Deri-Takacs, and A.C. Hinnell, 2024. Fort Nelson Aquifer Mapping and Hydrostratigraphic Characterization, Water Science Series, WSS2024-02. Province of British Columbia, Victoria.

[1] Default water level unit in GWELLS: feet below top of casing (ft btoc). Water levels converted to m btoc, with no corrections made based on the presence or absence of reported stick-up values.

A.5 REVISION HISTORY

Date	Version	Revision Class	Comments	Author
2013	1	Major	Initial mapping of aquifer.	Kohut, A.P.
2023	2	Major	Remapping of aquifer, aquifer separated from overlying glaciofluvial aquifer (Aquifer 1288).	Tibor Lengyel, M.SC., P.Geo. Judit Deri-Takacs, Ph.D. Andrew Hinnell, Ph.D., P.Geo.

Aquifer Name: Fort Nelson River Alluvial Aquifer

Aquifer Number: 1041

Date of Mapping: October 30, 2023

Authors: Tibor Lengyel, M.Sc., P.Geo., Judit Deri-Takacs, Ph.D., and Andrew Hinnell, Ph.D., P.Geo.

A. AQUIFER DESCRIPTION FOR AQUIFER 1041

A.1 CONCEPTUAL UNDERSTANDING OF HYDROSTRATIGRAPHY

A.1.1 AQUIFER EXTENTS

The aquifer is located along the Fort Nelson River and its tributary, Cridland Creek. It was delineated based on the spatial distribution of alluvial sediments along the Fort Nelson River and the water licensing watershed boundary to the west (Levson and Fournier 2012; Trommelen and Levson 2011).

The aquifer boundaries are uncertain where they follow the margin of the Study Area in the north and south, and along the water licensing watershed boundary (Lengyel et al. 2024).

Water licensing watershed boundaries were used as an approximation of groundwater flow system boundaries. Where water licensing watershed boundaries are used, aquifer boundaries are uncertain, and groundwater resources may be hydraulically continuous across the boundary.

The aquifer boundaries are uncertain where they correspond to alluvial deposit boundaries, as digitization of the surficial geological map (Levson and Fournier 2012; Trommelen and Levson 2011) may have introduced inaccuracies.

A.1.2 GEOLOGIC FORMATION (OVERLYING MATERIALS)

Where coarse-grained materials are not on the surface, the aquifer is overlain by silt, sandy silt, topsoil, and sandy clay that are part of the same alluvial deposit. Two of the three wells associated with the aquifer reported fine-grained material (silt and clay) on the surface, and one reported overburden on the surface. The thickness of the overlying material ranges from 0.6 to approximately 1.5 m.

A.1.3 GEOLOGIC FORMATION (AQUIFER) – 1A UNCONFINED FLUVIAL AQUIFER

The overburden aquifer is comprised of alluvial sediments, including alluvial floodplain, blanket, fan, and fluvial terrace deposits (silt, clay, sand, gravel; Levson and Fournier 2012). The unit is at surface but comprises interspersed coarse-grained and fine-grained materials; where the fine-grained materials are at surface, the coarse-grained materials may be locally confined.

A.1.4 VULNERABILITY

Depth to groundwater is shallow (5.2 to 7.3 metres below top of casing [mbtoc][1]). The aquifer is close to ground surface but may be locally covered by fine-grained material.

The aquifer is vulnerable to surface contamination near the edges of the river valley, as this is upgradient from the aquifer. The overall vulnerability of the aquifer to surface contamination has been qualitatively assessed to be high.

A.2 CONCEPTUAL UNDERSTANDING OF FLOW DYNAMICS

A.2.1 GROUNDWATER LEVELS AND FLOW DIRECTION

Static water levels recorded in the provincial groundwater wells database (GWELLS) are shallow, ranging from 5.2 to 7.3 mbtoc. There is one active provincial observation well within the aquifer, OW 481 (Well Tag Number [WTN] 118702). Although the groundwater flow direction could not be determined, the inferred shallow groundwater flow direction is expected to be primarily towards the Fort Nelson River and its tributaries.

A.2.2 RECHARGE

Recharge to the aquifer could occur via distributed infiltration of precipitation in areas where the overburden is thin. Much of the recharge is expected to occur in the spring associated with snowmelt. The aquifer may also be seasonally recharged by overlying the Fort Nelson River and its minor tributaries during high river water level periods. Correspondingly, the aquifer may discharge, providing baseflow to the river during periods of lower river water levels. However, the spatial and temporal understanding of the recharge mechanism is unknown, and further investigation is required to confirm this hydraulic connection.

A.2.3 POTENTIAL FOR HYDRAULIC CONNECTION

Groundwater in the aquifer is in direct hydraulic connection with its neighbouring overburden Aquifer 1289. Groundwater may also be hydraulically connected with the Fort Nelson River and its tributaries. Further investigation is required to better evaluate these hydraulic connections; however, the aquifer likely provides baseflow to the river or receives recharge from the river, depending on the relative water levels in the two water sources.

A.3 WATER MANAGEMENT

A.3.1 ADDITIONAL INFORMATION ON WATER USE AND MANAGEMENT

Stated yields in the well records range from 1.9 to 13.7 L/s, with a geometric mean of 5.6 L/s indicating high productivity with localized zones of medium productivity. Groundwater is used for domestic water

[1] Default water level unit in GWELLS: feet below top of casing (ft btoc). Water levels converted to m btoc, with no corrections made based on the presence or absence of reported stick-up values.

supply (two wells) and provincial monitoring (one well). No licences are associated with any of the wells, based on the GWELLS database.

A.3.2 ADDITIONAL ASSESSMENTS OR MANAGEMENT ACTIONS

No water availability or water budget studies have been completed in the area.

A.4 AQUIFER REFERENCES

Lengyel, T., J. Deri-Takacs, and A.C. Hinnell, 2024. Fort Nelson Aquifer Mapping and Hydrostratigraphic Characterization, Water Science Series, WSS2024-02. Province of British Columbia, Victoria.

Levson, V., Fournier, M. 2012. Surficial geology, Fort Nelson (NTS 94 J/NE), British Columbia, Geological Survey of Canada, Open File 7041, British Columbia Ministry of Energy and Mines, BCGS Geoscience Map 2011-06, scale 1:100,000. DOI:10.4095/291399

Trommelen, M., Levson, V. 2011. Surficial geology, Adsett Creek (NTS 94J/SE), British Columbia; British Columbia Ministry of Energy and Mines, BCGS Open File 2011-05; Geological Survey of Canada, Open File 6832, scale 1:100 000. DOI: 10.4095/288643.

A.5 REVISION HISTORY

Date	Version	Revision Class	Comments	Author
2013	1	Major	Initial mapping of aquifer	Kohut, A.P.
2023	2	Major	Aquifer boundaries updated to include hydraulically connected deposits	Tibor Lengyel, M.SC., P.Geo. Judit Deri-Takacs, Ph.D. Andrew Hinnell, Ph.D., P.Geo.

Aquifer Name: Muskwa-Fort Nelson Glaciofluvial Aquifer

Aquifer Number: 1288

Date of Mapping: October 30, 2023

Authors: Tibor Lengyel, M.Sc., P.Geo., Judit Deri-Takacs, Ph.D., and Andrew Hinnell, Ph.D., P.Geo.

A. AQUIFER DESCRIPTION FOR AQUIFER 1288

A.1 CONCEPTUAL UNDERSTANDING OF HYDROSTRATIGRAPHY

A.1.1 AQUIFER EXTENTS

The aquifer is located between the Muskwa and Fort Nelson rivers, east of the Prophet River. It was delineated based on the presence of glaciofluvial terrace sediments (Levson and Fournier 2012) in the west, east, and south and topography in the north (Lengyel et al. 2024).

A.1.2 GEOLOGIC FORMATION (OVERLYING MATERIALS)

Where coarse-grained materials are not on the surface, the aquifer is overlain by silt and sandy topsoil. One of the three wells assigned to the aquifer reported fine-grained material (silt) on the surface, one well reported coarse-grained (gravel) sediments, and one well reported overburden. The thickness of the overlying material ranges from 0 to approximately 2.7 m.

A.1.3 GEOLOGIC FORMATION (AQUIFER) – 4A UNCONFINED GLACIOFLUVIAL AQUIFER

The overburden aquifer is comprised of glaciofluvial terrace sediments, including sand and gravel, relatively high above the modern floodplain sediments. This aquifer is interpreted to be unconfined.

A.1.4 VULNERABILITY

Depth to groundwater was reported for one well at 7.9 metres below top of casing (mbtoc)[1]. The confining layer is relatively thin and, where present, consists of silt (with sand and gravel) and topsoil that are expected to have medium to high permeability. The overall vulnerability of the aquifer to surface contamination has been qualitatively assessed to be high.

[1] Default water level unit in GWELLS: feet below top of casing (ft btoc). Water levels converted to m btoc, with no corrections made based on the presence or absence of reported stick-up values.

A.2 CONCEPTUAL UNDERSTANDING OF FLOW DYNAMICS

A.2.1 GROUNDWATER LEVELS AND FLOW DIRECTION

Static water level was recorded in one well at 7.9 mbtoc. Although the groundwater flow direction could not be determined, it is assumed that the shallow groundwater flow direction is primarily downgradient and follows the topography.

A.2.2 RECHARGE

Recharge to the aquifer is expected to occur via distributed infiltration of precipitation and snowmelt, particularly in areas where the overburden is thin. Much of the recharge is expected to occur in the spring, associated with snowmelt. The spatial and temporal understanding of the recharge mechanism, however, is unknown, and further investigation is required to confirm this hydraulic connection.

A.2.3 POTENTIAL FOR HYDRAULIC CONNECTION

Further investigation is required to evaluate the hydraulic connections of the aquifer. The aquifer is not expected to be in hydraulic connection with the underlying Aquifer 1040 due to the intervening layer of fine-grained sediments (Figure 2; Lengyel et al. 2024).

A.3 WATER MANAGEMENT

A.3.1 ADDITIONAL INFORMATION ON WATER USE AND MANAGEMENT

Stated yields in the well records range from 8.55 to 8.64 L/s, with a geometric mean of 8.6 L/s indicating high productivity. Groundwater use was reported unknown for three wells and the wells are unlicensed.

A.3.2 ADDITIONAL ASSESSMENTS OR MANAGEMENT ACTIONS

No water availability or water budget studies have been completed in the area.

A.4 AQUIFER REFERENCES

Lengyel, T., J. Deri-Takacs, and A.C. Hinnell, 2024. Fort Nelson Aquifer Mapping and Hydrostratigraphic Characterization, Water Science Series, WSS2024-02. Province of British Columbia, Victoria.

Levson, V., Fournier, M. 2012. Surficial geology, Fort Nelson (NTS 94 J/NE), British Columbia, Geological Survey of Canada, Open File 7041, British Columbia Ministry of Energy and Mines, BCGS Geoscience Map 2011-06, scale 1:100,000. DOI: 10.4095/291399

A.5 REVISION HISTORY

Date	Version	Revision Class	Comments	Author
2013	1	Major	Initial mapping of aquifer as part of Aquifer 1040.	Kohut, A.P.
2023	2	Major	Aquifer boundaries updated; aquifer separated from underlying Middle Wisconsinan fluvial aquifer (Aquifer 1040).	Tibor Lengyel, M.SC., P.Geo. Judit Deri-Takacs, Ph.D. Andrew Hinnell, Ph.D., P.Geo.

Aquifer Name: Muskwa River Alluvial Aquifer

Aquifer Number: 1289

Date of Mapping: October 30, 2023

Authors: Tibor Lengyel, M.Sc., P.Geo., Judit Deri-Takacs, Ph.D., and Andrew Hinnell, Ph.D., P.Geo.

A. AQUIFER DESCRIPTION FOR AQUIFER 1289

A.1 CONCEPTUAL UNDERSTANDING OF HYDROSTRATIGRAPHY

A.1.1 AQUIFER EXTENTS

The aquifer is located along the Muskwa River. It was delineated based on the spatial distribution of alluvial sediments along the Muskwa River and the water licensing watershed boundary in the east towards Aquifer 1041 and in the south towards Aquifer 1290 (Levson and Fournier 2012; Trommelen and Levson 2011).

The aquifer boundaries are uncertain where they follow the margin of the Study Area in the west and along the water licensing watershed boundary (Lengyel et al. 2024).

Water licensing watershed boundaries were used as an approximation of groundwater flow system boundaries. Where water licensing watershed boundaries are used, aquifer boundaries are uncertain, and groundwater resources may be hydraulically continuous across the boundary.

The aquifer boundaries are uncertain where they correspond to alluvial deposit boundaries, as digitization of the surficial geological map (Levson and Fournier 2012; Trommelen and Levson 2011) may have introduced inaccuracies.

A.1.2 GEOLOGIC FORMATION (OVERLYING MATERIALS)

Where coarse-grained materials are not on the surface, the aquifer is overlain by silt, silt and sand, and topsoil that are part of the same alluvial deposit. Four of the five wells associated with the aquifer reported fine-grained material (silt) on the surface, and one well reported overburden on the surface. The thickness of the overlying material ranges from 5.5 to approximately 11.6 m.

A.1.3 GEOLOGIC FORMATION (AQUIFER) – 1A UNCONFINED FLUVIAL AQUIFER

The overburden aquifer is comprised of alluvial sediments, including alluvial floodplain, blanket, fan, and fluvial terrace deposits (silt, clay, sand, gravel; Levson and Fournier 2012). The unit is at surface but comprises interspersed coarse-grained and fine-grained materials; where the fine-grained materials are at surface, the coarse-grained materials may be locally confined.

A.1.4 VULNERABILITY

Depth to groundwater is shallow (5.8 to 9.1 metres below top of casing [mbtoc][1]). The aquifer is close to ground surface but may be locally covered by fine-grained material.

The aquifer is vulnerable to surface contamination near the edges of the river valley, as this is upgradient from the aquifer. The overall vulnerability of the aquifer to surface contamination has been qualitatively assessed to be high.

A.2 CONCEPTUAL UNDERSTANDING OF FLOW DYNAMICS

A.2.1 GROUNDWATER LEVELS AND FLOW DIRECTION

Static water levels recorded in the provincial groundwater wells database (GWELLS) are shallow, ranging from 5.8 to 9.1 mbtoc. There is no active provincial observation well within the aquifer. Although the groundwater flow direction could not be determined, the inferred shallow groundwater flow direction is expected to be primarily towards the Muskwa River and its tributaries, with a northeastern component consistent with regional topographical decline.

A.2.2 RECHARGE

Recharge to the aquifer could occur via distributed infiltration of precipitation and snowmelt in areas where the overburden is thin. Much of the recharge is expected to occur in the spring associated with snowmelt. The aquifer may also be seasonally recharged by the overlying Muskwa River and its minor tributaries during high river water level periods. Correspondingly, the aquifer may discharge, providing baseflow to the river during periods of lower river water levels. However, the spatial and temporal understanding of the recharge mechanism is unknown, and further investigation is required to confirm this hydraulic connection.

A.2.3 POTENTIAL FOR HYDRAULIC CONNECTION

Groundwater in the aquifer is in direct hydraulic connection with its neighbouring overburden Aquifers 1041 and 1290. Groundwater may also be hydraulically connected with the Muskwa River and its tributaries and with Aquifer 1288. Further investigation is required to better evaluate these hydraulic connections; however, the aquifer likely provides baseflow to the river or receives recharge from the river depending on the relative water levels in the two water sources.

A.3 WATER MANAGEMENT

A.3.1 ADDITIONAL INFORMATION ON WATER USE AND MANAGEMENT

Stated yields in the well records range from 3.2 to 8.2 L/s, with a geometric mean of 4.7 L/s indicating high productivity with localized zones of medium productivity. Groundwater is used for domestic and

[1] Default water level unit in GWELLS: feet below top of casing (ft btoc). Water levels converted to m btoc, with no corrections made based on the presence or absence of reported stick-up values.

commercial water supply (two wells). The water use in three wells is unknown. The wells are unlicensed, based on the GWELLS database.

A.3.2 ADDITIONAL ASSESSMENTS OR MANAGEMENT ACTIONS

No water availability or water budget studies have been completed in the area.

A.4 AQUIFER REFERENCES

Lengyel, T., J. Deri-Takacs, and A.C. Hinnell, 2024. Fort Nelson Aquifer Mapping and Hydrostratigraphic Characterization, Water Science Series, WSS2024-02. Province of British Columbia, Victoria.

Levson, V., Fournier, M. 2012. Surficial geology, Fort Nelson (NTS 94 J/NE), British Columbia, Geological Survey of Canada, Open File 7041, British Columbia Ministry of Energy and Mines, BCGS Geoscience Map 2011-06, scale 1:100,000. DOI:10.4095/291399

Trommelen, M., Levson, V. 2011. Surficial geology, Adsett Creek (NTS 94J/SE), British Columbia; British Columbia Ministry of Energy and Mines, BCGS Open File 2011-05; Geological Survey of Canada, Open File 6832, scale 1:100 000. DOI: 10.4095/288643.

A.5 REVISION HISTORY

Date	Version	Revision Class	Comments	Author
2023	1	Major	Initial mapping of aquifer	Tibor Lengyel, M.SC., P.Geo. Judit Deri-Takacs, Ph.D. Andrew Hinnell, Ph.D., P.Geo.

Aquifer Name: Prophet River Alluvial Aquifer

Aquifer Number: 1290

Date of Mapping: October 30, 2023

Authors: Tibor Lengyel, M.Sc., P.Geo., Judit Deri-Takacs, Ph.D., and Andrew Hinnell, Ph.D., P.Geo.

A. AQUIFER DESCRIPTION FOR AQUIFER 1290

A.1 CONCEPTUAL UNDERSTANDING OF HYDROSTRATIGRAPHY

A.1.1 AQUIFER EXTENTS

The aquifer is located along the Prophet River. It was delineated based on the spatial distribution of alluvial sediments along the Prophet River and the water licensing watershed boundary in the north towards Aquifer 1289 (Levson and Fournier 2012; Trommelen and Levson 2011).

The aquifer boundaries are uncertain where they follow the margin of the Study Area in the south and along the water licencing watershed boundary in the north (Lengyel et al. 2024).

Water licensing watershed boundaries were used as an approximation of groundwater flow system boundaries. Where water licensing watershed boundaries are used, aquifer boundaries are uncertain, and groundwater resources may be hydraulically continuous across the boundary.

The aquifer boundaries are uncertain where they correspond to alluvial deposit boundaries, as digitization of the surficial geological map (Levson and Fournier 2012; Trommelen and Levson 2011) may have introduced inaccuracies.

A.1.2 GEOLOGIC FORMATION (OVERLYING MATERIALS)

The aquifer has no wells associated with it. Where coarse-grained materials are not on the surface, the aquifer may be overlain by silt, silt and sand, and clay (Levson and Fournier 2012).

A.1.3 GEOLOGIC FORMATION (AQUIFER) – 1A UNCONFINED FLUVIAL AQUIFER

The overburden aquifer is comprised of alluvial sediments, including alluvial floodplain, blanket, fan, and fluvial terrace deposits (silt, clay, sand, gravel; Levson and Fournier 2012). The unit is at surface but comprises interspersed coarse-grained and fine-grained materials; where the fine-grained materials are at surface, locally the coarse-grained materials may be confined.

A.1.4 VULNERABILITY

Due to insufficient data, the water level in the aquifer could not be determined. The aquifer is at shallow depth but may be locally covered by fine-grained material. The aquifer is vulnerable to surface contamination near the edges of the river valley, as this is upgradient from the aquifer. The overall vulnerability of the aquifer to surface contamination has been qualitatively assessed to be high.

A.2 CONCEPTUAL UNDERSTANDING OF FLOW DYNAMICS

A.2.1 GROUNDWATER LEVELS AND FLOW DIRECTION

Although the groundwater flow direction could not be determined, the inferred shallow groundwater flow direction is expected to be primarily towards the Prophet River and its tributaries, with a northern component consistent with regional topographic decline.

A.2.2 RECHARGE

Recharge to the aquifer could occur via distributed infiltration of precipitation and snowmelt in areas where the overburden is thin. Much of the recharge is expected to occur in the spring associated with snowmelt. The aquifer may also be seasonally recharged by the Prophet River and its minor tributaries during high river water level periods. Correspondingly, the aquifer may discharge, providing baseflow to the river during periods of lower river water levels. However, the spatial and temporal understanding of the recharge mechanism is unknown, and further investigation is required to confirm this hydraulic connection.

A.2.3 POTENTIAL FOR HYDRAULIC CONNECTION

Groundwater in the aquifer is in direct hydraulic connection with its neighbouring overburden Aquifer 1289. Groundwater may be hydraulically connected with the Prophet River and its tributaries; however, further investigation is required to better evaluate these hydraulic connections; however, the aquifer likely provides baseflow to the river or receives recharge from the river depending on the relative water levels in the two water sources.

A.3 WATER MANAGEMENT

A.3.1 ADDITIONAL INFORMATION ON WATER USE AND MANAGEMENT

No additional information on water use and management is available for the aquifer.

A.3.2 ADDITIONAL ASSESSMENTS OR MANAGEMENT ACTIONS

No water availability or water budget studies have been completed in the area.

A.4 AQUIFER REFERENCES

Lengyel, T., J. Deri-Takacs, and A.C. Hinnell, 2024. Fort Nelson Aquifer Mapping and Hydrostratigraphic Characterization, Water Science Series, WSS2024-02. Province of British Columbia, Victoria.

Levson, V., Fournier, M. 2012. Surficial geology, Fort Nelson (NTS 94 J/NE), British Columbia, Geological Survey of Canada, Open File 7041, British Columbia Ministry of Energy and Mines, BCGS Geoscience Map 2011-06, scale 1:100,000. DOI:10.4095/291399

Trommelen, M., Levson, V. 2011. Surficial geology, Adsett Creek (NTS 94J/SE), British Columbia; British Columbia Ministry of Energy and Mines, BCGS Open File 2011-05; Geological Survey of Canada, Open File 6832, scale 1:100 000. DOI: 10.4095/288643.

A.5 REVISION HISTORY

Date	Version	Revision Class	Comments	Author
2023	1	Major	Initial mapping of aquifer	Tibor Lengyel, M.SC., P.Geo. Judit Deri-Takacs, Ph.D. Andrew Hinnell, Ph.D., P.Geo.

Aquifer Name: Pouce Creek Bedrock Aquifer

Aquifer Number: 1291

Date of Mapping: October 30, 2023

Authors: Tibor Lengyel, M.Sc., P.Geo., Judit Deri-Takacs, Ph.D., and Andrew Hinnell, Ph.D., P.Geo.

A. AQUIFER DESCRIPTION FOR AQUIFER 1291

A.1 CONCEPTUAL UNDERSTANDING OF HYDROSTRATIGRAPHY

A.1.1 AQUIFER EXTENTS

The aquifer is located north of the Muskwa River. It was delineated based on water licensing watershed boundaries and surface water bodies. The aquifer is bound to the east by the Muskwa River, to the south and west by the Pouce Creek and an unnamed tributary of the Pouce Creek, and to the north by the water licensing watershed boundary.

The aquifer boundaries are uncertain in the west along the unnamed tributary of the Pouce Creek and in the north, where they follow watershed boundaries.

Water licensing watershed boundaries were used as an approximation of groundwater flow system boundaries. Where water licensing watershed boundaries are used, aquifer boundaries are uncertain, and groundwater resources may be hydraulically continuous across the boundary.

A.1.2 GEOLOGIC FORMATION (OVERLYING MATERIALS)

The aquifer is overlain by till, glaciolacustrine, alluvial, organic, and colluvial deposits (Levson and Fournier 2012). Twenty-two out of the 27 wells associated with the aquifer reported fine-grained material (clay, till) at surface, one well reported coarse-grained (sand, gravel) sediments, one well reported overburden, one well reported bedrock (shale), and two wells had unknown lithology on the surface. The thickness of the overlying material ranges from 0 to 45.7 m.

A.1.3 GEOLOGIC FORMATION (AQUIFER) – 5A FRACTURED BEDROCK

The bedrock aquifer is comprised of sediments of the Sikanni and Buckinghorse formations of the Cretaceous Fort St. John Group. The Buckinghorse Formation consists of fine-grained deposits of mudstone, siltstone, and shale. The Buckinghorse Formation is overlain by the Sikanni Formation, which is dominated by sandstone (Massey et al. 2005). Permeability may be associated with both primary and secondary porosity (through fracturing) of the Sikanni, as well as of the Buckinghorse Formation (Lengyel et al. 2024). This aquifer is interpreted to be confined.

A.1.4 VULNERABILITY

Depth to groundwater varies from shallow to deep (6.1 to 91.5 metres below top of casing [mbtoc][1]).

The permeability of the overlying material is low. Surficial mapping by Levson and Fournier (2012) and borehole logs indicate that the bedrock aquifer is covered by fine-grained materials (dominantly clay and till) of variable thickness, including blankets of till, and with one well reported to have shale at the surface. The overall vulnerability of the aquifer to surface contamination has been qualitatively assessed to be moderate, except where overlain by till blankets or the bedrock outcrops, where the vulnerability is expected to be high.

A.2 CONCEPTUAL UNDERSTANDING OF FLOW DYNAMICS

A.2.1 GROUNDWATER LEVELS AND FLOW DIRECTION

Static water levels recorded in the provincial groundwater wells database (GWELLS) range from shallow (6.1 mbtoc) to deep (91.5 mbtoc). Groundwater flow direction in the bedrock was not determined; however, the groundwater surface is assumed to be a subdued representation of the topography based on the static water levels recorded in the GWELLS database (Lengyel et al. 2024; Figure 2). Groundwater is interpreted to flow from topographic highs towards topographic lows, primarily towards the Fort Nelson and Muskwa rivers and their tributaries towards the south and southeast.

A.2.2 RECHARGE

Recharge to the aquifer could occur via distributed infiltration of precipitation and snowmelt, particularly where the aquifer is in a topographically elevated position and in areas where the overburden is thin. Much of the recharge is expected to occur in the spring, associated with snowmelt. The spatial and temporal understanding of recharge mechanisms, however, is unknown, and further investigation is required to confirm this hydraulic connection.

A.2.3 POTENTIAL FOR HYDRAULIC CONNECTION

Groundwater in the aquifer is in direct hydraulic connection with its neighbouring bedrock Aquifer 1034. Aquifer boundaries are defined based on inferred groundwater flow paths within the Fort St. John Group rather than by structural boundaries. Hydraulic connection may exist between Aquifer 1291 and the overlying Middle Wisconsinan fluvial aquifer (Aquifer 1040) and with Aquifer 1289, where the intervening sediments have high conductivity and/or absent.

[1] Default water level unit in GWELLS: feet below top of casing (ft btoc). Water levels converted to m btoc, with no corrections made based on the presence or absence of reported stick-up values.

A.3 WATER MANAGEMENT

A.3.1 ADDITIONAL INFORMATION ON WATER USE AND MANAGEMENT

Stated yields in the well records range from 0.02 to 1.36 L/s, with a geometric mean of 0.20 L/s indicating low productivity with localized zones of moderate productivity. Groundwater use was reported for domestic purposes at four wells and for unknown purposes at 19 wells.

A.3.2 ADDITIONAL ASSESSMENTS OR MANAGEMENT ACTIONS

No water availability or water budget studies have been completed in the area.

A.4 AQUIFER REFERENCES

Lengyel, T., J. Deri-Takacs, and A.C. Hinnell, 2024. Fort Nelson Aquifer Mapping and Hydrostratigraphic Characterization, Water Science Series, WSS2024-02. Province of British Columbia, Victoria.

Levson, V., Fournier, M. 2012. Surficial geology, Fort Nelson (NTS 94 J/NE), British Columbia, Geological Survey of Canada, Open File 7041, British Columbia Ministry of Energy and Mines, BCGS Geoscience Map 2011-06, scale 1:100,000. DOI:10.4095/291399

Massey, N.W.D., MacIntyre, D.G., Desjardins, P.J. & Cooney, R.T. 2005. Geology of British Columbia. Ministry of Energy and Mines, BC Geological Survey, Geoscience Map 2005-3.

A.5 REVISION HISTORY

Date	Version	Revision Class	Comments	Author
2013	1	Major	Initial mapping of aquifer as part of 1034	Kohut, A.P.
2023	2	Major	Remapping of aquifer	Tibor Lengyel, M.SC., P.Geo. Judit Deri-Takacs, Ph.D. Andrew Hinnell, Ph.D., P.Geo.

APPENDIX B: AQUIFER SUMMARY

Table 1 - Summary of Aquifer Properties

Aquifer Number	Name	Lithostratigraphic Unit	Descriptive Location	Vulnerability	Subtype[1]	Material[2]	Quality Concerns[3]	Productivity	Artesian Conditions Noted	Obs. Wells	Changes to the Aquifer
1034	Cridland Creek Bedrock Aquifer	Sikanni and Buckinghorse formations	West of the Fort Nelson River, south of Cridland Creek	Moderate/High	5a	Bedrock	None	Moderate	Yes (WTN 102516)	Yes (OW 496)	Revised extent
1040	Muskwa-Fort Nelson Buried Valley	Middle Wisconsinan fluvial sand and gravel	Between the Fort Nelson and the Muskwa rivers, near Muskwa	Low	4b	Sand and Gravel	None	High	No	Yes (OW 482)	Revised extent, updated description
1041	Fort Nelson-River Alluvial Aquifer	Alluvial sand and gravel	Along the Fort Nelson River, both upstream and downstream of its confluence with the Muskwa River	High	1a	Sand and Gravel	None	High	No	Yes (OW 481)	Revised extent
1288	Muskwa-Fort Nelson Glaciofluvial Aquifer	Late Wisconsinan glaciofluvial	Along the Alaska Highway near Muskwa	High	4a	Sand and Gravel	None	High	No	No	Introduced as new aquifer
1289	Muskwa River Alluvial Aquifer	Alluvial sand and gravel	Along the Muskwa River upstream of its confluence with the Fort Nelson River	High	1a	Sand and Gravel	None	High	No	No	Introduced as new aquifer
1290	Prophet River Alluvial Aquifer	Alluvial sand and gravel	Along the Prophet River upstream of its confluence with the Muskwa River	High	1a	Sand and Gravel	Not available	High	No	No	Introduced as new aquifer
1291	Pouce Creek Bedrock Aquifer	Sikanni and Buckinghorse formations	Northwest of the Muskwa River, along Highway 97	Moderate/High	5a	Bedrock	None	Low	No	No	Introduced as new aquifer

Notes:

Parameters defined according to Berardinucci and Ronneseth, 2002

1 Aquifer subtype description available through the BC Data Catalogue https://catalogue.data.gov.bc.ca.

2 Aquifer 1041 may include silt and clay. Material description refers to the coarse-grained alluvial deposits

3 Based on available information. A more detailed review of water quality data would be required to understand water quality concerns. Due to the lack of wells in aquifer 1290, no information on water quality concerns is available.

APPENDIX C: AQUIFER SHAPEFILES

Digital files attached

APPENDIX D: AQUIFER-WELL CORRELATIONS

Digital files attached

APPENDIX E: WELL STRATIGRAPHY

Digital files attached