WATER SCIENCE SERIES

# Surficial Mapping British Columbia's Landforms to Support Groundwater Understanding

## Phase 1: Vanderhoof Watershed Group

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**Cover Photographs:**
Areal photograph of Vanderhoof Watershed Group with new surficial material mapping polygons.

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## EXECUTIVE SUMMARY

Understanding of British Columbia's (B.C.) complex surficial geological materials is crucial to understanding groundwater and surface water resources. Surficial material and landform mapping is foundational to many mapping inventories and decisions, including aquifer mapping and water allocation. Surficial material mapping is described in several different mapping types such as surficial geology, terrain and soils mapping. However, none of these surficial material maps cover the entire province at an appropriate and consistent scale for aquifer mapping and water allocation decisions.

This project is the first phase in a multi-phase project towards the development of simplified, unified and easy to understand surficial material mapping to support land use and water allocation decisions in the Province of B.C., Canada. This report describes and compares three surficial material maps in B.C.: surficial geology, terrain, and soils mapping. A table was developed to explore the relationship between the *common surficial material names* in the various types of maps and to harmonize the surficial material terms and descriptors from these three surficial material maps. Methods were explored to amalgamate and refine surficial material information from the three mapping inventories into a harmonized surficial mapping inventory.

The Vanderhoof Watershed Group was selected to compile data, develop, and test methods for harmonizing existing surficial material maps. This area lacked provincial aquifer mapping when the project was initiated, had a variety of mapping inventories with patchy coverage, and had gaps in these map inventories.

Existing data was reviewed to test the *common surficial material name* table by attempting to translate existing surficial material mapping to the *common surficial material name* categories; this proved very challenging. Harmonizing existing mapping and applying unified classification and resolving linework from overlapping surficial material maps was complicated due to different mapping purposes and conventions. Inconsistencies between mapping projects inhibited automation or scripting of the process and attempts to apply rules to the dataset always had exceptions.

New mapping was completed to delineate surficial materials and apply the simplified categories and test efficiency of gap filling. This proved challenging as compiling background information, preparing stereo imagery, project planning, and reporting were time consuming. As such, simplified mapping did not provide sufficient efficiencies for gap filling. Despite these challenges, the common terms and closed legend was a useful outcome of this study that supports the second phase of the project to pursue use of machine learning algorithms for harmonizing surficial material mapping.

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# 1. BACKGROUND

Understanding of British Columbia's (B.C.) complex surficial geological materials is crucial to understanding groundwater and surface water resources. Surficial geological materials (i.e., unconsolidated deposits) make up approximately seventy percent of mapped aquifers in the province, and there are many surficial aquifers that have not yet been mapped. B.C. lacks provincial and regional map coverage of mid-scale (i.e., 1:50 000 – 1:200 000 or 25-100 m pixel size), spatially accurate surficial material (substrate and landform) information, yet B.C. has the greatest variety of geology, materials and landforms in Canada. This variety is a driver for the wealth of natural resources in the province including water resources as well as forestry, mining, biodiversity, wildlife habitat, agriculture and cultural values (i.e., archeological studies). Surficial material information is often neglected or minimized in land-use and resource planning and decision making due to the lack of provincial and regional mapping.

In B.C., surficial aquifers can provide relatively shallow, abundant, and easy to access sources of groundwater. These aquifers can be vulnerable to contamination and often require considerations of surface water connectivity related to contamination, direct influence of surface water and environmental flow needs. With the implementation of the *Water Sustainability Act* (WSA) in 2016, non-domestic groundwater users require a water authorization. When considering an authorization application, decision makers consider the other water users, the volume of groundwater extracted from an aquifer and whether the volume allocated is sustainable. Additionally, impacts to potentially hydraulically connected streams are considered as groundwater extraction can reduce the amount of base-flow in streams and impact aquatic habitat. Where aquifer mapping is available, this information is invaluable in assessing the potential for impacts to neighbouring water supply wells, depletion of the aquifer and impacts to hydraulically connected streams.

## 1.1 Aquifer Mapping

To effectively manage groundwater and land use impacts, it is essential to understand the distribution and hydrogeologic characteristics of B.C.'s aquifers. Provincial aquifer mapping is often the first step in developing this understanding. Provincial aquifer mapping:

- Provides the regional context for groundwater development.
- Enables provincial priority setting for more detailed groundwater resource assessments and ongoing monitoring of groundwater availability and quality.
- Increases public understanding of this valuable resource.

Currently, aquifers are mapped using the aquifer classification system (Kreye and Wei, 1994) in high use, developed areas that have a relatively high number of groundwater wells. Aquifer mapping is not available for all aquifers in the province and approximately 14% of the wells in B.C. are not in mapped aquifers (GWELLS, 2022). The need for aquifer mapping and identification of groundwater resources will change as communities expand or new resource development projects are initiated. The province periodically initiates new aquifer mapping studies to address these needs.

While aquifer mapping is a useful first step, sustainable management of groundwater resources often requires more comprehensive aquifer characterization, completed through detailed studies which may include field-based measurements of groundwater levels or collection of groundwater samples. In complex systems, computer models may also be required to understand detailed groundwater information. Since 2016, the province has been publishing these types of studies through the B.C. Water Science Series (Water Science Series, 2023).

In areas where there is no aquifer mapping available, surficial materials maps could be used by decision makers to better understand the local geology with the goal of assessing potential impacts to other groundwater users and hydraulically connected streams. In addition, reconnaissance level surficial material mapping can identify data gaps and deficiencies to optimize investment in more detailed mapping.

## 1.2 Surficial Material Mapping in B.C.

Surficial material maps describe three dimensional landforms by mapping and dividing the landscape into two dimensional polygons with associated attributes describing the materials, their three-dimensional shape, and geomorphological processes within the delineated areas (Miller et al., 2017). Polygons are delineated by mappers using three-dimensional imagery so that landform edges can be detected, such as sharp breaks in slope at the edge of a floodplain.

Surficial material maps are useful tools for characterizing groundwater, to inform aquifer mapping, and to assess groundwater resources where aquifer mapping is not available. There are several types of surficial material maps, which are created for a variety of purposes, including surficial geology maps, terrain maps, and soils maps. Surficial material mapping coverage of B.C. is incomplete and has been done over several decades on a project-by-project basis. This mapped data is inconsistent in terms of scale, methods, classification, and mapper style. These inconsistencies, or issues, can be observed when looking at polygons that delineate the same feature, for example a fan, but the polygon lines (i.e., line work) does not exactly match up.

Mapping projects completed after 2005 are prepared by registered qualified professionals, who follow standards, protocols, and quality control and quality assurance procedures in line with their professional regulating body. Most surficial material maps in the province predate 2005 and were conducted by the province or through government funding. More recent mapping has been conducted by industry and qualified professionals but have no requirement for provincial data submission.

Closed and open legends are used in surficial maps. In a closed legend each polygon is assigned to a defined category listed in the legend (e.g., Till or Colluvium). In an open legend, sometimes referred to as a flexible legend, a combination of letters and numbers are used to construct a map label that describes the properties of the area defined by the polygon. In terrain mapping, for example, symbols can be constructed to describe combinations of materials in the horizontal plane and stratigraphic sequences in the vertical plane (Howes and Kenk, 1997). The almost infinite number of possible combinations makes this a very descriptive tool for an individual polygon but difficult for landscape level queries and analysis.

**Surficial Geology Maps** show the spatial distribution of surficial materials and their surface expression. These maps are created by defining project specific map units used in a closed legend, establishing the nature of map unit boundaries and establishing map unit geometries. Units are defined by surficial material type and surface expression, using a project-specific closed legend. Surficial geology maps are typically used for mineral and aggregate exploration, identifying suitable construction sites and natural hazard mitigations. They are produced by the British Columbia Geological Survey, the Geological Survey of Canada, and Geoscience B.C. Arnold and Ferbey (2019) summarize the spatial extent of available surficial geology maps in B.C.

**Terrain Maps** show the distribution of surficial materials and describe their surface expression. They also characterize the geomorphological processes that have shaped, or continue to shape, the landscape, such as a meandering channels or debris flows. Map unit boundaries are based on surficial material type, surface expression (landform and three-dimensional shape of the materials), geomorphic process, slope and drainage. These maps use an open legend in which a combination of characters describe each unit. This map type can have many unique polygons labels. Some terrain mapping projects include closed legend themes such as slope class, drainage and slope stability. Terrain mapping inventories are completed for different purposes that fall under three main types: terrain inventory maps, terrain stability maps, and bioterrain maps. Terrain mapping in B.C. is done under the B.C. Terrain Classification Standard (Howes and Kenk, 1997; B.C. Ministry of Environment, 2010; Resources Inventory Committee, 1996). Uses of these maps includes:

- Management of landslide risk to values such as water quality, high value habitat, timber resources, utilities, and infrastructure.
- Planning of forest road and cut block locations.
- Managing risk of sedimentation to values such as water quality, fish habitat, and wildlife habitat.
- Aggregate resources identification.
- Ecosystems and habitat mapping projects.
- Till prospecting.
- Terrain hazard and constraint identification.
- Identification of parent materials for soil classification.
- Watershed assessments.
- Environmental impact studies.
- Geological hazard mapping and geological risk assessment.

**Soil Maps** describe and classify those parts of the soil profile that support biologic activity, otherwise defined as the rooting depth of native perennial plants. This information is obtained by describing the basic soil unit, or pedon. Map unit boundaries are based on soil association descriptions. Information on landform classification (i.e., surficial material type), surface form (i.e., surface expression), and topographic class (i.e., slope) is also included in map unit labels. Like terrain maps, soil maps use an open legend in which map units are specified by a combination of characters. However, soil names/associations have a closed legend within an individual soil survey and have been correlated provincially and federally (B.C. Ministry of Environment, 2016).

Soil survey coverage varies in scale from 1:20,000 in the populated and agricultural valley bottoms to 1:100,000-1:250,000 in the forested uplands. There are large gaps in remote mountainous and northern areas of the province. Uses of these maps include:

- Agriculture capability mapping
- Land use planning
- Environmental impact studies
- Forestry

## 1.3 Purpose and Objectives of Study

This multiphase study was completed to provide a compilation of available surficial material mapping (i.e., terrain, soil and surficial geology maps) and pilot various ways of amalgamating these maps into a harmonized surficial material map. A mid-scale provincial coverage map of substrate and landform information is required to fill a scale and information gap for provincial and regional level prioritization and decision making.

The objectives of this multiphase study include:

- Testing and development of a methodology to produce easily accessible, scalable, and high-quality mid-scale surficial material map for B.C.
- Increasing the coverage and availability of surficial material maps at the regional scale in B.C.
- Supporting greater use of surficial material maps in groundwater stewardship and the spatial analysis of groundwater-surface water interactions.
- Increasing the availability and use of surficial material and landform information for resource allocation decision making and land-use planning.

The objective of Phase 1 includes testing of methodologies to produce a scalable and high-quality mid-scale surficial material map using a common classification system for the Vanderhoof Watershed Group (Figure 1). A priority of this work is that the available mapping was in an easily accessible GIS based mapping application (e.g., iMapBC).

## 2. SCOPE

To test alternative methodologies for producing a unified surficial materials map, a watershed was chosen which has existing mapping inventories that include:

- A variety of surficial material map types (including surficial material, terrain and soil).
- A variety of scales and coverages (overlapping maps versus only one map type available).
- Different vintages of mapping work (mapped across several decades).

The Vanderhoof Watershed Groups was chosen to support water resource mapping in the North Area, as there is limited aquifer mapping in this region. The Vanderhoof Watershed Groups consists of 43 map sheets (1:20,000). Within this area, three map sheets shown in Figure 1 were selected for new mapping where linework was delineated using a *common surficial material name* (described in Section 3). The Vanderhoof Watershed Groups was selected as they had the greatest variety of surficial maps, including gaps and overlaps to be reconciled by the proposed approach and had stereo imagery coverage.

## 3. METHODOLOGY

### 3.1 Unified Classification Development

A *common surficial material name* was identified as the "English name" of the domain parent material from terrain mapping, dominant surficial materials from soils mapping and surficial geology code from surficial geology mapping. A table was used to provide a common name to the various types of maps and naming systems used (Appendix A).

To support aquifer mapping, which are mapped based on geomorphic features, the dominant parent material from terrain mapping, dominant surficial materials from soils mapping and/or surficial geology code from surficial geology mapping were lumped together where possible (i.e., various types of peat and organic materials are lumped together into organic).

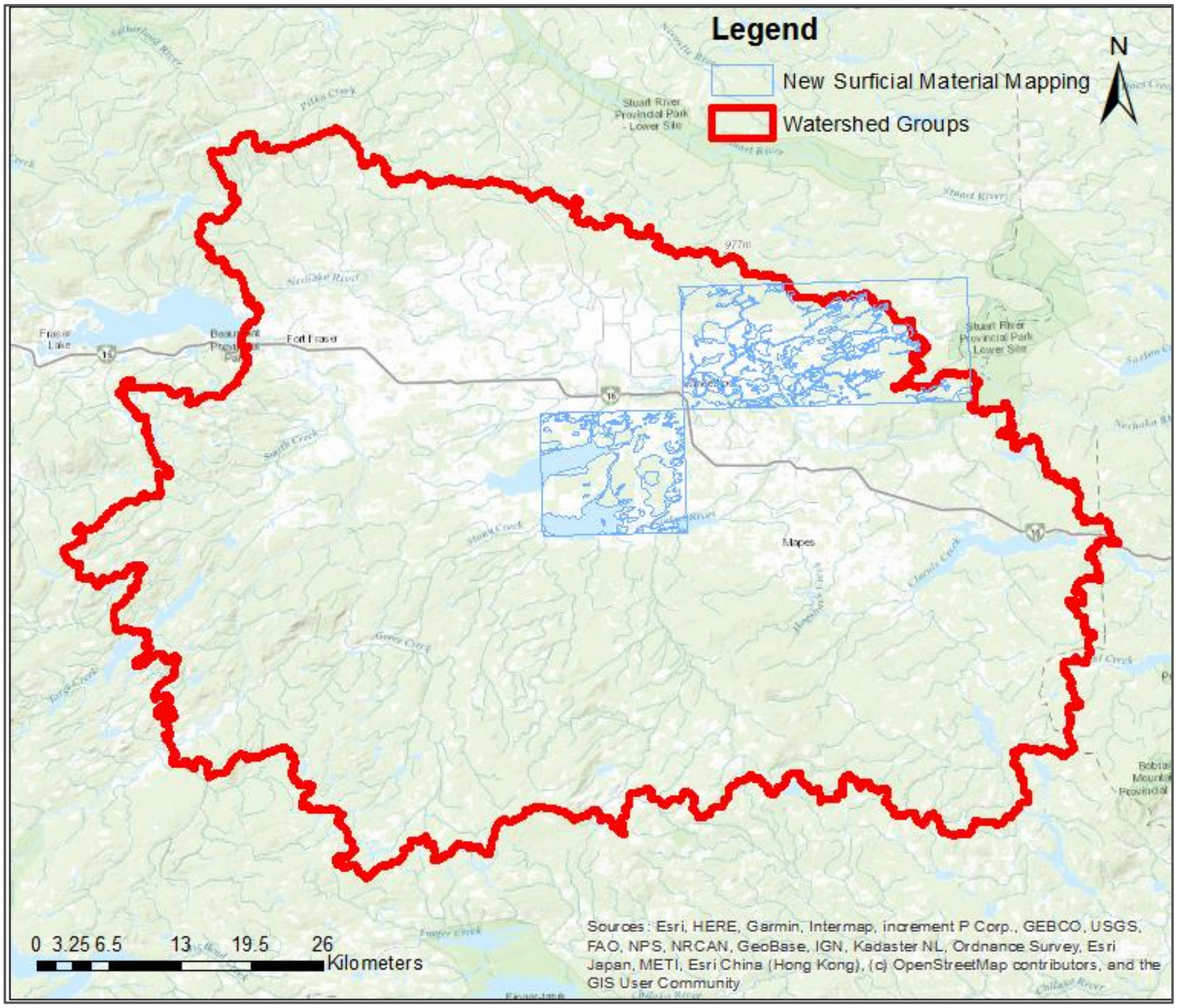


*Figure 1: Vanderhoof Watershed Group and new surficial material mapping area.*

## 3.2 Harmonizing Existing Mapping Inventories and Applying Unified Classification

The existing data inputs and mapping inventories used in this study were:

- Quaternary Geology
- Terrain Mapping Data
- Soils Survey Data
- Surficial Geology Mapping Projects
- Stereo Imagery

Two-dimensional stereo imagery was obtained through GeoBC. Available stereo-images from 2005 and 2006, with a minimum scale of 1:10:000, were acquired and viewed with PurView in ArcGIS 10.4. Figure 2 shows the available stereo-imagery coverage for the Vanderhoof Watershed Group. These were used for expert interpretation and assessment of the existing mapping layers.

To amalgamize the surficial material mapping in the Vanderhoof Watershed Group into a single map, overlapping polygons had to be resolved. This was approached by overlaying all available surficial material maps over stereo imagery and reviewing them to assign a *common surficial material name*. Where there is disagreement between polygon boundaries, a boundary was chosen or delineated using expert interpretation. Overlaps were reviewed at both the inventory scale and the polygon scale to explore whether a systematic approach to resolving discrepancies could be identified.

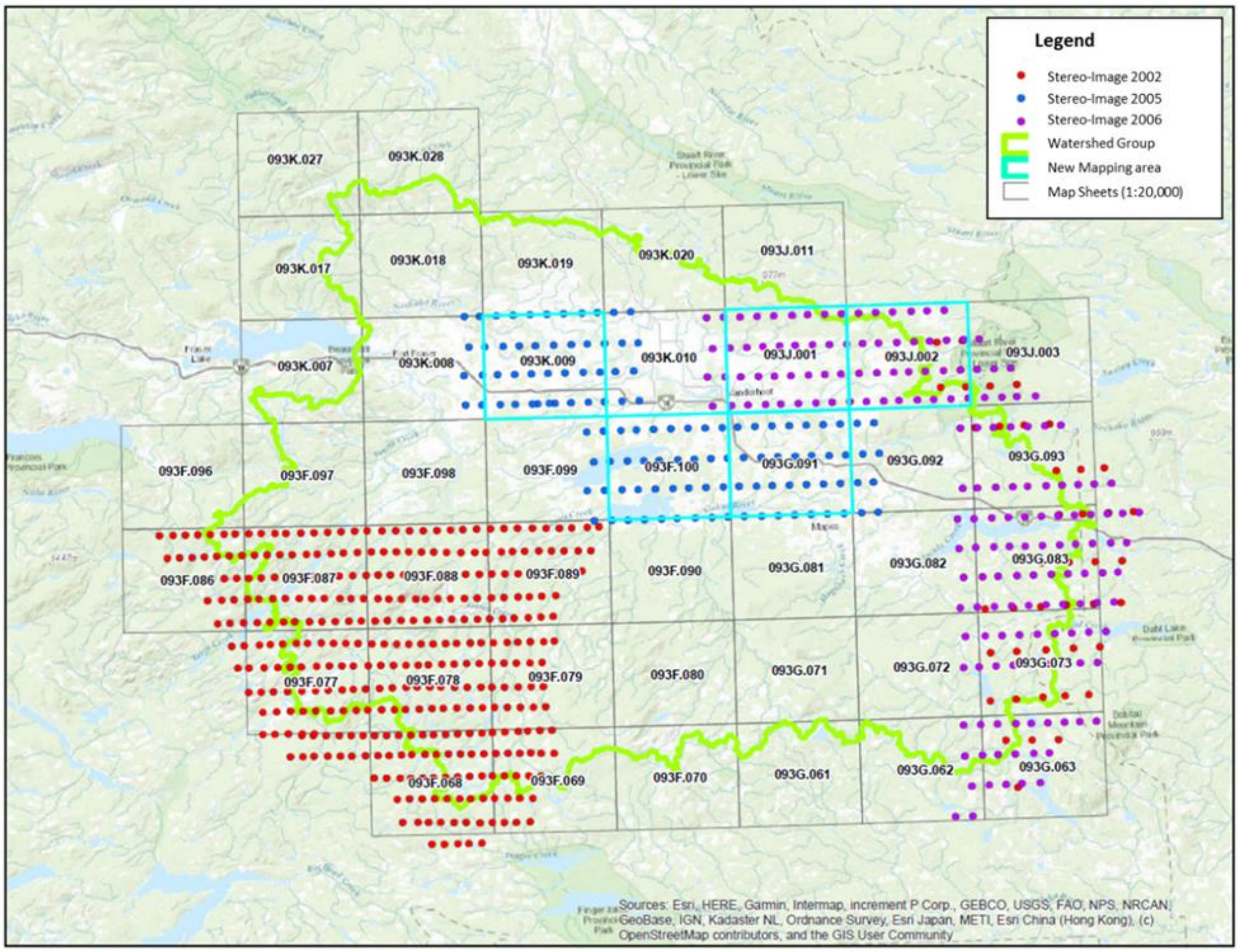


*Figure 2: Overview of available stereo imagery.*

## 3.3 New Surficial Material Mapping with Unified Classification

To fill in gaps and resolve overlaps with different polygon boundaries, new surficial material mapping, image interpretation and creation of new linework was done by mappers from Madrone Environmental (Madrone). This was completed for three map sheets in the Vanderhoof Watershed Group. The mappers subdivided the map sheets into priority envelopes based on land-use (e.g., agriculture land would be a high priority area while forested areas were not) and large geomorphic features. These defined areas were mapped first, reducing the map sheets into areas that require more detailed assessment. Surficial material and drainage were inferred based on the type of geomorphic feature identified following sections 4 and 6 of the Specifications and Guidelines for Terrain Mapping in British Columbia (Resources Inventory Committee, 1996). Terrain mappers use three-dimensional air photos observing texture, shape, colour and spatial relationships of geomorphic features to identify landforms and geomorphic processes. For example, indicators of active river channel include flat lying sediments adjacent major rivers with meander scars and river bars evident in three-dimensional shape and colour imagery. Braided and anastomosing river channels are typically associated with coarse textured sands and gravels. Vegetation cover and colour patterns are other clues to soil drainage and texture.

Madrone had two qualified professionals working on the map and report. Working at a minimum scale of 1:10,000 allowed Madrone to identify most features and draw polygons. For polygon attribution, Madrone utilized the B.C. Terrain Classification System (Resources Inventory Committee, 1996; Howes and Kenk, 1997) for terrain and surficial material descriptions. Additional information for each polygon included drainage and observations that assisted in interpretation. A column was created in the attribute table to assign each polygon a *common surficial material name*.

# 4. RESULTS AND DISCUSSION

## 4.1 Unified Classification Development

The table for the *common surficial material name* can be found in Appendix A.

The table indicates that nearly all materials have shared terms across terrain, soils code and surficial material codes where a common surficial material name could be easily identified. There was one instance where there was not a common name across the mapping terms (Not classified). Finally, there were some instances where multiple material names were combined in the soils mapping materials. These include the organics materials, fluvial materials, weathered bedrock, and bedrock types.

## 4.2 Amalgamizing Existing Mapping Inventories and Applying Unified Classification

Figure 3 shows the amalgamized existing map inventories and the new surficial materials mapping. Superficially, terrain mapped polygons are shown in black lines and soil mapping is shown as coloured polygons (classified by parent material). New mapping linework can be seen as light blue lines. Existing surficial material mapping was completed at different scales. This can be seen by the finer resolution of the terrain mapping in the southwest corner of the Vanderhoof Watershed Group and to the northeast of the Vanderhoof Watershed Group, and by the absence terrain mapping in the central area. Soils mapping was completed for the entire Vanderhoof Watershed Group.

The terrain and soil mapping line work are similar, although there are areas where there are significant differences. The greatest discrepancies between mapping appears to occur in areas of glacial lacustrine deposits (purple polygons on the soils map). These discrepancies were the most challenging to resolve and required expert interpretation by Madrone, which led to a refined process of harmonizing the existing mapping inventories by drawing new line work.

Although some mapping objectives were not achieved in Phase 1, there were a number of learnings from this study that will benefit Phase 2 of the mapping project. In general, the pilot did not cover as much area as anticipated with the available budget. The efficiencies gained through the *common surficial material name* (Appendix A) were minimal compared to the efforts needed for gathering of existing data, stereo image compilation and setup, report writing and other project tasks. Many challenges were encountered in working with legacy data.

Challenges arose related to differing mapping conventions describing mapping project type and purpose. It was difficult to choose one surficial material mapping project over another. Due to these challenges, the methodology done for this phase of the project was not conducive to automation or work on a large scale as each polygon required individual consideration.

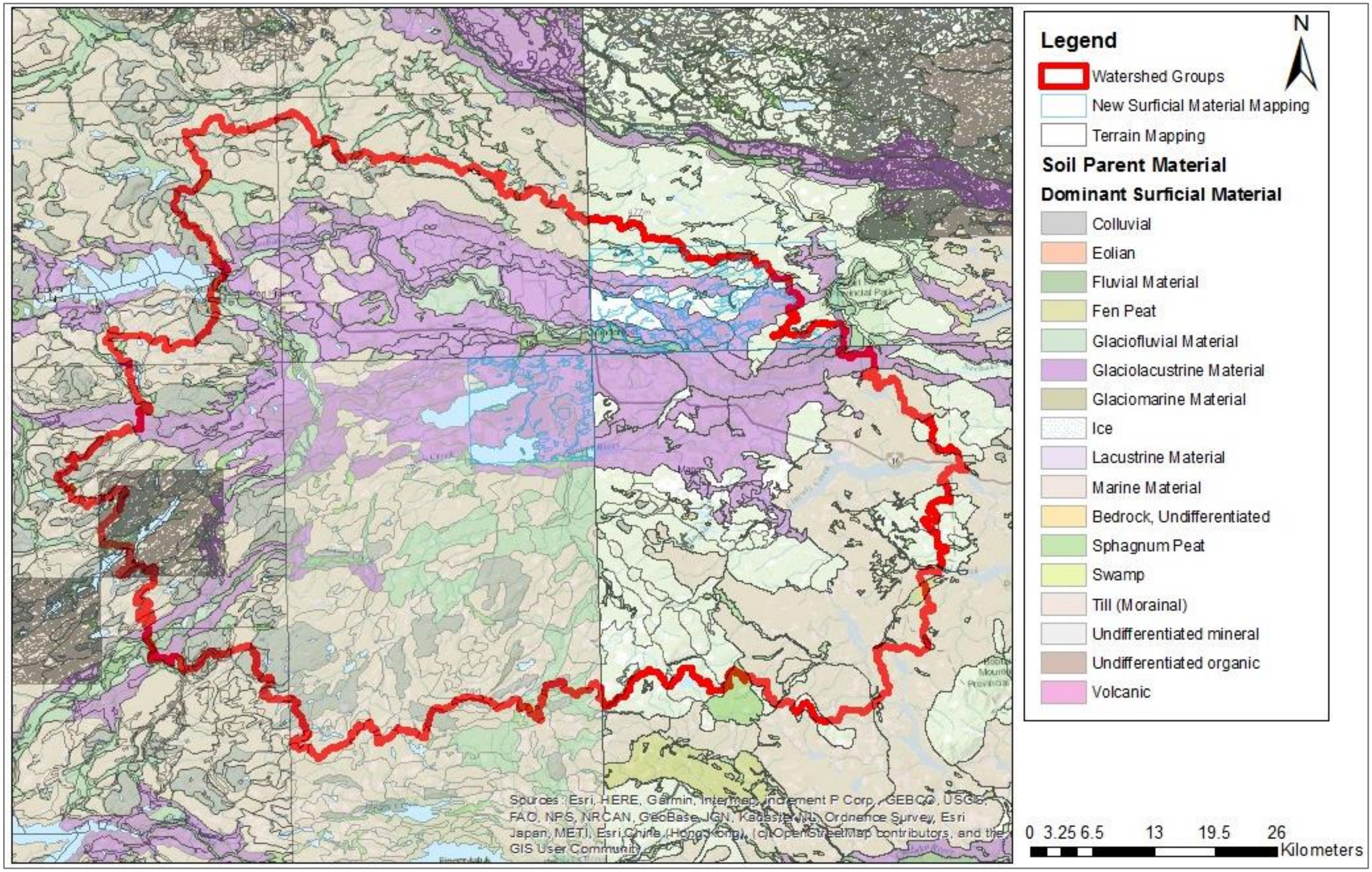


*Figure 3: Multiple overlapping surficial mapping inventories of various scales in the Vanderhoof Watershed Group resulting in spatial confusion.*

This method proved problematic as there were differences in polygon boundaries between projects. There does not appear to be a reliable combination of attributes to assign priority to different surficial material maps using values such as map type, scale, map purpose, study date and mapper. In addition, few of the overlain polygon linework agree (polygon location and boundary) as the intended application of the different maps are concerned with different depths of the surficial material based on the map project goals and purpose (i.e., soil rooting zone, slope breaks for stability, importance of thin surface layers for ecological mapping), as shown in Figure 3.

### 4.3 Refined Approach for Harmonized Mapping with Unified Classification

Due to the challenges encountered in harmonizing the existing mapping inventories, the methodology was adjusted to allow creation of new linework using expert knowledge and image interpretation. Subdividing areas into priority areas based on land-use was considered useful. It was observed that differing land-uses were distributed between private land parcels, which resulted in a patchwork of variously sized squares and rectangles. Within priority areas, it was found that mapping features such as terraces, scarps and riparian was straight-forward. However, small-scale features with minimal relief presented a challenge. Working at a minimum scale of 1:10,000 was efficient and allowed the mappers to identify most features and draw polygons.

It is suspected that along with issues in the study methodology, including issues in prioritizing the various map types as discussed above, the Vanderhoof Watershed Group was challenging in other ways. Specifically, the surficial materials consist of very thick valley fill, which can be difficult to map using stereo image interpretation alone.

## 5. LEARNINGS AND RECOMMENDATIONS

### 5.1 Learnings

A mid-scale provincial coverage of substrate and landform mapping is required to fill a scale and information gap for groundwater stewardship and decision support. Current datasets that cover the entire province have poor spatial accuracy and landscape classification that is too generalized for provincial and regional spatial analysis with other provincial data sets. Detailed inventories have gaps and overlaps, inconsistencies between projects, and use a variety of classification schemes that make provincial compilations challenging. Open and complex legends are not conducive to GIS analysis and use outside of a small community of experts. These challenges make it difficult to automate translation of project level data into the *common surficial material name* proposed in Appendix A.

A method to fill gaps in current datasets should be more consistent, broadly understood, and cost effective than existing and well-established approaches. Phase 2 of this project begins to explore a methodology to advance this goal. To effectively fill gaps in coverage, the layers need to be at a finer resolution and have more attribution than existing datasets that cover the province. For example, the Quaternary Geology DataBC layer has poor spatial accuracy and polygon sizes that are too generalized for provincial and regional spatial analysis with other provincial data sets (B.C. Geological Survey, 2018) (Figure 4).

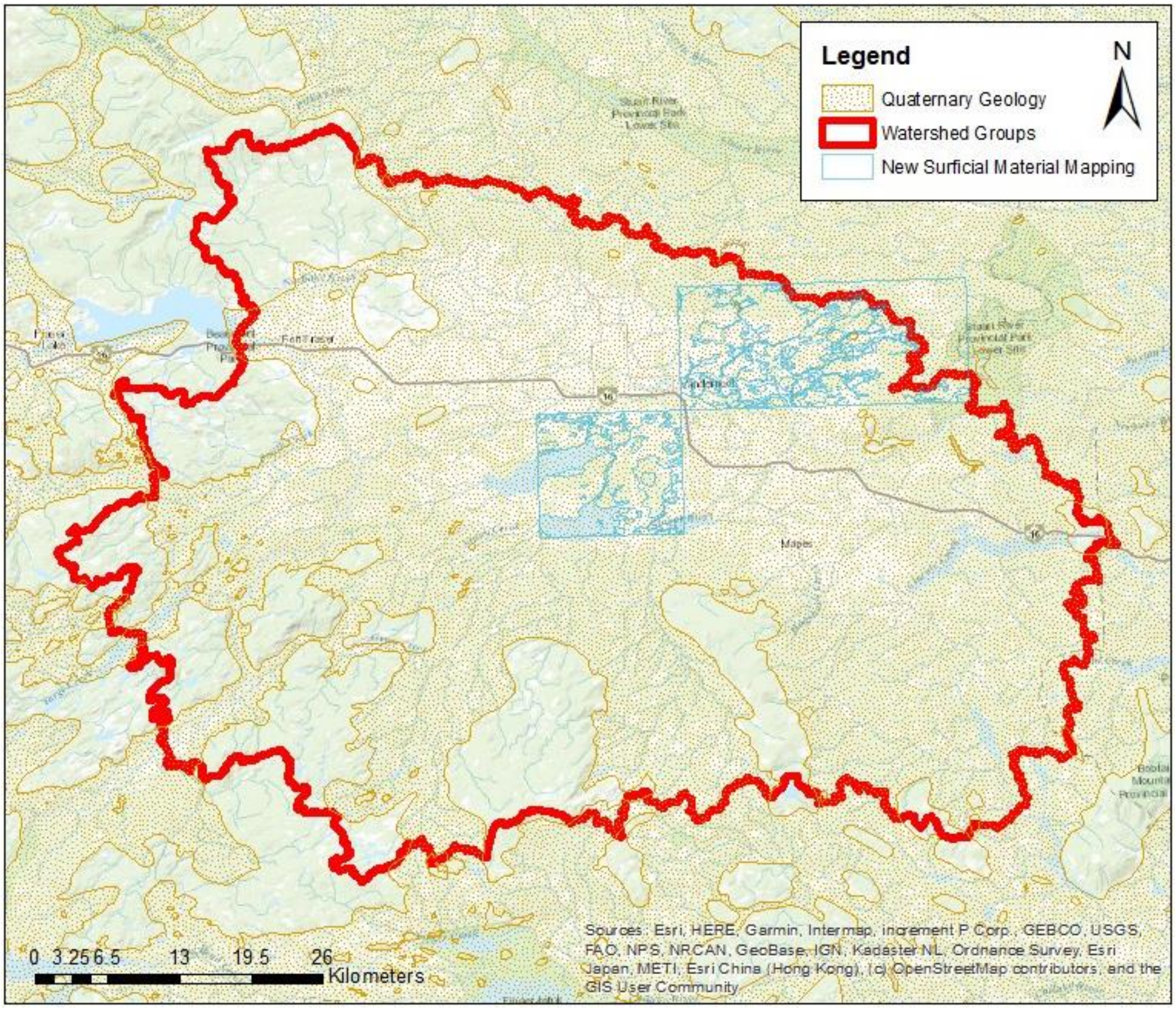


*Figure 4: Quaternary Geology of the Vanderhoof Watershed Group.*

This study identified *common surficial material names* in the existing surficial material maps. This *common surficial material name* provides a closed legend that describes landforms and substrate complexes in B.C., which supports groundwater stewardship and decision making by identifying repeating patterns of enduring features and by defining the surficial materials, landforms and processes that dominate these surficial material maps. The proposed *common surficial material name* in Appendix A provides consistent terminology across surficial material mapping that describe surficial materials and soils in B.C and Canada. This is a step towards consistent mapping relevant to natural resource management including land-use planning, climate change strategy, water resources, environmental assessment, habitat management, mapping, monitoring and cumulative effects. This unified classification will be conducive to machine learning and GIS analysis.

## 5.2 Next Steps

Learnings from this Phase 1 study point towards the following potential actions and recommendations:

- Amalgamize existing surficial material information and make it available to decision makers, industry, and the public. This would include:
    - Existing project footprints and metadata with links to the data.
    - Development of web interfaces.
    - Education and outreach for use of existing sources of surficial material information, for example content and targeted presentations for how to use these maps (e.g., water authorization, water professionals).
- Further steps towards development of a provincial surficial materials map:
    - Develop requirements for field observations and mapping of surficial materials to be submitted to the province in machine readable formats.
    - Pilot test machine learning techniques for mapping the harmonized *surficial material name*.
    - Establish other mappable categories such as landforms, aquifer class, and material characteristics.

## 5.3 Conclusions

Compiling background information, preparing stereo imagery, project planning and reporting were time consuming. Harmonizing existing mapped inventories was complicated due to different surficial material mapping purposes and inconsistencies that precluded automation or scripting of the process. Simplified mapping did not provide sufficient efficiencies for gap filling. However, the closed legend for *common surficial material name* classification provides a consistent and mappable unit that may facilitate further efforts towards a provincial map such as a machine learning approach. The next steps are to use the benefits of the harmonized legend and machine learning to overcome the various surficial material mapping issues as well as mapper bias.

# REFERENCES


Arnold, H. and T. Ferbey, 2019. British Columbia Surficial Geology Map Index. British Columbia Geological Survey, Open File 2019-03 version 2020-01.

B.C. Geological Survey, 2018. Geology Quaternary Alluvium and Cover. Online from the B.C. Data Catalogue: https://catalogue.data.gov.bc.ca/dataset/geology-quaternary-alluvium-and-cover (Retrieved 2023).

B.C. Ministry of Environment, 2010. Terrestrial Ecosystem Information Digital Data Submission Standard - Draft for Field Testing: Database and GIS Data Standards. B.C. Ministry of Environment, Ecosystems Branch, Victoria.

B.C. Ministry of Environment, 2016. Soil Name and Layer Files. B.C. Ministry of Environment, Knowledge Management Branch. Online from the B.C. Data Catalogue: https://catalogue.data.gov.bc.ca/dataset/a3bc4cd3-0f1b-4a2f-bd88-76f821756d10 (Retrieved 2020).

GWELLS, 2022. Government of B.C. Groundwater Wells and Aquifers Database (GWELLS). Online: https://apps.nrs.gov.bc.ca/gwells/ (Accessed November 2022).

Howes, D.E. and E. Kenk, 1997. Terrain Classification System for British Columbia (Version 2). Resources Inventory Branch, B.C. Ministry of Environment, Lands and Parks, Victoria.

Kreye, R. and M. Wei, 1994. A Proposed Aquifer Classification System for Groundwater Management in British Columbia. B.C. Ministry of Environment, Lands and Parks, Water Management Division, Hydrology Branch, Victoria.

Miller, B., D. Filatow, A. Dufresne, M. Geertsema and M. Dinney, 2017. Engineering Geomorphological Mapping. In: Bobrowsky, P., Marker, B. (eds) Encyclopedia of Engineering Geology. Encyclopedia of Earth Sciences Series. Springer, Cham. https://doi.org/10.1007/978-3-319-12127-7_108-1

Resources Inventory Committee, 1996. Guidelines and Standards to Terrain Mapping in British Columbia. Surficial Geology Task Group, Earth Sciences Task Force, British Columbia.

Water Science Series, 2023. Government of B.C. Water Science Series. Online: https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-science-data/water-science-series (Accessed July 2023).

## APPENDIX A: UNIFIED CLASSIFICATION SURFICIAL MATERIAL TABLE

| Common Surficial Material Name | Terrain Code[2] | Terrain Name | Soils Code[3] | Soils Name | Surficial Geology Code[4] | Surficial Geology Name |
|---|---|---|---|---|---|---|
| Not mapped | N | Not Classified | | | | |
| Ice | I | Ice | ICE | Ice | I | Ice |
| Anthropogenic | A | Anthropogenic Material | ANTH | Anthropogenic | A | Anthropogenic Material |
| Organic | O | Organic Material | FNPT | Fen Peat | O | Organic Material |
| | | | FOPT | Forest Peat | | |
| | | | SEPT | Sedimentary Peat | | |
| | | | SPPT | Sphagnum Peat | | |
| | | | SWMP | Swamp | | |
| | | | UNDO | Undifferentiated organic | | |
| Undifferentiated | U | Undifferentiated Material | UNDM | Undifferentiated mineral | U | Undifferentiated Materials |
| Colluvial | C | Colluvium | COLL | Colluvial | C | Colluvium |
| Eolian | E | Eolian | EOLI | Eolian | E | Eolian Material |
| Fluvial | F | Fluvial Material | FLUV | Fluvial | F | Fluvial Material |
| | | | FLEO | Fluvioeolian | | |
| | | | FLLC | Fluviolacustrine | | |
| Lacustrian | L | Lacustrian Material | LACU | Lacustrine | L | Lacustrine Material |
| Marine | W | Marine Material | MARI | Marine | W | Marine Material |
| Glaciocolluvium | CG | Glaciocolluvium | | | | |
| Glaciofluvial | FG | Glaciofluvial Material | GLFL | Glaciofluvial | $F^G$ | Glaciofluvial Material |
| Glaciolacustrian | LG | Glaciolacustrian Material | GLLC | Glaciolacustrine | $L^G$ | Glaciolacustrine Material |
| Glaciomarine | WG | Glaciomarine Material | GLMA | Glaciomarine | $W^G$ | Glaciomarine Material |
| Till | M | Morainal Material (till) | TILL | Till (Morainal) | M | Morainal Material (Till) |
| | | | LATL | Lacustro-Till | | |

| Common Surficial Material Name | Terrain Code[2] | Terrain Name | Soils Code[3] | Soils Name | Surficial Geology Code[4] | Surficial Geology Name |
|---|---|---|---|---|---|---|
| Weathered Bedrock | D | Weathered Bedrock (in situ) | SAPR | Saprolite | D | Weathered Bedrock (in situ) |
| | | | RESD | Residual | | |
| Bedrock | R | Bedrock | RKCA | Calcareous bedrock (dominantly sandstone and shale) | R | Bedrock |
| | | | RKGN | Gneiss bedrock | | |
| | | | RKIA | Igneous, acidic bedrock (dominantly granite) | | |
| | | | RKIB | Igneous, basic bedrock (dominantly basalt) | | |
| | | | RKIC | Igneous, basic coarse bedrock (coarse grained basalts) | | |
| | | | RKIF | Igneous, basic fine grained bedrock (dominantly andesites) | | |
| | | | RKLS | Limestone bedrock (limestone and dolomite) | | |
| | | | RKQU | Quartzite bedrock | | |
| | | | RKSA | Slate bedrock | | |
| | | | RKSH | Shale bedrock | | |
| | | | RKSM | Siltstone and mudstone bedrock | | |
| | | | RKSP | Schist and phyllite bedrock | | |
| | | | RKSS | Sandstone bedrock | | |
| | | | RKUD | Bedrock Undifferentiated | | |
| Volcanic | V | Volcanic Material | VOLC | Volcanic | V | Volcanic Material |

Note: 1. Cells align to “English word” and not necessarily align between soils, terrain and surficial geology code. 2. Terrain Mapping domain parent material name and symbol. 3. Soils mapping dominant surficial material name and symbol. 4. Surficial geology mapping material name and symbol.