BGC

District of Wells

Regional Flood Hazard Assessment

DRAFT

Prepared by BGC Engineering Inc. for:

February 10, 2025

Project 2546-007

Document 2546007-001-RT-RevA

Pioneering responsible solutions to complex earth science challenges

February 10, 2025

Project 2546-007
Document 2546007-001-RT-RevA

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Attention: Randy Brown, Senior Project Manager

Regional Flood Hazard Assessment – DRAFT

Please find the above-referenced DRAFT report attached for your review and comment on the general structure of the report and its preliminary Table of Contents. We appreciate the opportunity to collaborate with you on this challenging and interesting project.

Should you have any questions, please do not hesitate to contact the undersigned.

Yours sincerely,

BGC Engineering Inc.
per:

Hamish Weatherly, M.Sc., P.Geo.
Principal Hydrologist

EXECUTIVE SUMMARY

Body text

TABLE OF REVISIONS

Date	Revision	Remarks
February 10, 2025	A	Draft report

CREDITS AND ACKNOWLEDGEMENTS

BGC would like to acknowledge *Name* and *Name* for their contributions to this report.

BGC would also like to express its appreciation for the support and input provided by external reviewers/contributors including *Name, Title, Company, or Organization*.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF DRAWINGS

Enter the list of drawings here, if applicable, otherwise delete this list entry.

LIST OF APPENDICES

NO TABLE OF CONTENTS ENTRIES FOUND.

1.0 INTRODUCTION

1.1 Background

The District of Wells (DoW) is located in central British Columbia within the Cariboo Regional District (CRD). Situated along BC Highway 26, the DoW covers an area of approximately 168 km² and has a population of just over 200 people. The region's economy thrives on tourism, forestry, and mining, which attract an additional 200 to 3,500 people depending on the season. Small businesses play a crucial role in supporting these industries. Major changes may also be coming to the community, as Osisko Development Corporation (Osisko) has been granted an operating permit by the provincial government for the underground Cariboo Gold Mine.

The DoW is renowned for its rich history, vibrant art scene, and adventurous spirit, drawing many visitors each year. Barkerville Historic Town & Park, a world-class tourist attraction, borders the District. Moreover, it serves as the gateway to Bowron Lake Provincial Park and Cariboo Mountains Provincial Park, offering essential services to the surrounding communities. The DoW lies within the Traditional Territory of the Lhtako Dene Nation.

In March 2024, BGC Engineering Inc. (BGC) supported the DoW, with the Lhtako First Nation as a regional partner, in the development of a Union of BC Municipalities (UBCM) Disaster Risk Reduction-Climate Adaptation (DRR-CA) application for Category 1, 2 and 3 funding. This funding provides support for communities and other applicants to reduce risks associated with natural hazards and climate-related risks through the development of foundational knowledge of natural hazards and associated risks under a changing climate, as well as the development of effective strategies to prepare for, mitigate and adapt to the identified risks.

The DoW and Lhtako First Nation subsequently received funding for a Category 1 study, which is the development of a Regional Flood Hazard Assessment for four key watersheds within the DoW: Jack of Clubs Creek, Lowhee Creek, Williams Creek, and Downey Creek (Figure 1-1). This report provides the results of that Regional Flood Hazard Assessment.

R. Radloff and Associates Inc. (Radloff) are administering the Regional Flood Hazard Assessment work on behalf of the DoW. As such, this work is being conducted under the Terms and Conditions laid out in the Professional Services Agreement between Radloff and BGC, dated January 19, 2024.

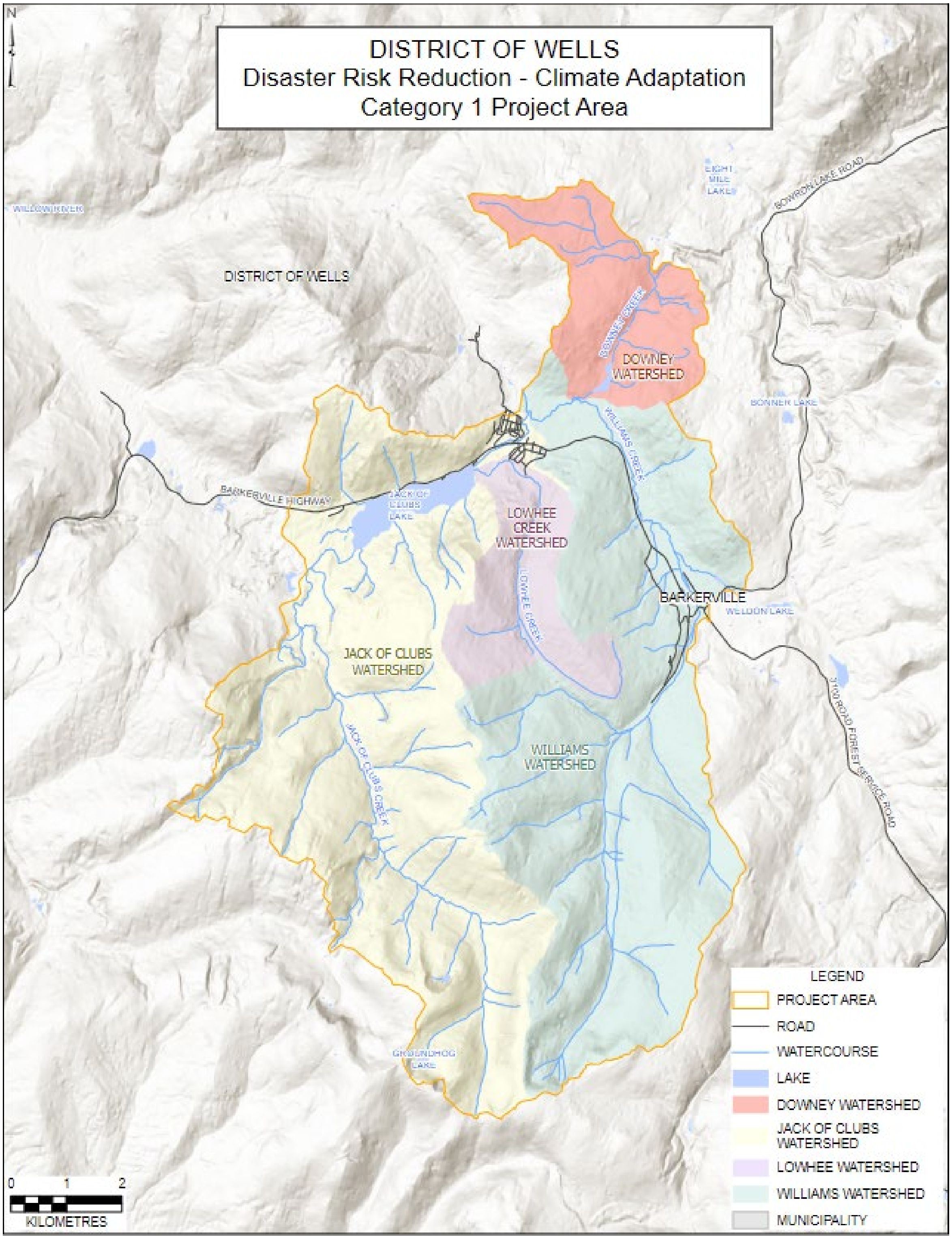

Figure 1-1 Location map of the study area.

1.2 Level of Detail

The primary objective of this study is to characterize clear-water flood hazards ("hazards") in the DoW. The goal is to support decisions that prevent or reduce injury or loss of life, environmental damage, and economic loss due to clear-water floods. The assessment includes floods resulting from elevated discharge on creeks and rivers due to rainfall and snowmelt runoff.

The deliverables of this study include "base level" flood hazard maps for Williams Creek and Downey Creek and "detailed" flood hazard maps for Lowhee Creek and Jack of Clubs Creek. While flood mapping studies are an important tool for developing safe and resilient communities, detailed studies are expensive and time consuming and therefore undertaken only when there are recognized hazards.

Recognizing the cost of detailed flood mapping, organizations responsible for flood management in the USA have begun to consider less costly flood mapping at a screening level. The US Federal Emergency Management Agency (FEMA) refers to this level of assessment as "Base Level Engineering" (BLE) (FEMA, 2018) and it is here referred to as "base level" hazard mapping.

While not as accurate as detailed flood studies, "base level" flood hazard maps can be completed at far lower cost per area assessed (factor of 10 lower). A key aspect of "base level" flood hazard maps is that the topographic data used for hydraulic modelling are based on available digital elevation models that generally do not account for the full river bathymetry[2]. As such, it is possible to complete mapping over much larger areas to support decision making. Where required, "base level" flood hazard maps can also be applied to serve as a basis for more detailed mapping in the future, given it is more efficient to refine the models than prepare detailed flood maps from scratch.

The original grant application envisioned "base level" flood hazard maps for all four watercourses. However, the DoW has also received Category 3 funding for the construction of flood mitigation infrastructure along Lowhee Creek and Jack of Clubs Creek. As part of that work, "detailed" flood hazard assessments have been generated for both creeks, the results of which are reported here-in.

Table 1-1 clarifies these levels of detail in terms of their applicability to decision making. Each increased level of detail is a refinement of previous work. Effort (cost) increases exponentially with the level of detail required, and this phased approach will help the DoW make progress on flood management across multiple funding cycles, focusing effort on the highest priority areas.

[2] In cases, where lidar data are available, a significant component of the river bathymetry can be captured if the data were acquired during a period of low flow.

Table 1-1 Hazard assessment levels of detail.

Points of Comparison	Hazard Identification Maps	Flood Hazard Assessment & Maps	
		Base Level	Detailed
Applicability for decision making	Suitable for prioritization and definition of the outer boundary of hazard areas subject to subdivision regulation in Official Community Plans (OCPs)	Suitable for application in planning and policy, and emergency management; limited application for land development regulation, & mitigation planning.	Suitable for parcel scale risk management, including risk assessment & bylaw enforcement, hazard monitoring, and detailed emergency response & mitigation planning
Level of detail	Hazard boundary (hazard extent and attributes, but not mapped flow characteristics)	Hazard characteristics (flow velocity or depth) displayed within the hazard boundary	Hazard characteristics displayed within the hazard boundary
Relative level of effort for a given study area	$	$$	$$$$
Examples and application to this scope of work.	Floodplain identification map	Base level flood mapping; **provided in this study**.	Detailed flood mapping; **provided in this study.**
Inputs	Desktop analyses	Desktop analyses, limited fieldwork	Desktop analyses, field surveys of bathymetry of hydraulic structures, and field surveys of geomorphic factors.
Hazard return periods considered	Single (to compare sites)	One or more return periods	Multiple return periods & scenarios
Qualitative/Quantitative	Relative, qualitative	Quantitative	Quantitative
Map Deliverables	Hazard boundaries	Hazard maps	Hazard maps
Applicable Guidelines	NRCAN (2018)	NRCAN (2018); FEMA (2018)	EGBC (2017, 2018)

1.3 Scope of Work

BGC's scope of work is outlined in the proposed work plan (January 23, 2025). Radloff and Associates Inc. (Radloff) are administering the Regional Flood Hazard Assessment work on behalf of the DoW. As such, this work is being conducted under the Terms and Conditions laid out in the Professional Services Agreement between Radloff and BGC, dated January 19, 2024.

The scope of work included:

Background Review and Analysis:

- Conduct a comprehensive review and synthesis of past reports and studies. Compile and review existing spatial datasets, including lidar and aerial imagery. Assess regional characteristics such as geology, vegetation, hydrology, and climate to establish a foundational understanding of the area.
- Identify key regional issues such as the Cariboo Gold Mine development, forestry, wildifre, past placer mining, water quality, and seidment contamination.
- Kick off meeting with the DoW to discuss the project goals, timeline and engagement.
- Kick off meeting with the Lhtako Dene First Nation to align on project scope and identify interest/opportunities for integration of Traditional Knowledge.
- Plan and facilitate a public Introductory Open House to provide the community with an overview of the project scope, and to review and discuss the community's understanding of regional flood hazards and current flood mitigation.

Regional Assessment

- Develop an overview of historical flood-related hazards and existing flood mitigation within the project area to identify historical flood trends and key events, and to consider the effectiveness of current mitigation.
- Utilize results from the CRD flood risk assessment to develop a refined high-level overview of flood risk for the DoW.
- Undertake a regional flood frequency and climate change assessment to understand potential future impacts on flood patterns and frequencies.

Technical Study of Riverine Flooding

- Plan and execute an initial site visit to gather relevant onsite observations and collect data to be used in the flood hazard assessments.
- Undertake hydrological assessments of the four key watersheds under current and climate change conditions to determine design flows.
- Conduct base level floodplain mapping (Tier 2) using available lidar data
    - Develop hydraulic models (i.e., 2D HEC-RAS) of selected reaches in each of the four key watersheds.
    - Calibrate, validate and perform sensitivity testing for each model.
- Produce floodplain mapping to visualize potential inundation areas.

Flood Hazard Threat Assessment

- Plan and facilitate an engagement session geared towards "Flood Hazards and Identifying Valued Assets in the District of Wells" that reviews the results of floodplain mapping, provides an overview of how flood hazard threat is assessed, and gathers input on what the community sees as valued assets within the project area.
- Identify and catalog valued assets, such as buildings and critical infrastructure, within potentially flood exposed areas.
- Assess hazard threat for each design flood.

The flood hazard maps support the DoW with flood hazard information that can inform land use planning, policy development, and emergency management planning. Section X describes how the work can be leveraged further to complete further steps of risk management, including detailed hazard mapping, emergency flood modelling, and long-term geohazards management planning.

The study scope was informed by Engineers and Geoscientists of British Columbia (EGBC, 2018) professional practice guidelines, *Legislated Flood Assessments in a Changing Climate in BC* and EGBC (2017) guidelines for flood map preparation. The assessment is consistent with the *Federal Floodplain Mapping Framework* (Natural Resources Canada [NRCAN], 2018). Within the NRCAN framework, this study provides the foundation to risk assessment and mitigation (Figure 1-1).

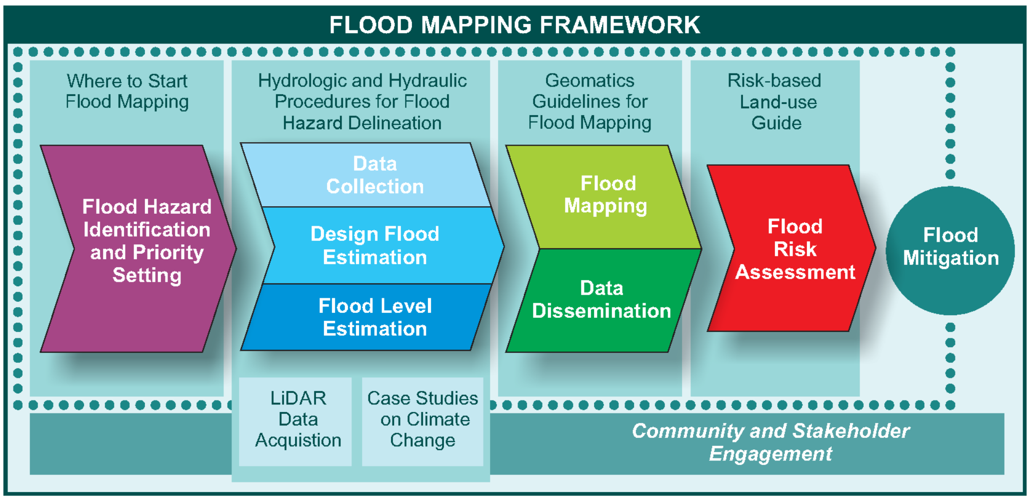

Figure 1-2 Federal flood mapping framework (NRCAN, 2017).

The study scope examines flooding resulting from rainfall and snowmelt runoff. Other types of flood-generating hazards may exist in the region (such as dam breach, dike breach, landslide dam outbreak floods, sewer-related flooding, ice jam flooding or debris flows) but were not within the scope of the project herein. Potential secondary effects of high river levels, such as rising groundwater tables, were also not within the study scope.

2.0 STUDY AREA CHARACTERIZATION

The following section provides a characterization of the study area including physiography, hydroclimatic conditions and projected impacts of climate change, glacial history and surficial geology, and a description of the four watersheds.

2.1 Physiography

2.2 Hydroclimatic Conditions

Discuss hydrology and climate.

2.3 Projected Climate Change Impacts

2.4 Glacial History and Surficial Geology

3.0 MINING HISTORY

3.1 Placer Mining

The DoW is the epicentre of the Cariboo Gold Rush, which took place between 1861 and 1867. John Rose and Ranald McDonald were the first prospectors to discover substantial placer deposits within the Cariboo Goldfields (Brown & Ash, 2009). Late in the fall of 1860, they traversed up Keithley Creek and across the Snowshoe Plateau to Cunningham and Antler Creek, where they found some rich placer deposits at shallow depths (Figure 3-1). Immediately after their discovery a heavy snowfall forced them to retreat to Keithley Creek for supplies. In early 1861 they set off again by snowshoe and were followed by a number of other prospectors who suspected their success. As a result, a number of claims were staked and many settled in to mine Antler Creek for a period of several years. Other prospectors pushed beyond Antler in the spring of 1861 to the northwest. Discoveries were made that year on all the important creeks and many lesser ones (Figure 3-1). The largest discoveries of free gold were made at Williams, Lightning and Lowhee Creeks. Williams Creek and its tributaries were the richest and became the centre of mining operations for the district.

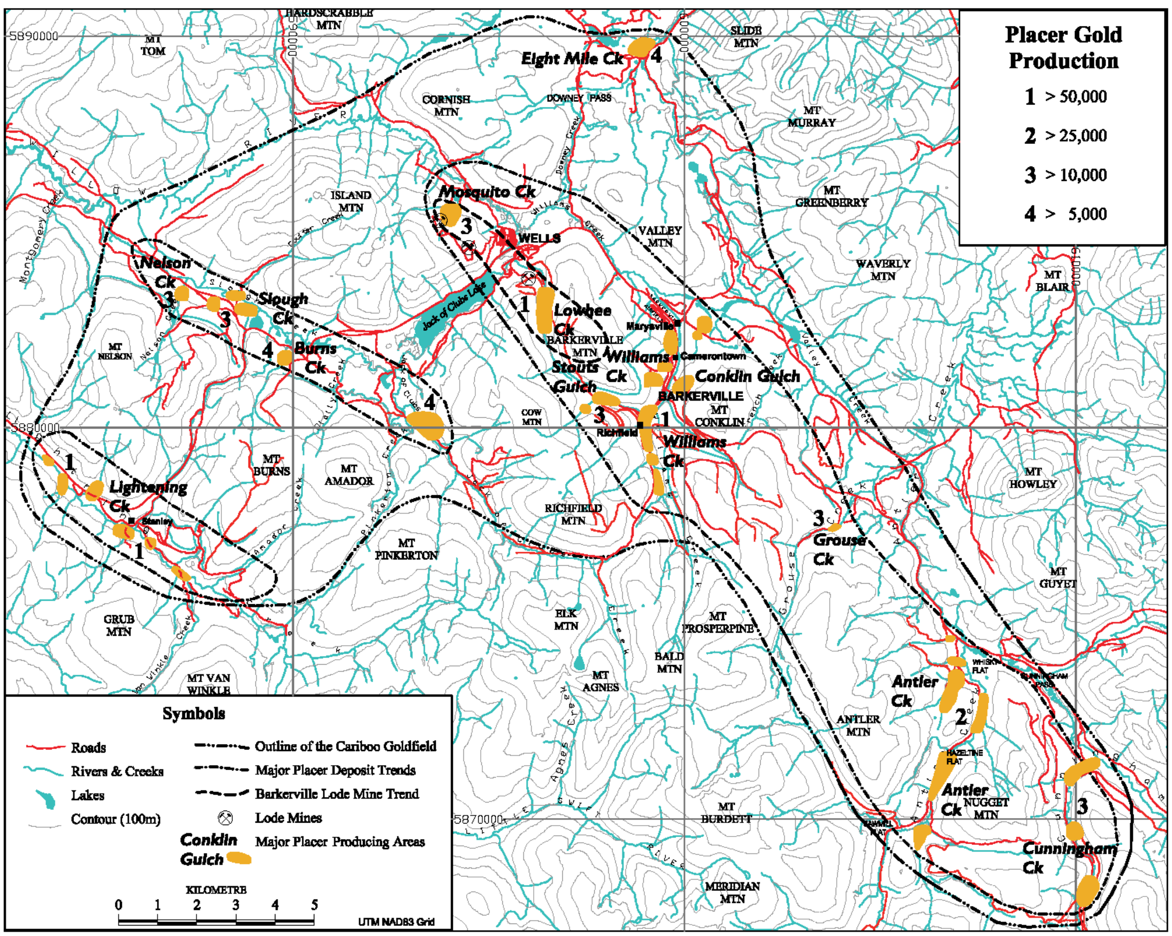

Figure 3-1 Topographic map showing the distribution of major placer deposits (from Ash & Brown, 2009).

Initial transport to the Cariboo Mining District was by a combination of foot, canoe or dog sled and the route taken was to Keithley Creek and over the Snowshoe Plateau. By 1860 gold returns from the area convinced Governor Douglas of the colonial administration to request help from the British government to construct a 650 km long wagon road (the Cariboo Road) through the Fraser Canyon to the Interior. A contingent of Royal Engineers was brought from Britain to survey the route from Yale to the administrative centre of the Cariboo. The work was begun by the army engineers in 1862, who completed the 2 most difficult stretches - 10 km from Yale to Boston Bar and 15 km from Cook's Ferry along the Thompson River. Much of the road through these sections had to be blasted through bedrock. The rest of the construction was let out to private contractors, and the road was opened in 1865. The current Highway 97 alignment largely follows the Cariboo Road route.

The initial discoveries were shallow, but mining at depths up to 20 m was soon accomplished as prospectors followed leads into deep gravel by excavating drifts into the surficial deposits. Water was an ongoing impediment to the drift mining, with insufficient flows to sluice in summer and too much flowing through the deep gravels, even in winter. Pumps were driven by water wheels until late in the 19th century, when steam engines and eventually diesels became available.

Drift mining was eventually replaced by more efficient hydraulic mining (MINFILE No. 093H 118). Hydraulic mining is a form of mining that uses high-pressure jets of water to dislodge rock material or move sediment. In the placer mining of gold, the resulting water-sediment slurry is directed through sluice boxes to remove the gold, which has a very high specific gravity.

Significant placer mining took place on about a hundred stream beds in the district, fifteen of which produced in excess of 5,000 ounces of gold (Brown & Ash, 2009). Unfortunately, production before 1874, which include the most productive years of 1861 to 1867, was not accurately recorded. Placer gold production between 1874 and 1945, which was well recorded by banks and government, is tabulated by Holland (1950). Table 3-1 summaries placer gold production from creeks within the DoW boundaries for the period 1874-1945. Those records indicate that 201,000 ounces of placer gold were mined, which would be worth around $800 million CAD at current prices ($2,800 USD per ounce).

Placer gold deposits in the region are generally found in relatively young Pleistocene[3] gravels. The morphology and mineral associations of the gold suggests that it was derived locally, the most obvious sources are the numerous gold-bearing veins in the Snowshoe Group (MINFILE No. 093H 063). These rocks are Upper Proterozoic to Lower Paleozoic in age and are predominantly metasedimentary.

[3] The Pleistocene is the geological epoch that lasted from 2.6 million to 11,700 years ago.

Table 3-1 Placer gold production (ounces) within the District of Wells between 1874 and 1945 (after Holland, 1950).

Year	Conklin Gulch	Emory Gulch	Jack of Clubs Creek	Lowhee Creek	McArthur Gulch	Mosquito Creek / Red Gulch	Stouts Gulch	Walker Gulch	Williams Creek
1874-1875	2,410			5,577			225		10,369
1876-1880	2,790		882	2,181		1,158	1,595	59	22,555
1881-1885	962		5,918	3,946		2,117	1,381		13,940
1886-1890	1,180			1,530		2,638			7,201
1891-1895				1,315		3,319	312		6,616
1896-1900				192		478			1,824
1901-1905				1,986		322	450		938
1906-1910				2,485		4,241	8,899		21,701
1911-1915				21,292		1,783	2,344		176
1916-1920				5,754				59	
1921-1925			104	4,603				174	
1926-1930				5,134			615		16
1931-1935				3,543		407			136
1936-1940		20		9,033	7	1,505		105	58
1941-1945		52	12	5,471	12	327	101	6	
Total	**7,342**	**72**	**6,916**	**74,022**	**19**	**18,295**	**15,922**	**403**	**85,330**

3.1.1 Mining Activity in Lowhee Creek

The first recorded mining activity on Lowhee Creek occurred in 1861, when Richard Willoughby, recovered approximately 3,000 ounces of gold from the fan of Lowhee Creek near the mouth (Lowhee Creek – BC Gold Adventures). Subsequent mining activities proceeded upstream into thick (tens of metres) sequences of young Pleistocene gravels located along the entire length of the stream. Mining was first done at shallow depth in the channel bed near the mouth. As depth to the buried channel increased, upstream mining by drifting took place. This mining method was eventually replaced by more efficient hydraulic mining. Placer mining eventually took place along most of the length of Lowhee Creek.

Archival photos of the placer operations from Lowhee Creek show the extraordinarily large volumes of sediment mined (Figure 3-2) as do historical air photos. Historical air photos also show constructed dams within the lower 500 m of the stream (Figure 3-3). The purpose of these dams is unknown, though based on anecdotal evidence from community members, the dams were likely constructed to retain sediment from the upstream hydraulic mining operations. Remnants of these dams are visible in modern imagery and on the ground.

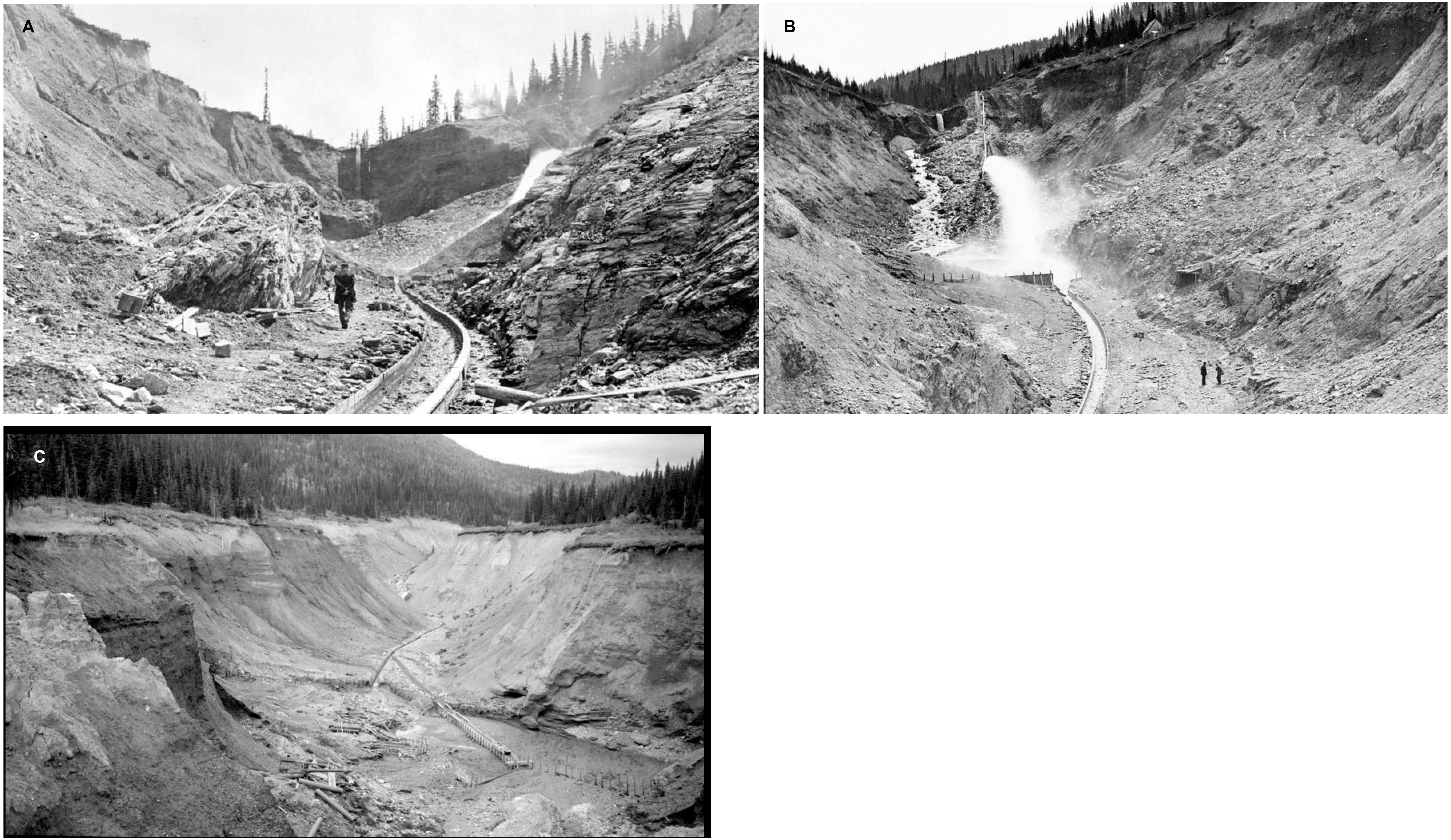

Figure 3-2 Archival photographs of placer operations on Lowhee Creek. Image A: 1916 (BC Archives, Item H-02768 - Lowhee Creek). Image B: 1912 (BC Archives, Item A-03835 – Lowhee Cree). Image C: 1946 (BC Archives, Item I-33439 – Old Lowhee Pit; Stout Creek).

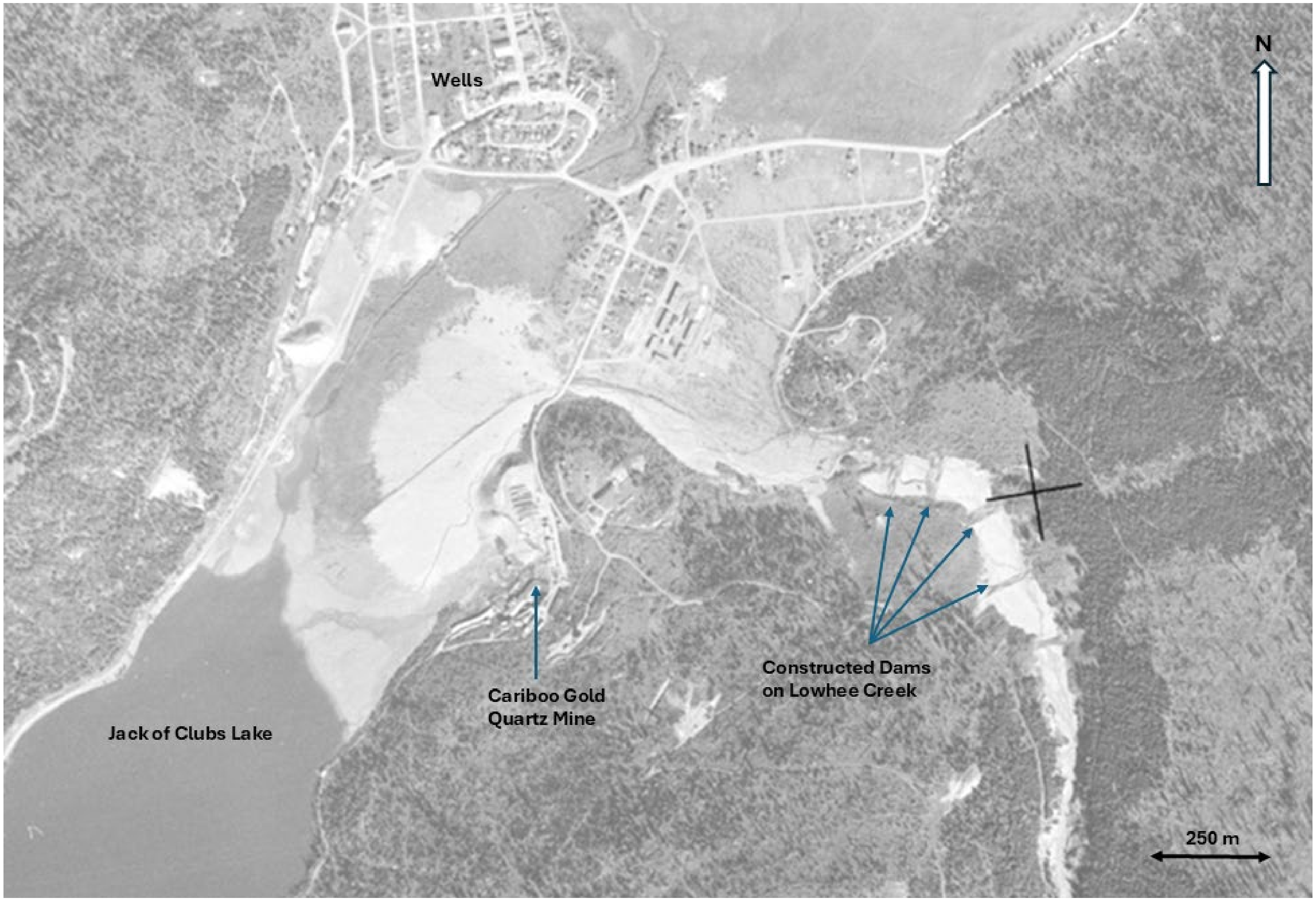

Figure 3-3 1952 airphoto showing constructed dams within the Lowhee Creek lower watershed. Photo source: National Airphoto Library[4], September 1, 1952.

[4] National Airphoto Library, Roll Number A13524, Photo 084.

3.1.2 Williams Creek

Williams Creek was originally discovered in 1861 by a party of miners headed by William Dietz who named the creek after their leader. They set to work mining the shallow ground in the vicinity of the confluence of Walker Gulch with Williams Creek. The town of Richfield quickly formed at that location, with Williams Creek becoming the epicentre of the Cariboo gold rush. Richfield had several saloons, a jail, a courthouse, two banks, a Roman Catholic church, a hotel, a post office and several stores (Figure 3-4). However. the gold around Richfield proved to be fairly shallow and was mined out quite quickly, causing people to migrate further downstream as more prospectors arrived.

Figure 3-4 1867 photograph of Richfield and Williams Creek. Source: BC Archives: Item A-04046 – Richfield, Williams Creek, Cariboo.

The migrant prospectors included William Barker and John Cameron who worked the creek bed below Richfield. Working on separate claims, both prospectors found significant gold concentrations. Soon hundreds of men left Richfield and the towns of Barkerville (Figure 3-5, Figure 3-6) and Camerontown would spring up next to the discoveries. A fourth town, Marysville, formed where Williams Creek discharges from confinement into a swampy meadow. Marysville was mainly a community of residences for miners and businessmen.

Figure 3-5 1868 photograph looking downstream to Williams Creek and the Town of Barkerville. Source: BC Archives, Item A-03748 – View on Williams Creek looking towards Barkerville.

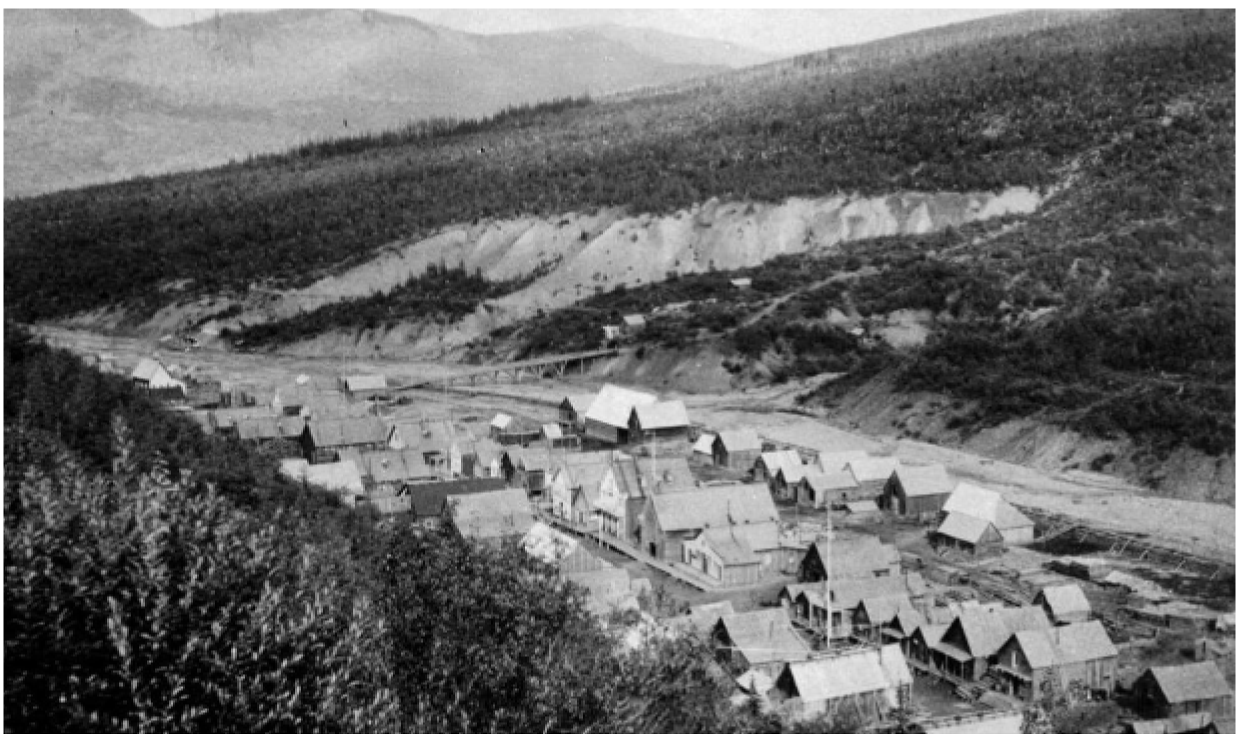

Figure 3-6 1897 photograph of Barkerville and Williams Creek. Conklin Gulch is visible in the background. Source: BC Archives, Item I-55171 – Barkerville.

By 1864, there was virtually one long street of buildings extending along the west bank of Williams Creek, from Richfield at the south end to Marysville at the north. One writer noted that the path alongside the creek was “a difficult one, over endless sluices, flumes, and ditches; across icy planks and logs.” (Sale, January 11, 2025). Because of its central location, Barkerville was the community which became the largest and lasted the longest. At its peak in the 1860s, it is estimated that the local population was on the order of 10,000 people. At least half of these inhabitants were miners working gold claims in the area while the rest were merchants and business people (Sale, January 11, 2025).

A large fire in September 1886 destroyed almost all the buildings in Barkerville. While the town was rebuilt quickly, it never regained its former size or prominence. Similar to Lowhee Creek, Williams Creek and its tributaries (Stouts Gulch, Emory Gulch, Walker Gulch, and Conklin Gulch) were ultimately hydraulically mined, drastically widening these watercourses.

3.2 Underground Mines

The search for bedrock sources followed the discovery of the placer gold. In the late 1920s, lodes were developed underground on either side of Jack of Clubs Lake which later proved economically feasible. Two mines came on stream, the Cariboo Gold Quartz Mine on Cow Mountain southeast of the lake in 1933 and Island Mountain Mine[5] north of the lake in 1934. The former mine was founded by Fred Wells, a mining engineer and hard rock miner who purchased a claim on Lowhee Creek in 1927 and began tunnelling into Cow Mountain. At its peak in the 1940s, Wells had a population of 4,500.

The Cariboo Gold Quartz Mine purchased the Island Mountain Mine in 1954. The former mine operated until 1959, while the latter operated until 1967 before closing due to unfavourable economics. In 1980, higher gold prices allowed the Mosquito Creek Gold Mine to open further northwest on Island Mountain. This mine operated intermittently until 1987.

While the Cariboo Gold Quartz Mine and Island Mountain Mine do not connect below Jack of Clubs Lake, all the mines are on the same northwesterly trend. Between 1933 and 1987 the three mines produced 1.23 million ounces of gold and 101,439 ounces of silver (Brown & Ash, 2009), which would be worth more than $5 billion CAD at current prices ($2,800 USD per ounce). During the operation of the Cariboo Gold Quartz Mine, approximately 2.65 million t of flotation mill tailings were deposited into the northeastern end of Jack of Clubs Lake near its outlet into Jack of Clubs Creek, filling approximately 30 ha of the original lake area (SNC Lavalin, 2011).

More recently in 2011, Barkerville Gold Mines Ltd. (BGM) received a *Mines Act* permit to develop an open pit gold mine at Bonanza Ledge, enabling a four-year mining operation. The Bonanza Ledge Mine is located at the divide between Lowhee Creek and Stouts Gulch, 3.5 km south-southeast of the community of Wells and 2 km southeast of the main workings of the past-producing Cariboo Gold Quartz Mine. Production at the Bonanza Ledge open pit mine

[5] Also known as Aurum Mine.

started in March 2014, with ore processed at the company's Quesnel River (QR) Mill. The QR Mill is approximately 60 km southeast of Quesnel and 110 km from Wells (by road).

The Bonanza Ledge Mine saw limited production as an open pit mine between March 2014 and June 2015, before being placed into care and maintenance. In December 2016, BGM applied for a permit to mine the remaining resource by underground methods. BGM restarted the mine in 2017 as an underground operation, with an estimated life span of 3.5 years. However, the mine was again placed on care and maintenance in December 2018. Mining resumed in mid–2019 before being placed on care and maintenance in June 2022 [Osisko Development Corp. (Osisko), December 30, 2022].

Much of the recent activity at the Bonanza Ledge Mine has been to allow for the continuity of mining while permitting was sought for the larger Cariboo Gold Project.

3.3 Cariboo Gold Project

The Cariboo Gold Project, owned by Osisko[6], is an advanced stage feasibility level gold project that would exploit gold resources around the historic underground mines that surround the community of Wells. The Project consists of three main zones (Cow, Shaft, and Valley) with two smaller satellite zones (Lowhee and Mosquito). The rate of exploitation of each deposit will change over time. The life-of-mine (LOM) plan has a 12-year mine life. Ore production will begin at 1,500 tpd for 2.75 years (Phase 1) and will ramp up to 4,900 tpd for 8.5 years (Phase 2). The overall mine plan comprises 16.7 million tonnes (Mt) of ore that will be processed with an average grade of 3.8 grams per tonne (g/t) gold. The mine will produce 7.1 Mt of waste from the development over the LOM.

The Project includes the following key components (Figure 3-7, Figure 3-8):

- Underground extraction infrastructure including two access portals (Valley and Cow Mountain), conveyor and crushing facility
- Access roads
- A Mine Site Complex including (Figure 3-9):
    - a services building containing a surface concentrator, paste backfill plant, and other related infrastructure
    - Electrical substation
    - Camp
    - Water Treatment Plant (WTP)
    - Sediment Pond for containment of contact water.
- A waste rock storage facility (WRSF) located at the Bonanza Ledge Site and associated water management structures (including a sediment pond), access roads, and ancillary infrastructure.
- A new 69 kV Transmission Line, including access roads and a substation

[6] Osisko's predecessor of the Project was BGM. In December 2020, Osisko was officially created, and ownership of BGM was transferred from Osisko Gold Royalties to Osisko. BGM is a 100% owned subsidiary of Osisko.

- Upgrades to the existing QR Mill, water supply and management structures and facilities, access roads, ore storage, expansion of the existing WTP, and construction of a tailings dewatering plant and a filtered stack tailings storage facility (FSTSF).

Ore produced by the mine will undergo crushing, ore sorting, milling, flotation, and dewatering before being trucked as a concentrate along Highway 26 and the 500 Nyland Lake Forest Service Road to the QR Mill for the final stage of processing. A new highway bypass would be built west of Wells from Highway 26 to the Mine Site (across Jack of Clubs Creek) to enable traffic to exit the highway before the community.

There will be two portals accessing underground ramps. The existing Cow Portal[7], on the north side of Lowhee Creek, will allow access to the Lowhee, Shaft, and Mosquito zones in the earlier stages of the Project. The Valley portal will be built during the expansion to develop the Main ramp connecting the previous zones to the new Cow and Valley Zones. The Valley Portal will be used as the main services access.

The Project is designed in phases: in Phase 1, a 1,500 tpd crushing and ore sorting plant will be built at the Bonanza Ledge Site; and in Phase 2, a pre-concentrator designed to have a capacity of 4,900 tpd will be built at the Mine Site Complex. The QR Mill will ramp down from 859 tpd in Phase 1 to 644 tpd in Phase 2. The pre-concentration steps in Phase 2 are designed to produce less concentrate at higher grades. Phase 2 will include the construction of an underground crushing system, to be located below the services building. Ore will be brought to the crusher by underground trucks from all mining zones.

Ore will be brought to the surface using a vertical conveyor to be pre-concentrated by sorting and flotation. The material rejected by the sorter will be transferred back underground and either used as backfill material or hauled to the Bonanza Ledge WRSF, which will have capacity to store 8.5 Mt (4.25 million m^3) of waste material from the Project.

A combination of cemented rock fill (CRF), uncemented rock fill (URF), and tailings paste backfill will be used for stope backfilling. The use of CRF and URF as backfill will help to minimize the amount of waste rock and ore sorter rejects to be stored at the WRSF. A dedicated tailings storage facility (TSF) is not required at the Mine Site Complex. The sorting of the mined ore prior to milling and flotation, as well as the use of flotation tailings for paste backfill, will eliminate the requirement for a TSF at or near the Mine Site Complex.

[7] Note that the EA application of Osisko proposed construction of two portals: the Valley and Island Mountain portals. The latter portal is located directly west of Wells on the north side of Jack of Clubs Creek (Figure 3-6). However, the recent feasibility study has replaced the Island Mountain Portal with the Cow Portal. The Cow Portal was completed by Osisko in December 2021 to access and develop a bulk sample at the Cow Mountain portion of the mineral resource.

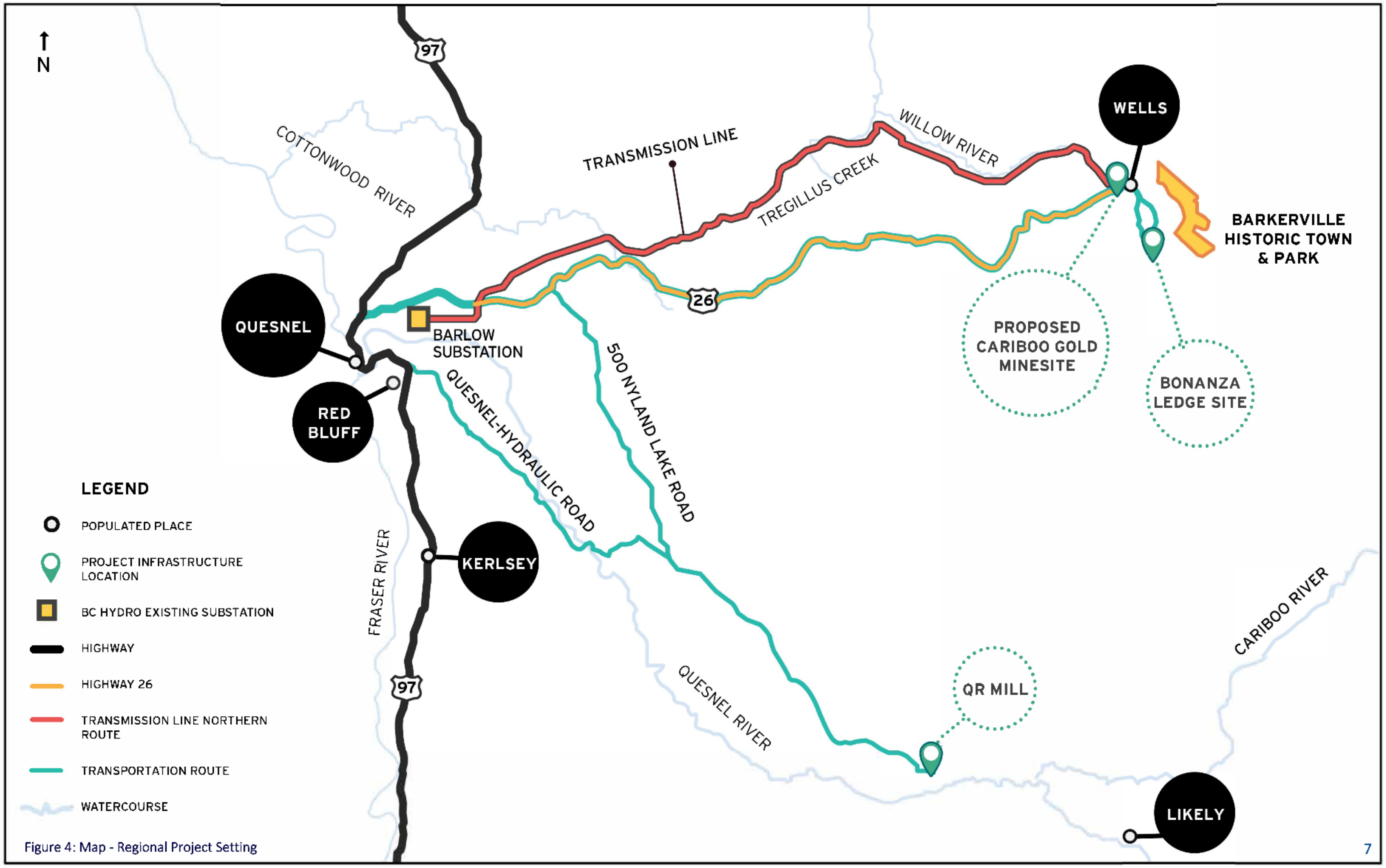

Figure 3-7 Regional setting for the Cariboo Gold Project (BC Environmental Assessment Office, September 2023).

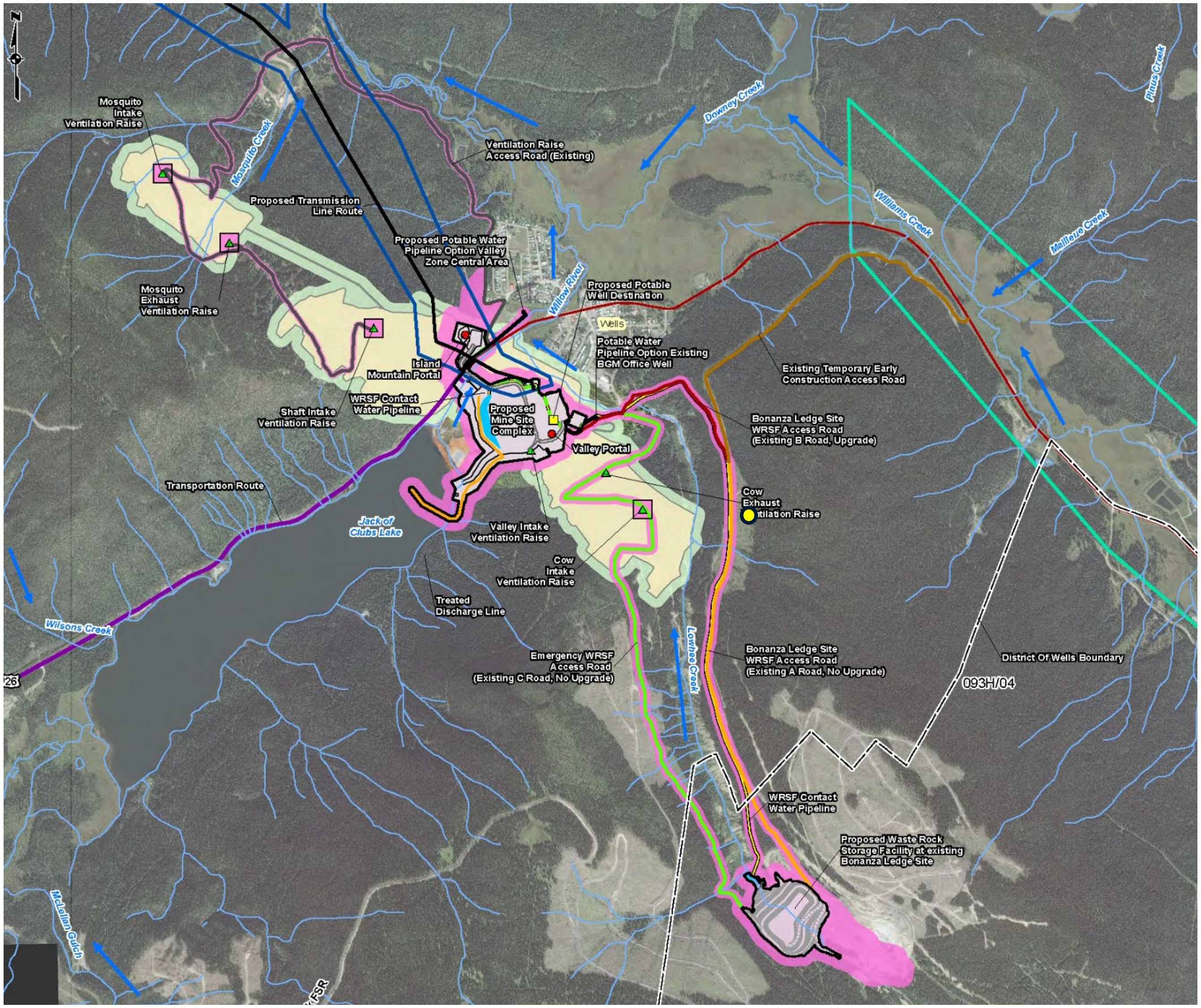

Figure 3-8 **Current and proposed infrastructure for the Cariboo Gold Project (Osisko, December 30, 2022). The yellow dot is the approximate location of the Cow Portal, which is intended to replace the Island Mountain Portal shown on this figure.**

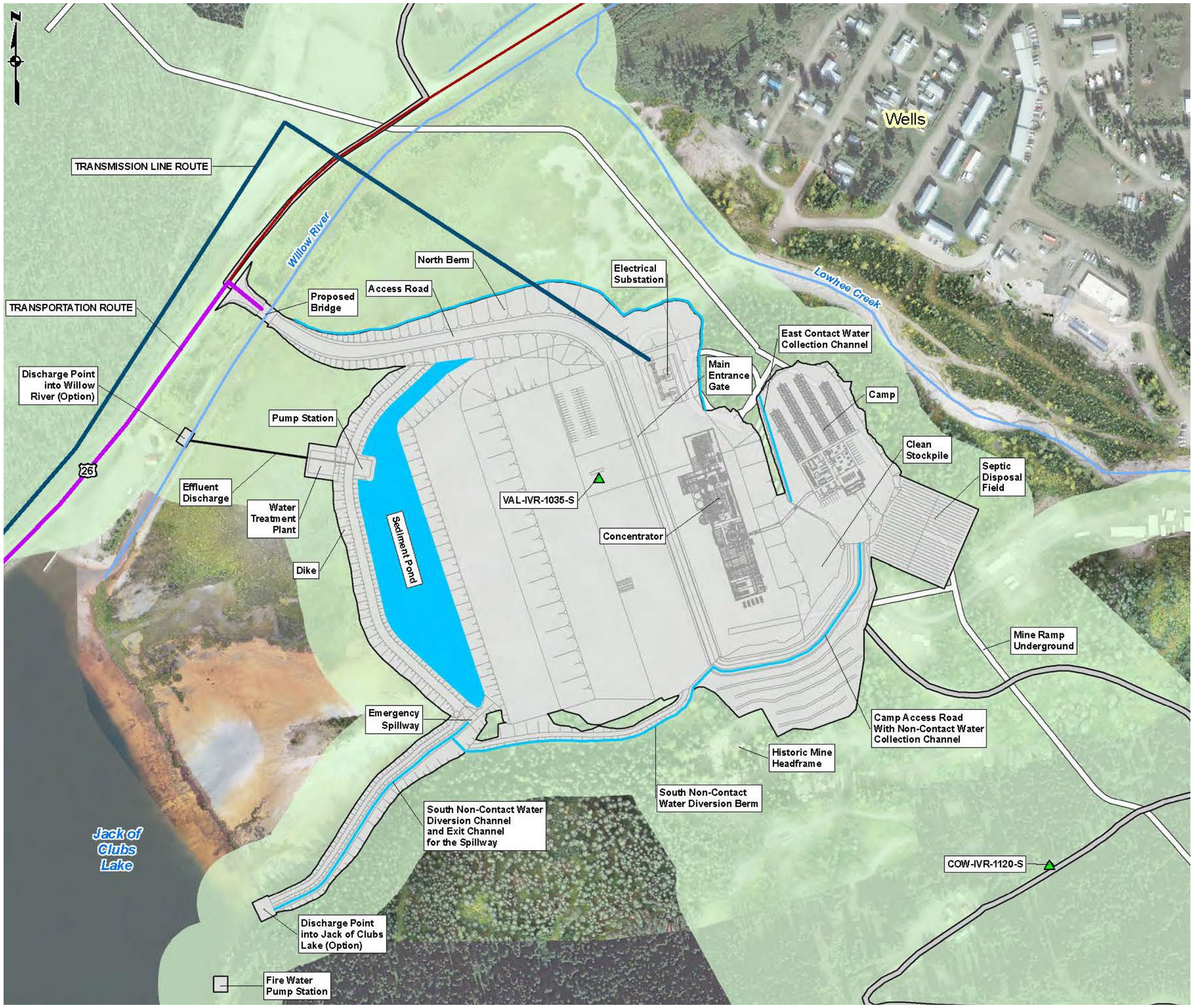

Figure 3-9 Proposed surface infrastructure for the Mine Site Complex, Cariboo Gold Project (from BGM, October 2019).

The water management facilities required at the Mine Site include the following:

- Two sediment ponds, one located at the Mine Site Complex and the other at the Bonanza Ledge Site, which will serve as central collection ponds for contact water at each site;
- Contact and non-contact water conveyance infrastructure, including diversion berms, collection channels, pumps, and pipelines to separately manage these flows;
- A mine dewatering system for the historic underground mining areas; and
- A WTP at the Mine Site Complex that includes a conventional high-density sludge (HDS) lime neutralization, ferric coprecipitation, organo-sulphide precipitation, nitrifying moving bed bioreactor (MBBR), and denitrifying fluidized bed reactor (FBR) system.

The Project received an Environmental Assessment (EA) Certificate on October 10, 2023, in accordance with the BC Environmental Assessment Act (2018). Receipt of the EA Certificate concluded the EA process for the Project, which was launched in October 2019. Osisko received the BC *Mines Act* permits on November 20, 2024, which grant the Company the ability to proceed with the construction and operation of the project. *Environmental Management Act* permits were received in December 2024.

Full-scale construction could commence in the second half of 2025, once Osisko makes a final investment decision.

4.0 SITE HISTORY

4.1 Area Development

4.2 Historical Flood Events

4.3 Hydraulic Structures

4.4 Previous Mitigation Works

Discuss diking work on Lowhee Creek.

4.5 Critical Facilities

5.0 COMMUNITY OPEN HOUSE AND LHTAKO DENE FIRST NATION FEEDBACK

6.0 GEOMORPHIC ASSESSMENT

The historic hydraulic placer mining has had a significant impact on the geomorphology of Lowhee Creek and Williams Creek. Drawing 01 is a georectified 1952 air photograph of the area, which clearly shows the impacts of the hydraulic mining.

6.1 Lowhee Creek

Drawing 01 clearly demonstrates that hydraulic placer mining took place along most of the length of Lowhee Creek. Inspection of available lidar data suggests that the valley sediments were mined hydraulically mined to depths of up to 30 m with the sluiced sediment being transported downstream and depositing on the alluvial fan of Lowhee Creek.

The volume of sediment transported onto the alluvial fan is not known but the volume must have been significant. A 1923 map of the area shows multiple channels on the alluvial fan, which is indicative of very high sediment transport rates (Figure 6-1). This map also shows Jack of Clubs Lake extending much further north than it currently does.

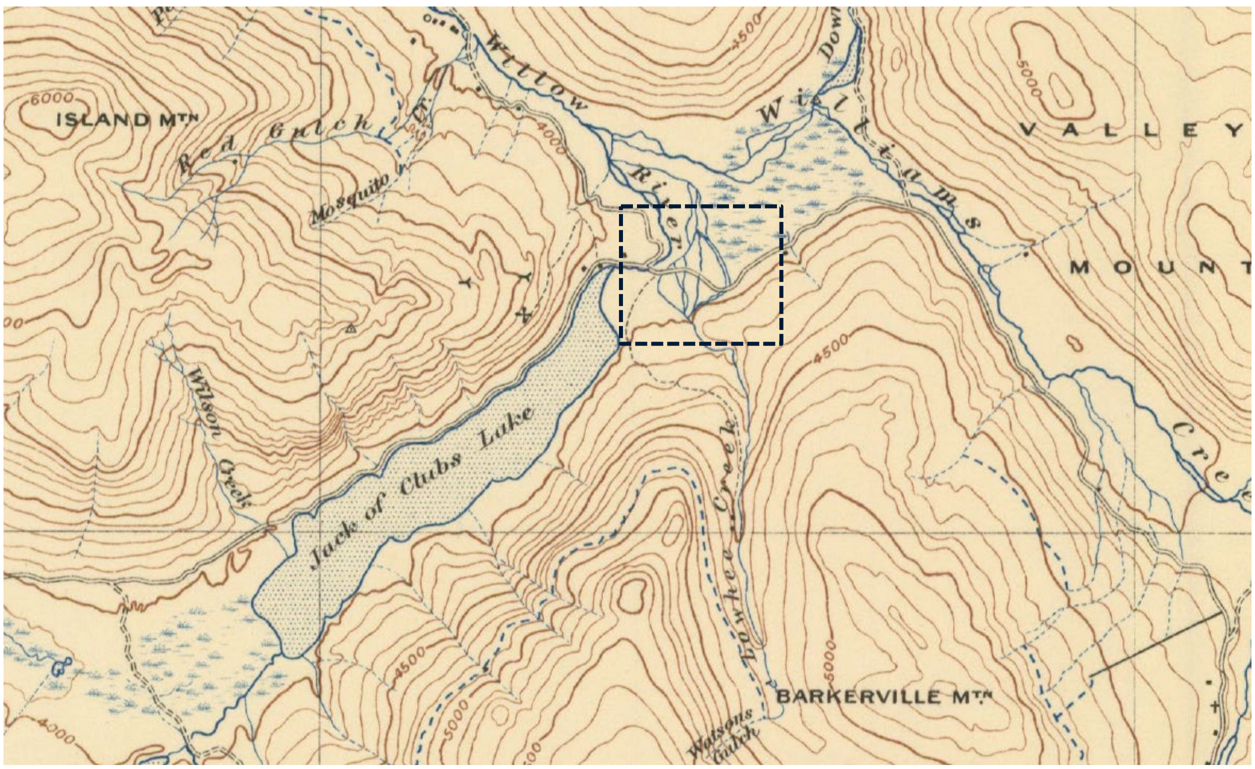

Figure 6-1 1923 map of the study area. Note the braided channel pattern of Lowhee Creek (black dashed rectangle) on its alluvial fan (Canada Department of Mines, 1923).

Recent geotechnical drilling by SoilTech Consulting Inc. (SoilTech, February 3, 2025) provides some insight into the depth of hydraulically mined sediment on the alluvial fan. As part of dike construction along the right bank of Lowhee Creek, SoilTech drilled twelve (12) boreholes on the alluvial fan of Lowhee Creek (Figure 6-2). Each of those boreholes encountered hydraulically mined sediment, which was described predominantly as sand and gravel with some silt and the coarse particles being highly fractured. Most of the boreholes did not encounter the full depth of the hydraulically mined sediment, including BH24-07 which was still drilling into those sediments when terminated at a depth of 22 m (Table 6-1).

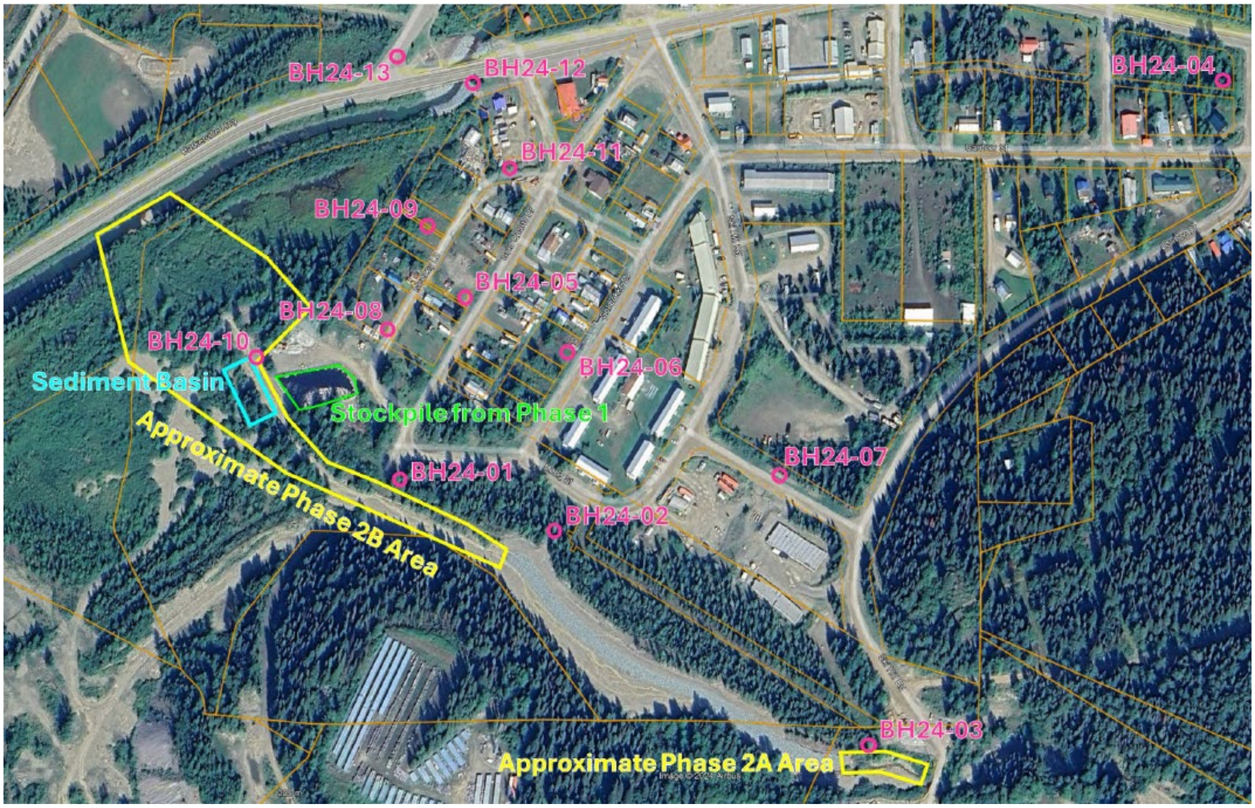

Figure 6-2 SoilTech borehole locations on the alluvial fan of Lowhee Creek (SoilTech, February 3, 2025).

Table 6-1 Depth of hydraulically mined sediment encountered in SoilTech boreholes.

Borehole	Depth of Hydraulic Mined Sediment
BH24-01	> 11 m
BH24-02	> 11 m
BH24-03	> 7 m
BH24-04	5 m
BH24-05	> 8 m
BH24-06	> 11 m
BH24-07	> 22 m
BH24-08	> 7 m
BH24-09	> 7 m
BH24-10	> 7 m
BH24-11	> 5 m
BH24-12	2 m
BH24-13	2 m

Sediment was also introduced onto the Lowhee Creek fan by the underground mining operations. During the operation of the Cariboo Gold Quartz Mine, approximately 2.65 million t of flotation mill tailings were deposited into the northeastern end of Jack of Clubs Lake near its outlet into Jack of Clubs Creek. SNC Lavalin (2011) has reported that these tailings filled approximately 30 ha of the original lake area (SNC Lavalin, 2011).

While most of the hydraulically mined sediment appears to have deposited to the east of the current Lowhee Creek channel, some of this sediment appears to have partially infilled the northeastern end of Jack of Clubs Lake also. The earliest air photographs of the area date to 1952, which post-dates the deposition of flotation tailings and a majority of the hydraulically mined sediment (Figure 3-3). However, the approximate pre-development downstream extent of Jack of Clubs Lake can be inferred from several sources.

1. Before the town of Wells was established in the early 1930s, there were a small number of people living in the area. After the Cariboo Gold Rush had waned, there were still some miners and people living in Barkerville and, on the future site of Wells, there was a tiny camp that housed a few miners, a stopping house (or roadhouse), and a sawmill operation owned by Clarke. Early 1900 photographs of that camp and the original outlet of Jack of Clubs Lake are shown in Figure 6-3. Those photographs show the outlet of Jack of Clubs Lake at approximately the intersection of Polley Street and Highway 26.

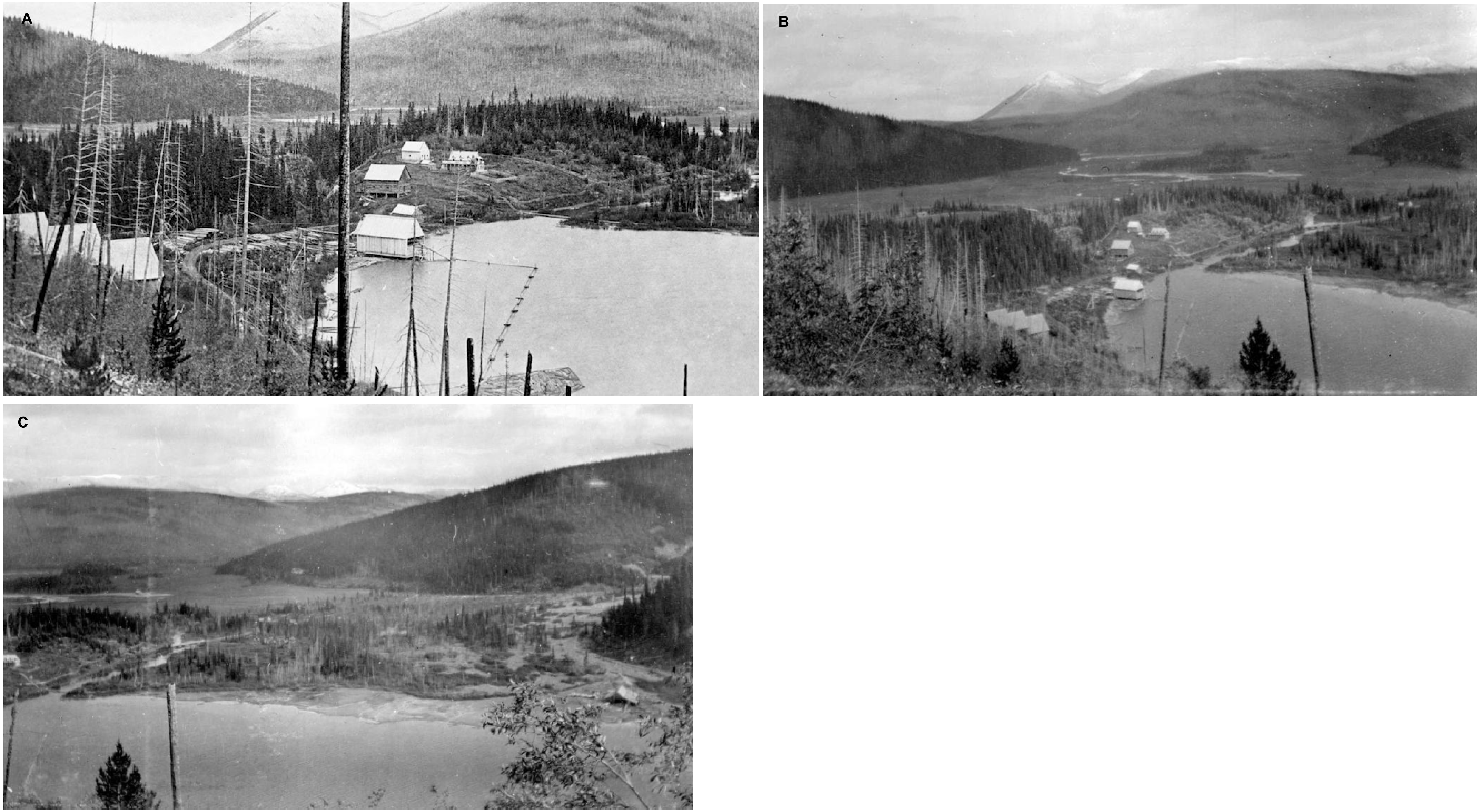

Figure 6-3 Archival photographs of the Clarke sawmill and the original outlet of Jack of Clubs Lake. Image A: 1901 (P-1326 Barkerville photograph collection. Acc. #1961.126.17.01). Image B: 1902 (BC Archives, Item I-56134). Image C: 1902 photograph looking east toward the alluvial fan of Lowhee Creek (BC Archives, I-56159).

2. An 1886 map also shows the outlet Jack of Clubs Lake in the approximate location as seen in the photographs above (Figure 6-4), as does the 1923 map shown in Figure 6-1.

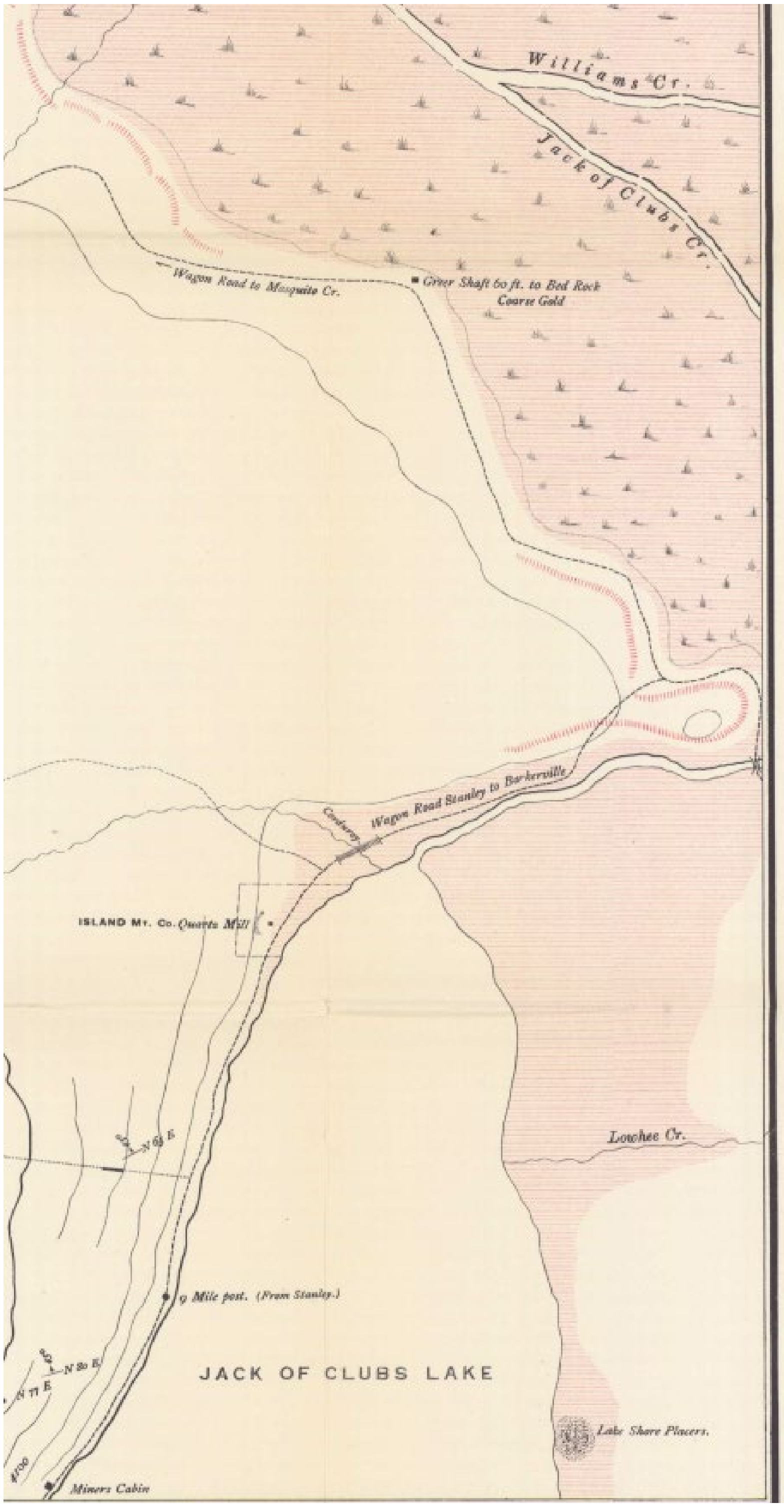

Figure 6-4 Excerpt of 1886 map of Wells area (Geological and Natural History Survey of Canada, 1886).

Finally, Jack of Clubs Creek has an unnaturally straight planform from the current outlet of Jack of Clubs Lake to just downstream of the Highway 26 crossing, a distance of about 1 km. This channel was likely artificially constructed to allow the conveyance of lake outflows through the flotation tailings and distal hydraulically mined sediment deposits.

Figure 6-5 1940 photograph looking toward south Wells and Lowhee Creek alluvial fan. Source: City of Vancouver Archives Items: CVA-289-005.602 – South Wells, B.C.

6.2 Williams Creek

6.3 Geomorphic Mitigation

- Discuss sediment roadmap for Lowhee Creek
- Determine if any actions make sense for Williams Creek

7.0 METHODS

7.1 Topographic Data and Bathymetric Surveys

7.2 Hydrologic Analysis

7.3 Hydraulic Modelling

7.3.1 General Approach

7.3.2 Model Inputs

7.4 Flood Hazard Mapping

8.0 RESULTS

8.1 Peak Discharge Estimates

8.2 Hydraulic Modelling

8.3 Flood Hazard Mapping

8.4 Flood Hazard Threat Assessment

8.5 Limitations and Uncertainties

9.0 RECOMMENDATIONS

10.0 CLOSURE

We trust the above satisfies your requirements. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

BGC Engineering Inc.
per:

[Writer's Name, Credentials]
[Writer Title/Position]

[Name, Credentials (if none, type a space)]
[Title/Position (if none, type a space)]

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REFERENCES

Barkerville Gold Mines Ltd. (2019, October). *Cariboo Gold Project, Project Description*.

BC Environmental Assessment Office. (2023, September). *Assessment Report: Cariboo Gold Project*. With Respect to the Application by Osisko Development Corp. for an Environmental Assessment Certificate.

Canada Department of Mines, Geological Survey. (1923). Barkerville Area, Cariboo District, British Columbia. Topographic Map, 1:63,360 scale.

Geological and Natural History Survey of Canada. (1886). Quartz Veins & Placer Mines of Island Mountain and Mosquito Creek in Cariboo District, British Columbia.

Osisko Development Corp. (2022, December 30). *NI 43-101 Technical Report: Feasibility Study for the Cariboo Gold Project. District of Wells, British Columbia, Canada*.

Sale, B. (2025, January 11). Haphazard History: Towns of the Goldfields. Quesnel Cariboo Observer.

SNC Lavalin. (2011, March 31). *Risk Based Detailed Site Investigation, Wells Tailings Deposit, Wells, BC*. Vol. 1. 110 p.

SoilTech Consulting Ltd. (2025, February 3). *Geotechnical Assessment: Lowhee Creek Dike Rehabilitation, Phase 2* [Report]. Prepared for R. Radloff & Associates Inc.