WATER SCIENCE SERIES

Compendium of Provincial Groundwater Science and Monitoring Projects: 2019-20

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Cover Images:
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1) Illustration showing mechanisms of saltwater intrusion into coastal aquifers. Source: Sylvia Barroso
2) Drill rig at observation well 487 near Lumby B.C. Photo credit: John Pogson
3) Well ID Plate on observation well 484, Mayne Island B.C. Photo credit: Graeme Henderson
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5) Measuring streamflow, Bertrand Creek, B.C. Photo credit: Simon Fraser University
6) Mapped aquifers in the Comox-Merville area, B.C. Source: Advisian Consulting
7) Observation well 492 in Columbia Valley, B.C. Photo credit: Bryan Jackson

Acknowledgements

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EXECUTIVE SUMMARY

The Provincial Groundwater Program originated in 1961 when the *Water Act* was revised to enable the licensing of groundwater. The primary goal of the groundwater program has been to increase the understanding of the groundwater resources in British Columbia, and to ensure the sustainable management and protection of the resource. As the Province moves forward with the implementation of groundwater licensing under the new *Water Sustainability Act* (*WSA*) which was brought into force in 2016, there is an even greater need to improve the level of scientific knowledge of aquifers, groundwater availability and the interactions between surface water and groundwater. This knowledge is critical to support the sustainable management of groundwater and to support science-based decision making. The Ministry of Environment and Climate Change Strategy (ENV) and the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) share joint responsibility for the Groundwater Program. Currently, groundwater science and monitoring projects are funded out of three main funding envelopes:

- The Strategic Water and Air Monitoring Planning Process (SWAMPP), administered by the Knowledge Management Branch (KMB) within ENV;
- The Groundwater Science Program, administered by the Water Protection & Sustainability Branch (WPS) within ENV; and,
- Water Research Portfolio research funding, administered by FLNRORD

In some cases, the province also partners with other agencies such as Geoscience BC, the BC Oil and Gas Commission (OGC), the Geological Survey of Canada (GSC), universities and local governments to fund groundwater related studies.

This compendium is published under the *Water Science Series* to bring together a compilation of short summaries of the groundwater science and monitoring projects supported by the province during the 2019-20 fiscal year. The intent is to communicate to a wide audience the nature of the projects undertaken and to provide a quick overview of the project results. Links to key personnel and additional reporting are provided within each summary for anyone who might require more detailed information.

The projects outlined in this compendium meet some of the objectives of FLNRORD's Ministry Strategic Roadmap. Specifically, the installation of new groundwater observation wells and the remapping of aquifers provides provincial groundwater staff with the ability to sustainably manage groundwater resources in British Columbia. These projects also support ENV's Service Plan and the critical work needed to interpret the state of the Province's environmental health so that all British Columbians will continue to benefit from the wise and prudent management of natural resources.

CONTENTS

1. AQUIFER MAPPING

To effectively manage groundwater resources and the impacts of land development on groundwater availability and quality, it is essential to understand the existence and characteristics of B.C.'s aquifers. Identifying and mapping aquifers is often the first step in developing this understanding. The Groundwater Wells and Aquifers (GWELLS) application is the primary resource of this screening level, groundwater resource information throughout the Province. The GWELLS aquifer catalogue is currently utilized for: i) tracking and informing the management of groundwater rights; ii) prioritizing management; iii) protection and remedial efforts; and, iv) increasing public understanding. It is also used as a resource by several provincial government ministries including the Ministries of Environment and Climate Change Strategy (ENV), Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD), Health (HLTH)and Agriculture (AGRI).

As of August 2020, the database contained over 1,200 aquifers. The province continues to conduct new aquifer mapping projects to expand and refine the database. The need for mapping aquifers is ongoing as communities expand and / or new resource development projects are initiated. In addition, previously mapped aquifers are revisited periodically and updated as new information becomes available or a more detailed level of assessment is required. Aquifer mapping studies are prioritized based on a number of factors, including, but not limited to: (i) the local knowledge of emerging issues that regional offices have identified through their work with communities and in supporting water authorizations; (ii) the locations of water wells in the provincial GWELLS database that are not yet associated with a mapped aquifer; and, (iii) the locations of major resource development projects (e.g., mines, oil and gas).

In 2019/20, aquifers were mapped or revised in several areas of the province including the Comox-Merville area and the Regional District of Nanaimo (RDN) on Vancouver Island, and the Vanderhoof area in northeast B.C. This information will be utilized as a reference to inform groundwater licensing under the *Water Sustainability Act* and is available to the public to inform well protection and land use planning.

Spatial information about mapped aquifers can be accessed using the following tools, supporting a range of user needs:

- GWELLS – The Provincial database for storing and retrieving water well records and aquifer information;
- Groundwater Level Data Interactive Map Portal – a user friendly map-based tool to view and access information from the Provincial Groundwater Observation Network (PGOWN); and,
- iMapBC – view and analyze mapped aquifers along with hundreds of other data layers compiled from across the BC Government and other public-sector agencies.

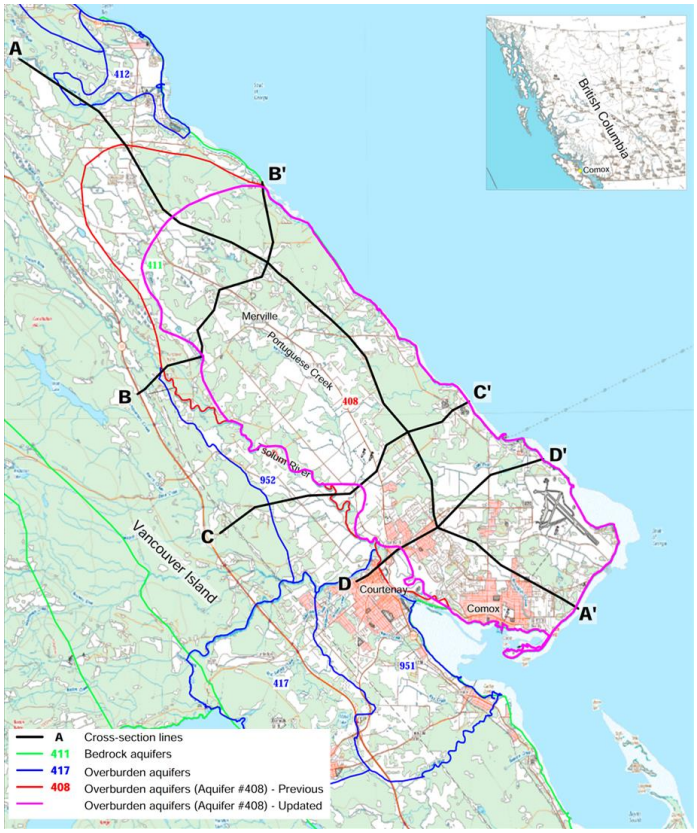
Aquifer Mapping Studies, West Coast Region

Project Description

Water well records from the GWELLS database were integrated with mapping of geology, topography, streams and springs to map aquifers on Vancouver Island in the vicinity of Port McNeill on Malcolm Island, North Campbell River on Quadra Island and in Comox-Merville area. More detailed analysis was conducted in the Comox-Merville area to understand the greater geological complexity and water resource development of this area.

Summary of Project Outcome

A total of five bedrock and seven unconsolidated aquifers were either mapped as new aquifers or were revised and remapped based on interpretation of updated information. Thirteen previously mapped aquifers were consolidated into other aquifers and retired. Aquifer fact sheets and aquifer spatial extents (GIS polygons) were developed or revised and integrated into the provincial GWELLS and spatial databases.



Mapped aquifers in the Comox-Merville area.

Relevance

Study results support and inform groundwater licensing decisions and resource management through the improved understanding of hydrogeologic settings, aquifer hydraulic properties, and hydraulic connections with surface waters. The study results also provide foundational information for broader water management planning and groundwater availability studies including local or regional groundwater budget analyses, and development of numerical groundwater models.

Learnings & Recommendations

The aquifer system in the Comox-Merville area is comprised of three main units: an upper sand (Vashon sand), a discontinuous till layer (Vashon till) and a lower sand (Quadra sand). The upper sand is typically unsaturated based on available water level data, and thus the aquifer has been constrained to the lower sands. Additional studies are recommended in the Comox-Merville area to improve the understanding of how groundwater and surface water interact. These include field work to improve mapping of groundwater discharge zones and streambed conditions, and groundwater level and quality monitoring.

Partners and Linkages

Aquifer mapping and reporting was completed by Advisian Consulting under contract with ENV.

References

Hinnell, A.C., T. Lengyel, S.P. Funk and Z.M. Hammond. 2020. West Coast Region Foundational and Stage II Detailed Aquifer Mapping Studies: Port McNeill, Malcolm Island, North Campbell River, Quadra Island and Comox-Merville Study Areas. Water Science Series, 2020-04, Province of British Columbia, Victoria.

Project Contacts

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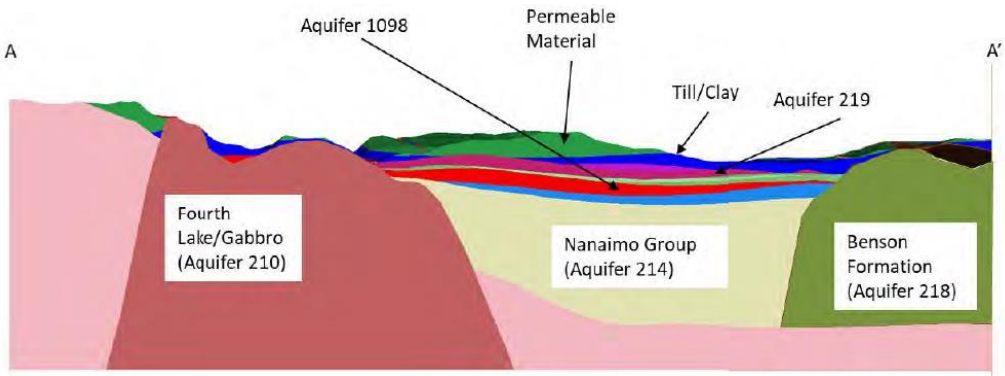
Acknowledgements:
Groundwater Science Program
FLNRORD West Coast Regional Operations

Refinement of Stacked Aquifers 219 and 1098, Nanoose Electoral Area E, Regional District of Nanaimo

Project Description

The Regional District of Nanaimo (RDN) retained Golder Associates Ltd. (Golder) to conduct a Refined Water Budget (Phase 3) for Nanoose (Electoral Area E) involving the development of a three-dimensional numerical groundwater flow model using FEFLOW (Golder 2020a). The study area includes two stacked confined unconsolidated aquifers (AQ219 and AQ1098). Additional characterization work was required to improve the existing aquifer boundaries and to correlate existing wells drilled in the study area to the appropriate aquifer. In collaboration with the RDN, the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) was able acquire additional funds to include the refinement mapping of Aquifers 219 and 1098 into RDN's scope of work.



Cross section through Conceptual Model showing AQ219 and AQ1098 (Golder, 2020b)

Relevance

Concurrently revising and improving the aquifer mapping of AQ219 and AQ1098 with RDN's numerical model and water budget analysis provided an up-to-date management tool that water managers and planners can use to make decisions and implement water management measures.

Learnings & Recommendations

The refined vertical and lateral extents of AQ219 and AQ1098 were used to improve the conceptual model of the study area and were imported into the numerical model. Aquifer mapping reports and shapefiles of the lateral aquifer boundaries were provided for both aquifers in addition to a master wells spreadsheet that correlates individual wells with each aquifer. The BC Aquifer Database will be updated with the revised aquifer mapping reports and polygons, which will become available in GWELLS.

Partners and Linkages

This project was done in partnership with the RDN through a Memorandum of Understanding with FLNRORD. The RDN engaged and collaborated with Snaw-naw-as First Nation, the Te'mexw Treaty Association (TTA), and GW Solutions who also recently completed groundwater analysis in the area on behalf of TTA.

References

Golder Associates Ltd. (Golder). 2020a. Refined Water Budget (Phase 3) for Nanoose (Electoral Area E). Regional District of Nanaimo, B.C.

Golder Associates Ltd. (Golder). 2020b. Stage 1 Foundational Mapping – Aquifer 219 and Aquifer 1098. Regional District of Nanaimo, B.C.

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Acknowledgements:
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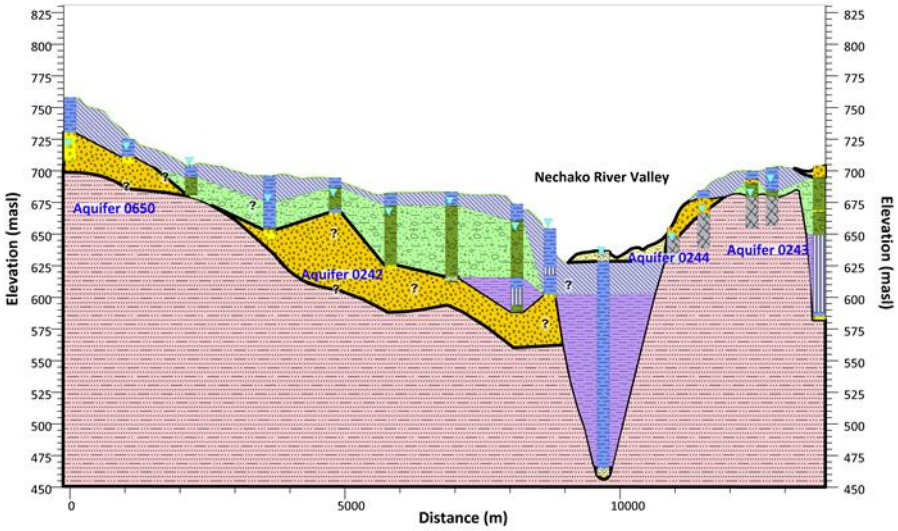
Groundwater Science Program

Aquifer Mapping Studies, North Area Phase 1

Project Description

Phase 1 of the North Area aquifer mapping project focused on aquifers in the Vanderhoof area, which is located in the Nechako River Valley approximately 80 kilometres west of Prince George. This project integrated water well records from the GWELLS database with mapping of geology, topography, streams and springs to map aquifers in the Vanderhoof area. Aquifer updates focussed on using regional-scale physical and hydraulic boundaries to delineate aquifer boundaries and to support water management efforts.



Cross section showing the hydrostratigraphy of the Nechako River Valley.

Summary of Project Outcome

The boundaries of 16 previously mapped aquifers were adjusted by expanding them to interpreted boundaries or by consolidation with other aquifers. Two previously mapped aquifers were recommended for deletion due to their small localized extent. One new bedrock aquifer was mapped near Cluculz Lake, and one new unconsolidated aquifer was mapped along the Nechako River, near Fort Fraser, B.C. The vulnerability of the aquifers was assessed as high (three aquifers), medium (five aquifers), or low (four aquifers). Mapping of the spatial extents and character of overburden and bedrock aquifers provides a resource for water licensing decisions and water management planning.

Relevance

This area, which is bisected by the Nechako River, is one of BC's largest agricultural areas. Groundwater is a major source of regional water supply for agriculture, municipal drinking water, and domestic use. Demand on groundwater resources is expected to increase due to surface water allocation restrictions for the Nechako River and surrounding streams. Updated aquifer mapping and aquifer characterization will inform groundwater licensing and assist in the future assessment of hydraulic connections with surface waters; aquifer hydraulic properties; local or regional groundwater budget analyses; and, development of numerical groundwater models.

Next Steps

Phase II of the project will extend the project area to include aquifers near Houston, B.C.

Partners and Linkages

Aquifer mapping and reporting was completed by Advisian Consulting under contract with ENV.

References

Hinnell, A.C., T. Lengyel, S.P. Funk, J.J. Clague, and Z.M. Hammond. In prep. Northern B.C. Aquifer Mapping Studies: Vanderhoof and Houston Study Areas. Water Science Series, Province of British Columbia, Victoria.

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2. GROUNDWATER MONITORING

The Provincial Groundwater Observation Well Network (PGOWN) monitors groundwater conditions in aquifers across British Columbia through a series of provincially managed groundwater monitoring wells. The water level measurements and water chemistry data collected through the network helps inform water resource management decisions across the province.

The objectives of the network include:

- understanding local and regional hydrogeological processes and characteristics;
- supporting groundwater licensing and sustainable resource management;
- flood forecasting;
- drought monitoring;
- climate change monitoring;
- cumulative effects monitoring; and,
- minimizing groundwater conflicts between users.

The data collected through the PGOWN is made publicly available through several Provincial portals:

- *Map tool - Groundwater Level Data Interactive Map;*
- *Aquarius Time-Series database - Aquarius web portal; and,*
- *Water quality data - Environmental Monitoring System (EMS) web reporting.*

The PGOWN was formally established in 1961 and the network has evolved over the years with new observation wells added while monitoring at other wells has been discontinued as priorities, staffing levels and funding levels have fluctuated. As of August 2020, there were 217 active observation wells in the PGOWN. During the 2019-20 fiscal year, a total of six new observation wells were added into the PGOWN; four new observation wells were drilled in priority areas of the province and two existing wells were adopted into the network. The new observation wells are described in the following project summaries.

Observation Well 484, Village Point, Mayne Island, B.C.

Project Description

The Provincial Groundwater Observation Well Network (PGOWN) monitors groundwater conditions in aquifers across British Columbia. This project resulted in adoption of an existing well into the PGOWN in coordination with Village Point Improvement District (VPID) on Mayne Island. Two existing VPID wells that had insufficient yield to be used as production wells were evaluated for suitability as PGOWN wells. The wells were instrumented with water level sensors in August 2017 and monitored for a period of two years.

Potential PGOWN well drilled in 1970.
Photo: G. Henderson

Summary of Project Outcome

One of the wells was determined to have a hydrograph representative of groundwater conditions in this area. The second well was substantially affected by pumping interference and could not be used for monitoring. This well was returned to VPID to be decommissioned.

Observation well (OW484) was completed into a bedrock aquifer in September 1970 and a recent inspection found the well to be compliant with the Groundwater Protection Regulation. Groundwater levels collected hourly will be publicly available on the provincial real-time water data website. Water chemistry samples will be obtained during the first year of operation, and the results will be publicly available online through the Environmental Monitoring System (EMS) web reporting tool.

Relevance

The Southern Gulf Islands have long been known as an area susceptible to drought and groundwater overuse. Long-term monitoring of groundwater levels helps with resource management decisions and educational opportunities for the public and all levels of government. Mayne Island has four mapped aquifers, of which three will have PGOWN sites after the addition of OW484. OW484 monitors Aquifer 632, the first PGOWN site in this sedimentary bedrock aquifer located on the south side of Mayne Island.

Learnings & Recommendations

Water levels in OW484 ranged from 10.1 to 26.7 m below ground surface over the two-year monitoring period, which is deeper than the other two Mayne Island observation wells by 10 to 15 metres. Water levels peaked in January and reached lowest levels in October of each year. Water quality results provided from VPID indicate the well produces hard water with some mineralization due to calcium and magnesium.

Partners and Linkages

The Village Point Improvement District approached the Province and offered a selection of wells that were slated to be closed but had potential as monitoring locations. Initiating monitoring in a new area of the island will benefit VPID and the residents of Mayne Island for years to come.

References

Province of British Columbia. 2020. Well Record for Observation Well 484. GWELLS, Well Tag Number 23162.

Project Contacts

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Acknowledgements:
Strategic Water and Air Monitoring Planning Process
FLNRORD West Coast Regional Operations

Observation Well 493, Koksilah River Watershed, Cowichan Station, B.C.

Project Description

The Provincial Groundwater Observation Well Network (PGOWN) monitors groundwater conditions in aquifers across British Columbia. The project objective was to install a new bedrock aquifer monitoring well in the Koksilah River watershed on Vancouver Island. The tasks included site selection, drilling and well construction, a long-term pumping test, evaluation of groundwater quality, and adding monitoring instrumentation to the well. The well is located in Jack Fleetwood Memorial Park, which was selected for its proximity to Koksilah River. Drilling at this site comprises the second phase of the Koksilah watershed groundwater monitoring project initiated in 2019; Phase I previously resulted in two new PGOWN locations. The second phase plan was to install a shallow well in the surficial sand & gravel aquifer and a deeper well in the bedrock aquifer. Area residents rely on the Koksilah River and groundwater from both aquifers for domestic and agricultural water supply.

Sonic drill rig at Jack Fleetwood Memorial Park.
Photo: G. Henderson

Summary of Project Outcome

Observation well 493 (OW493) was completed into the bedrock aquifer and instrumented with water level monitoring equipment in March 2020. Groundwater levels collected hourly will be publicly available on the provincial real-time water data website. Water chemistry samples were collected during a pumping test and the results are publicly available online through the Environmental Monitoring System (EMS) web reporting tool. No surficial aquifer was encountered at this location.

Relevance

Koksilah River watershed has been identified as a watershed to watch for drought conditions and conservation measures. This project will result in long-term water level data from Aquifer 198 to support authorization and management of groundwater, particularly during times of water scarcity. The project will also provide the opportunity to better understand hydraulic connection to streams, and groundwater level response to temporary pumping restrictions.

Learnings & Recommendations

After the pumping test, groundwater levels in OW493 ranged from 5.9 m below ground surface in March 2020 to 6.5 m in June 2020. Results from the pumping test indicate a well yield of approximately 2.5 gallons per minute (GPM).

Partners and Linkages

The Cowichan Valley Regional District (CVRD) was instrumental in selecting and obtaining permission for the location of OW493. Jack Fleetwood Memorial Park is owned and managed by CVRD and OW493 is owned and operated by the Province of British Columbia.

References

Province of British Columbia. 2020. Well Record for Observation Well 493. GWELLS, Well Tag Number 120148.

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Observation Well 490, Langley, B.C.

Project Description

As part of ongoing efforts to expand the Provincial Groundwater Observation Well Network (PGOWN), an existing monitoring well previously installed as part of a groundwater-surface water connectivity study was identified as being a suitable addition to the network. The well was originally installed in 2016 by the Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) in Langley, into the unconfined sand and gravel aquifer (Aquifer 24).

Groundwater level data from this well (now identified as Observation Well 490) has been collected since 2016, before its inclusion into the PGOWN. A review of the available data and other records indicated the suitability of this site for long-term groundwater level monitoring. As part of this project, minor site upgrades were completed by a contractor to ensure the longevity of this observation well.

The intention of this project was to provide a location for the long-term monitoring of groundwater levels and chemistry within Aquifer 24. With such data we can better understand the state of our aquifers and inform statutory decision makers in the allocation and licensing of groundwater use.

View of OW490 in Langley.
Photo: B. Jackson

Summary of Project Outcome

A direct-read cable and manual data loggers were added to this site to ensure continuous and accurate data collection. Groundwater level data will be manually downloaded periodically from this non-telemetry site. All groundwater level data are reported publicly through the Groundwater Level Data Interactive Map and the Aquarius time-series database. Water samples were collected from this well and submitted for baseline laboratory analyses; results are publicly available online through the Environmental Management System (EMS).

Relevance

Aquifer 24 is a high priority aquifer for monitoring due to the dependence of the local community on this aquifer for domestic and irrigation water supply. The intent of monitoring is to collect long-term groundwater level data. The data support implementation of the *Water Sustainability Act* (*WSA*) through groundwater allocation and licensing and inform management decisions that promote protection and sustainability of groundwater resources.

Learnings & Recommendations

Over the course of a year, water levels in OW490 typically range from approximately 2.6 to 5.4 metres below ground surface. The shallowest groundwater levels occur in January or February and the deepest levels in August or September. Seasonal pumping interference from irrigation wells can be observed typically from May to September.

Partners and Linkages

The Township of Langley provided a location on a road right-of-way for the installation of the observation well and agreed to the long-term use of this location for groundwater monitoring.

References

Province of British Columbia. 2020. Well Record for Observation Well 490. GWELLS, Well Tag Number 117645.

Project Contacts

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Observation Well 491, Maple Ridge, B.C.

Project Description

Aquifer 26 is a confined sand and gravel aquifer located in Maple Ridge, B.C. It has been monitored as part of the Provincial Groundwater Observation Well Network (PGOWN) since 1980 with Observation Well 259. However, water level measurements in Observation Well 259 exhibit significant pumping interference from nearby wells. The intention of this project was to install a second groundwater level monitoring well (Observation Well 491) within Aquifer 26 in an area that is not significantly influenced by pumping interference. This new well will also provide additional groundwater quality data from the aquifer.

This project involved researching and selecting sites, drilling the monitoring well, and adding telemetry and monitoring instrumentation to the well. With the data collected from this observation well, we can better understand the state of Aquifer 26 and inform statutory decision makers in the allocation and licensing of groundwater use.

View of OW491 in Maple Ridge.
Photo: B. Jackson

Summary of Project Outcome

Observation Well 491 was drilled to a total depth of 41.5 metres below ground surface (m bgs) on March 17 to March 19, 2020. The well was screened at a depth of 38.5 to 41.5 m bgs. Full satellite telemetry will be added to this well later in 2020. All groundwater level data are publicly available through the Groundwater Level Data Interactive Map and the provincial Aquarius time-series database. Water samples were also collected for laboratory analyses, and the results are publicly available through the Environmental Monitoring System (EMS).

Relevance

Aquifer 26 was identified as a high priority aquifer for monitoring due to the dependence of the local community on this aquifer, primarily for domestic and water supply system wells. The intent of monitoring is to collect long-term water level data. The data will be used to support implementation of the *Water Sustainability Act* (*WSA*) through licensing and to inform management decisions that promote protection and sustainability of groundwater resources.

Learnings & Recommendations

At the time of this report, there was only three months of groundwater level data available. The groundwater levels were at approximately 16.1 m bgs for the well during the spring of 2020. However, based on that limited dataset, it appears that Observation Well 491 does not suffer from significant pumping interference like Observation Well 259.

Partners and Linkages

The City of Maple Ridge provided a location within a municipal park (Selvey Park) for the installation of the observation well and agreed to the long-term use of this location for groundwater monitoring.

References

Province of British Columbia. 2020. Well Record for Observation Well 491. GWELLS, Well Tag Number 120403.

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Acknowledgements:
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FLNRORD South Coast Regional Operations

Observation Well 492, Columbia Valley, B.C.

Project Description

Aquifer 20 is an unconfined sand and gravel aquifer located in Columbia Valley, B.C. It has been monitored by Observation Well 465 in the Provincial Groundwater Observation Well Network (PGOWN) since 2018. However, due to construction challenges, Observation Well 465 had poor hydraulic connectivity to the aquifer, which resulted in unreliable data. Consequently, for this project, Observation Well 465 was decommissioned and replaced by Observation Well 492 a few metres away. The intention of this new well (Observation Well 492) is to establish a monitoring location for the long-term collection of groundwater level and groundwater quality data that are representative of Aquifer 20.

This project involved determining a decommissioning strategy, acquiring the necessary permits, drilling the monitoring well and adding telemetry and monitoring instrumentation. With the data collected from this observation well, we can better understand the state of Aquifer 20 and inform statutory decision makers in the allocation and licensing of groundwater use.

View of OW492 in Columbia Valley.
Photo: B. Jackson

Summary of Project Outcome

Observation Well 491 was drilled to a total depth of 82.6 metres below ground surface (m bgs) on February 24 to February 27, 2020. The well was screened at a depth of 79.2 to 82.6 m bgs. Full satellite telemetry was added to this well in June 2020. All groundwater level data is publicly available through the provincial Groundwater Level Data Interactive Map and Aquarius time-series database. Water samples were also collected for laboratory analyses, and the results are publicly available through the Environmental Monitoring System (EMS).

Relevance

Aquifer 20 was identified as a high priority aquifer for monitoring due to the dependence of the local community on this aquifer for domestic and irrigation water supply. The intent of monitoring is to collect long-term water level data. The data will be used to support implementation of the *Water Sustainability Act* (*WSA*) through licensing and to inform management decisions that promote protection and sustainability of groundwater resources.

Learnings & Recommendations

At the time of this report, there was a limited amount of groundwater level data available. The groundwater levels were at approximately 57.4 m bgs for the well in June 2020. Based on the available dataset, it appears that Observation Well 492 is hydraulically connected to Aquifer 20. Minor pumping interference is visible in the dataset as a result of nearby irrigation wells.

Partners and Linkages

The Ministry of Transportation and Infrastructure provided the necessary permit to drill on their road right-of-way for the decommissioning and drilling work.

References

Province of British Columbia. 2020. Well Record for Observation Well 492. GWELLS, Well Tag Number 120407.

Project Contacts

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Acknowledgements:
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FLNRORD South Area Regional Operations

Observation Well 487, Lumby, B.C.

Project Description

The Provincial Groundwater Observation Network (PGOWN) monitors groundwater conditions in aquifers across British Columbia. The project objective was to install an observation well in Aquifer (AQ) 314, a deep confined sand and gravel aquifer with documented occurrences of flowing artesian conditions. The well is located in the Whitevale area near Lumby, B.C. The project involved site selection, securing access, ground clearing, drilling and well construction, and collection of representative water samples for water quality analysis.

Early morning at the drill site.
Photo: John Pogson

Summary of Project Outcome

The observation well (OW487) was completed to a total depth of 90.95 metres below ground surface (m bgs) on March 5, 2020. The well design was carefully considered to plan for and mitigate against potential flowing artesian conditions and reduce the potential for creating a hydraulic connection between the deeper aquifer (AQ314) and the overlying shallow aquifer (AQ316).

The observation well is currently instrumented with temporary continuous water level monitoring equipment. Full satellite telemetry instrumentation is anticipated by August 2020, when groundwater levels will be publicly available through the provincial Groundwater Level Data Interactive Map. Water samples were collected for laboratory analyses and results are available through the Environmental Management System (EMS).

Relevance

OW487 is adjacent to existing observation well OW294, which monitors the overlying shallow water table aquifer and is considered reasonably likely to be hydraulically connected to Bessette Creek, a stream considered to be fully recorded. The proximity of the two wells allows for direct comparison of gradients and pressure differences in the stacked aquifers. AQ314 is considered a high priority aquifer for monitoring as it represents a relatively untapped groundwater resource below the water table aquifer and the location selected is in a previously unexplored part of the deep aquifer.

Learnings & Recommendations

Groundwater levels are near ground surface at the well (6.35 m bgs) and an upward vertical hydraulic gradient was calculated. There was evidence of partial cementation of aquifer materials and elevated dissolved manganese concentration. OW487 will provide resource managers, industry and the public with groundwater level and water quality data and support environmental protection, policy development, and water allocation decisions.

References

Province of British Columbia. 2020. Well Record for Observation Well 487. GWELLS, Well Tag Number 120396.

Project Contacts

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Acknowledgements:
Strategic Water and Air Monitoring Planning Process
FLNRORD South Area Regional Operations

3. GROUNDWATER CHARACTERIZATION AND RESEARCH

The projects in the following section highlight the wide variety of groundwater science and research projects undertaken by the province in 2019-20. These projects demonstrate the technical ability and expertise of provincial groundwater staff and the challenges and complexities of assessing and sustainably managing groundwater resources in the province.

The interaction between surface water and groundwater (SW-GW) continues to be an overarching theme in many of the projects undertaken in 2019-20. Under the *Water Sustainability Act*, water is managed as one interconnected resource. Statutory Decision Makers (SDM) must consider the potential impacts of groundwater pumping on the environmental flow needs (EFN) of connected streams in the adjudication of groundwater licence applications. Thus, studies to characterize the interaction between aquifers and hydraulically connected streams are a high priority for resource managers and licensing staff. SW-GW projects have been undertaken throughout the province using a variety of tools and approaches, including:

- Desktop analyses based on hydrogeologic mapping (Chemainus and Bonsall Watersheds; French Creek Area, Vancouver Island, British Columbia);
- Field based studies using hydrometric measurements and thermal imaging (Steele Park in the Lower Fraser Valley; Upper Bulkley River in Houston, B.C.);
- Field based studies using geochemical and isotopic analyses (Upper Fraser River near Valemount, B.C.; Terrace aquifer characterization project); and,
- Modeling tools to support assessments of groundwater pumping impacts on streams (UVic analytical depletion functions study; Groundwater modelling in the Nicola and Coldwater River valleys).

Other projects mainly focus on aquifer and groundwater characterization. These projects aim to advance the knowledge and understanding of groundwater resources and inform groundwater resource management:

- Aquifer mapping and monthly water balance analyses (Nicomekl-Serpentine watersheds; French Creek, B.C.);
- Groundwater quality assessments (GW quality survey in the South Cowichan watershed; Salt water intrusion risk assessment in coastal B.C.);
- Observation well network expansion to support transboundary groundwater management in the Fort Nelson, B.C.; and,
- Mapping studies (Artesian well mapping in the Okanagan Basin and Lower Fraser Valley; Surficial materials mapping study).

A third category of projects are initiatives to support water managers and groundwater resource management. These projects include:

- Assessing tools for managing groundwater availability and climate change impacts (Evaluation of aquifer storage and recovery potential in B.C.; Identifying indicators of drought);
- Groundwater data management support (Maintenance and enhancement of GWELLS);
- Groundwater licensing support (Updating guidance on technical assessment requirements).

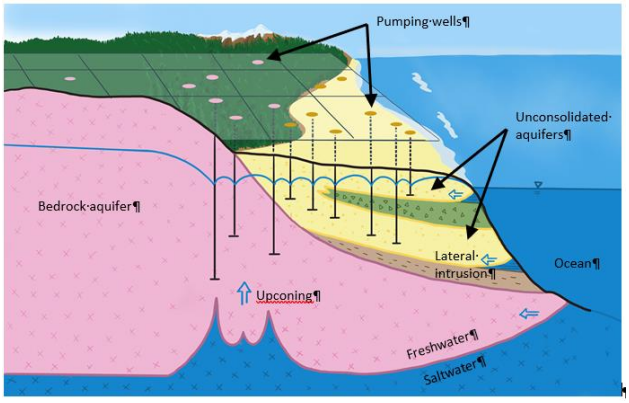
Many of the following projects are large in scope and, therefore, are being conducted over multiple years. In cases where the projects are ongoing, an update summary has been provided to report on progress and results or learnings achieved to date.

Modelling Saltwater Intrusion Risk along British Columbia's Coast

Project Description

Aquifers in coastal B.C. may be vulnerable to saltwater intrusion due to natural physiographic and hydrogeologic factors, coastal morphology and groundwater pumping. The quality of groundwater relied upon for potable water supplies and other purposes can be compromised by geochemical alteration that occurs due to changes in the location of the freshwater-saltwater interface (i.e., the reduced depth below ground and/or inland migration).

Mapping of saltwater intrusion (SWI) vulnerability and risk was previously completed for the southern Gulf Islands (Klassen and Allen 2016). This project extends the assessment to all coastal B.C.



Mechanisms of intrusion of saltwater in coastal unconsolidated and bedrock aquifers.

Summary of Project Outcome

A SWI risk assessment was prepared for coastal B.C. for both unconsolidated and fractured rock aquifers. A second phase of the project in 2020/21 will upscale risk assessment point values for unconsolidated deposits to an aquifer scale, incorporate groundwater demand data from the Vancouver Coastal Health region, and refine estimates of potential loss. The results will be presented at workshops for FLNRORD Coast Region staff and Islands Trust and published in the BC Data Catalogue. Documentation of the methodology will enable resultant maps to be updated in the future, as new information becomes available.

Relevance

Under the *Water Sustainability Act* S. 58, it is not permitted to operate a well in a manner that causes intrusion of saline groundwater or sea water into a freshwater aquifer. The SWI risk assessment maps will support statutory decisions by informing technical assessment requirements (e.g., baseline sampling) and authorization conditions (monitoring and reporting) when adjudicating groundwater licenses. Well drillers and consultants can apply best practices when drilling, designing, or testing water wells in higher risk coastal zones. Identified SWI areas may be targeted for more detailed characterization, monitoring, and development of area-based plans or regulations.

Learnings & Recommendations

Saltwater intrusion risk for both unconsolidated and bedrock aquifers is highest in low-lying areas closest to the ocean. Saltwater intrusion impacts from groundwater pumping is most strongly correlated to areas of high non-domestic groundwater use. Total dissolved solids (TDS), a measure of water salinity, generally increases in areas with higher vulnerability ratings.

Partners and Linkages

The project was a collaboration with ENV, FLNRORD, Islands Trust and Simon Fraser University. Western Water Associates Ltd and HydroGeoLogic contributed to the project under government contract.

References

- Klassen, J. and D.M. Allen. 2016. Risk of saltwater intrusion in coastal bedrock aquifers: Gulf Islands, B.C. Department of Earth Sciences, Simon Fraser University.
- Province of British Columbia, 2016. Best Practices for the prevention of saltwater intrusion. Victoria.
- Sivak, T. and M. Wei. In prep. Modelling Saltwater Intrusion Risk along British Columbia's Coast: Interim Report for 2019/2020. Water Science Series. Province of British Columbia, Victoria (Publication pending.)

Project Contacts

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Acknowledgements:
Groundwater Science Program
FLNRORD Coast Area Resource Stewardship

Chemainus and Bonsall Watersheds: Preliminary Desktop Assessment of Hydraulic Connection, Vancouver Island, British Columbia

Project Description

The Chemainus and Bonsall watersheds support important fisheries and aquatic habitat as well as development on the land base. Under the British Columbia *Water Sustainability Act* (*WSA*), new groundwater authorizations must consider hydraulic connection to streams and environmental flow needs if determined to be hydraulically connected. This project was developed to assess hydraulic connection between groundwater and surface water to support the application of the *WSA*.

The main goals of this study were to:

- use available data to identify stream reaches where hydraulic connection between surface water and groundwater is more likely; and,
- delineate groundwater management areas associated with those major connected stream reaches.

Chemainus River at Banon Creek.
Photo: West Coast Region Water Authorizations

Summary of Project Outcome

The project outcomes included a report to be published in the Water Science Series and a geodatabase including relevant spatial layers that were created to support the project.

Relevance

Determining where along a stream hydraulic connection likely occurs and the corresponding portion of the aquifer that participates in flow to those connected stream reaches is necessary to enable surface water and groundwater to be managed together as a single resource that allows decision makers to:

- Consider how diversion of groundwater may affect environmental flow needs of a stream;
- Operationally account for water demand from points of groundwater diversion along the stream; and,
- Consider hydraulically connected groundwater users when flow in a stream reach becomes critically low.

Learnings & Recommendations

Results show that groundwater in the study area flows towards the mouth of the Chemainus River and Bonsall Creek, and ultimately discharges to the ocean either directly or via the two streams. Pumping of groundwater from the unconsolidated and bedrock aquifers in the study area can deplete stream flows where stream reaches are hydraulically connected (no vadose zone nor low permeability sediments are present directly beneath the stream). This work identified three management areas for the Chemainus watershed and two areas for the Bonsall watershed in both the unconsolidated and bedrock aquifers. Recommendations include field work to verify assumptions and findings in the report, as well as operational recommendations to ensure and protect environmental stream flows.

Reference:

Sivak, T. and M. Wei. In prep. Chemainus and Bonsall Watersheds: Preliminary Assessment of Hydraulic Connection. Water Science Series, Province of British Columbia, Victoria.

Project Contact

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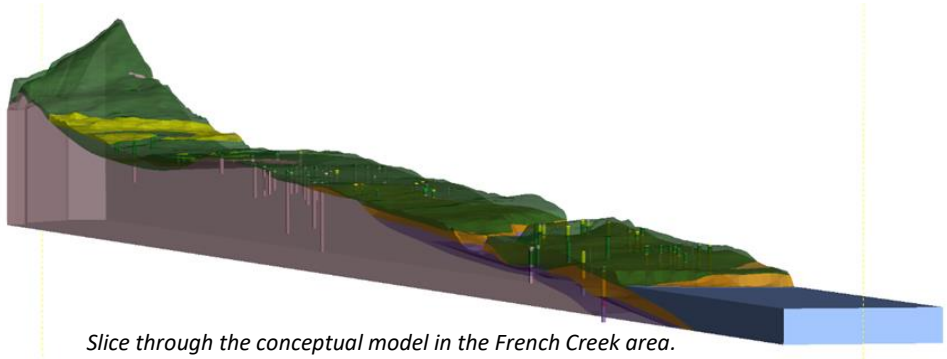
Acknowledgements:
FLNRORD West Coast Authorizations

French Creek Area Hydraulic Connectivity and Aquifer Mapping Study, Vancouver Island, British Columbia

Project Description

French Creek, Whiskey Creek, Englishman River, and Qualicum River watersheds support important fisheries and aquatic habitat and are experiencing development of the land base. Many of the study area streams are already under water allocation restrictions. In many cases, aquifers provide baseflow to perennial streams, which is vital in the summer time for the proper functioning of the stream ecosystem (Environmental Flow Needs – EFN). Understanding the hydraulic interactions between streams and aquifers, including the effect of groundwater diversion from a pumping well on streamflow, is required to support the application of the B.C. *Water Sustainability Act*.



Slice through the conceptual model in the French Creek area.

The objectives of the project were to:

- Update the spatial extent and information on existing mapped aquifers within the study area;
- Map and describe new aquifers within the study area;
- Correlate wells in the GWELLS database to the mapped aquifers; and,
- Identify and characterize where hydraulic connections occur between surface waters (e.g., streams, rivers, lakes) and aquifers to support the application of the *WSA*.

Summary of Project Outcome

The project outcomes included a report to be published in the Water Science Series and a geodatabase including relevant spatial layers that were created to support the project.

Relevance

This project provides technical information to decision makers, water allocation staff, and professional hydrogeologists related to aquifers and their connectivity to streams within the area of the Nanaimo Lowlands, from the Englishman River to Deep Bay.

Learnings & Recommendations

Results show that bedrock aquifers provide important baseflow to major streams such as French Creek, Englishman River, Little Qualicum River, Whisky Creek and Swane Creek. In the lowlands, streams mostly gain flow from Quadra-sand aquifers either directly (i.e., connected gaining) or from seepage (i.e., losing). Recommendations for additional fieldwork include monitoring of groundwater and surface water levels and stream discharge to verify results and assumptions.

Reference

Barroso, K.A., S.K. Richard, M. Vardal, and G. Wendling. In prep. French Creek Area Hydraulic Connectivity and Aquifer Mapping Study. Water Science Series, Province of British Columbia, Victoria. (pending publishing).

Project Contacts

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Acknowledgements:
FLNRORD West Coast Authorizations

Groundwater Quality Survey of Aquifers in South Cowichan, Vancouver Island, British Columbia

Project Description

A groundwater quality survey was completed in the South Cowichan area, Vancouver Island, British Columbia. Samples of untreated water quality were collected from 70 domestic and 12 water supply wells distributed across this primarily groundwater dependent area.

Rural residential-agricultural area of South Cowichan.
Photo: S. Barroso

Summary of Project Outcome

Overall, groundwater quality in unconsolidated (AQ197) and fractured bedrock (AQ198, AQ203) aquifers was excellent, with few exceedences of drinking water quality guidelines. The study found both naturally occurring (e.g., arsenic, manganese, iron) and anthropogenic (e.g., nitrate) water quality parameters were present in groundwater sampled. While only two sites exceeded water quality guidelines for arsenic (10 µg/L), approximately 25% of samples had arsenic >2 µg/L, which could be a concern with long-term exposure or for vulnerable populations based on Health Canada Guidance (e.g., children, elderly). Nitrate (NO_3) was undetected in 33% of samples, and the median concentration was 0.62 mg/L in samples from unconsolidated and bedrock wells. Analysis of isotopes in samples with NO_3>2 mg/L indicated the nitrate source was from human or animal waste.

Relevance

Domestic well owners benefitted from information provided on groundwater quality, well maintenance and protection. Pollutants such as arsenic, which have no obvious taste, colour or smell in water, can be a chronic health concern even when below drinking water guidelines; treatment is recommended to reduce concentrations to a level as low as reasonably achievable. The background concentration of nitrate in AQ197 was determined to be very low (0.5 mg/L), and concentrations above this may provide an early indicator of potential groundwater quality impacts from land-use.

Learnings & Recommendations

The nitrate concentration was linked to proximity to pollution point sources such as concentrated manure storage or permitted waste discharges. Lower aquifer vulnerability, indicated by the presence of confining materials such as till or clay overlying the aquifer, was not observed to provide significant protection (i.e. reduced percolation) where land-use contributes to nitrate loading. Continued collaborative work is recommended to identify and mitigate pollution from point- and non-point sources that affect both surface and groundwater quality in this area (e.g., compliance verification, and environmental farm, liquid waste management, and well head protection planning).

Partners and Linkages

The project was completed with funding and support from Ministry of Environment (ENV), Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) and Cowichan Valley Regional District (CVRD).

References

Barroso, S. and C. Melnechenko. 2019. Groundwater Quality Survey of Aquifers in South Cowichan, Vancouver Island. Water Science Series WSS2019-09. Province of British Columbia, Victoria.

Project Contacts

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Acknowledgements:
ENV Strategic Water & Air Monitoring Planning Process
FLNRORD West Coast Resource Stewardship
Cowichan Valley Regional District

Assessment of Aquifer-Stream Connectivity Related to Groundwater Abstraction in the Lower Fraser Valley, Langley, B.C.

Project Description

Water from a pumping well may be captured from a stream and lead to streamflow depletion. Under the *Water Sustainability Act*, groundwater and surface water are managed as one resource, which requires consideration of the interconnectivity of these resources in water use decisions. The goals of this multi-year study in Langley, B.C. are to build an understanding of the interaction between groundwater and surface water, and to assess how the hydrological regime and aquatic habitat respond to different stressors, including groundwater pumping and drought.

Bertrand Creek streamflow measurement.
Photo: Simon Fraser University

Summary of Project Outcome

Phase 1 of the study (2015-2017) was conducted at Steele Park, where Union Creek, a tributary to the Salmon River flows through the unconfined Hopington Aquifer. Streamflow response to groundwater pumping was assessed during two pumping tests, and various analytical methods were evaluated for quantifying streamflow depletion from groundwater pumping. The study yielded valuable data and provided critical knowledge on how to conduct a field study to assess groundwater-surface water interaction. In phase 2 (2018-2020), the study site shifted to Otter Park, where Bertrand Creek (critical habitat for the Nooksack Dace and Salish Sucker) flows through the unconfined Abbotsford-Sumas Aquifer. The hydraulic properties of the aquifer and streambed sediments were characterized using a variety of methods and hydrometric measurements were used to quantify streamflow depletion during a groundwater pumping test. The predictability of the Hunt (1999) streamflow depletion model was assessed through comparisons to measured streamflow depletion. Phase 3 of the study (in progress) adds a hydro-ecological component to understand how the aquatic habitat responds to stressors.

Relevance

This study builds a more comprehensive understanding of the relationship between instream flow conditions (e.g., groundwater exchange) and aquatic habitat, and provides staff with opportunities to explore environmental flow needs methodologies, including study processes, limitations and uncertainties. In addition, findings from this study will inform and assist decision makers working in the Bertrand Creek watershed in meeting their obligation to consider environmental flow needs under the *Water Sustainability Act*.

Learnings & Recommendations

Heterogeneity of aquifer and streambed sediments and the variability in gaining or losing flow conditions along the stream reach were found to influence and complicate the ability to characterize and quantify streamflow depletion. The effect of groundwater pumping on environmental flow needs is a significant knowledge gap.

Partners and Linkages

The project was conducted by the Department of Earth Sciences at SFU under the direction Dr. Diana Allen in partnership with FLNRORD staff. The Township of Langley provided access to the park land for the study site.

References

- Hunt, B. 1999. Unsteady stream depletion from ground water pumping. Ground Water, 39(1): 98-102.
- Johnson, B., D.M Allen, M. Simpson, and M. Lepitre. In prep. Assessment of Aquifer-Stream Connectivity Related to Groundwater Abstraction in the Lower Fraser Valley: Phase 2 Field Investigation at Otter Park, Langley. Water Science Series, Province of British Columbia, Victoria (publication pending).

Project Contacts

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Acknowledgements:
Groundwater Science Program
FLNRORD South Coast Authorizations

Aquifer Mapping and Monthly Water Balance, Nicomekl-Serpentine Watersheds, Lower Mainland, B.C.

Project Description

The Serpentine and Nicomekl watersheds are located in south Surrey, B.C. with headwaters predominantly within the urbanized areas of Langley and Surrey. Both rivers flow into Boundary Bay. This area has been important for agricultural production. Water supply for agricultural (irrigation), commercial/industrial, municipal, and domestic uses is sourced from both surface and groundwaters. However, there have been ongoing water quantity issues including agricultural water shortages during peak irrigation season and reduced recreational opportunities.

Serpentine River.
Photo: Hatfield Consultants LLP

Given the significant amount of surface and groundwater users in both watersheds, the Province is exploring a more strategic, long-term and sustainable planning process to address the water use issues (e.g., Fraser Basin Council, 2018). The objectives of this study are to enhance understanding of the hydrogeology and mapping of aquifer extents, and to improve estimates of overall water demand and water availability in this area.

Summary of Project Outcome

This study was initiated in early 2019. During the initial stage, aquifer characterization and maps were updated, and a basic environmental flow needs (EFN) assessment was completed for each river. An integrated (i.e., surface and groundwater) water balance model was developed using the updated aquifer mapping, observation well data, and surface water data utilized in the EFN study. Findings will be published as a report in the Water Science Series.

Relevance

This project will enable development of a sustainable water allocation plan for the watersheds to support allocation and management decisions for current and future water use, and to protect fish and aquatic values.

Learnings & Recommendations

As existing groundwater users are transitioned into the water management framework with the implementation of the *Water Sustainability Act*, our understanding of the groundwater demand in the Serpentine and Nicomekl watersheds will improve over time. Given the complex hierarchy of aquifers in the study area, it is recommended that a three-dimensional groundwater model be developed for both watersheds to quantify groundwater and surface water connectivity and refine the analysis of potential impacts of water use on the EFN of both streams.

Partners and Linkages

This project was carried out by Hatfield Consultants LLP in partnership with FLNRORD.

References

Fraser Basin Council. 2018. Process Roadmap for Sustainable Water Allocation in the Nicomekl and Serpentine Watersheds. Prepared for: Ministry of Forests, Lands, Natural Resource Operations and Rural Development. 25pp.

Nunn, J., B. Stevenson, I. Bystron, P. Kobler, J. Beckers and T. Bennett. In prep. Aquifer Mapping and Monthly Water Balances, Nicomekl-Serpentine Watersheds, Lower Mainland, B.C. Water Science Series, Province of British Columbia, Victoria. (in preparation).

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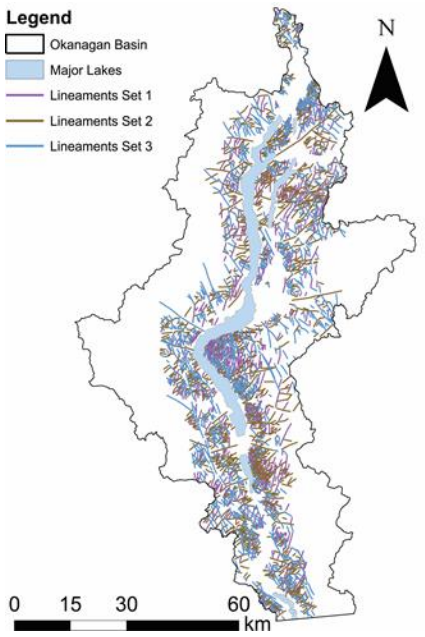
Acknowledgements:
Groundwater Science Program
FLNRORD South Coast Authorizations

Mapping and Mitigating Risk of Flowing Artesian Wells in B.C.: Okanagan Basin and Lower Fraser Valley

Project Description

The goals of this project are to develop a comprehensive understanding of factors controlling where flowing artesian conditions occur, to identify where there is greater risk when drilling into those conditions, and to examine current policies and regulatory requirements regarding flowing artesian wells.



Map showing flowing bedrock lineament sets in the Okanagan Basin.

Summary of Project Outcome

This multi-year project has four overlapping phases. Phase 1 was a preliminary geostatistical analysis on the occurrence of flowing artesian wells in the Okanagan Basin and Lower Fraser Valley. Phase 2 is a GIS-based analysis of factors controlling artesian wells, incorporating information from conceptual hydrogeological models (e.g., geological cross-sections), groundwater flow modelling, and expert knowledge from well drillers on the occurrence of flowing artesian wells in mountainous (e.g., Okanagan) and low relief (e.g., Lower Fraser Valley) settings. Phase 3 involves mapping the likelihood (or risk) of flowing artesian wells in each study area, and Phase 4 focuses on providing recommendations to government, Engineers and Geoscientists BC (EGBC), drillers, and other hydrogeological professionals.

Relevance

Flowing artesian wells are a known problem in many regions of B.C., particularly in the Lower Fraser Valley and the Okanagan. Uncontrolled flow from artesian wells can impact the long-term sustainability of aquifers, leading to reduced water yield from wells and springs, as well as reduced groundwater discharge to streams, which in turn can impact aquatic habitat. Moreover, flowing artesian wells may significantly increase the risk of subsidence or sinkholes as recently occurred in the City of Vancouver. The result may be extensive property damage, loss of property value, exorbitant costs to property owners, and restrictions on future use of the land. Controlling artesian flow is a requirement of the *Water Sustainability Act* (S. 52 and 53).

Learnings & Recommendations

This project will yield insight into the hydrogeological factors that control the occurrence of flowing artesian wells. The maps produced for the Okanagan Basin and Lower Fraser Valley will show areas of high and moderate risk for flowing artesian conditions. These maps can be used to identify priority areas for monitoring and development of flowing artesian conditions advisories. The project is intended to support regulatory requirements for controlling artesian flow by providing better understanding of where such conditions occur, and how B.C. and other jurisdictions are managing the problem through policy and regulation.

Partners and Linkages

The project is being carried out by Dr. Diana Allen (Professor) and Brynje Johnson (M.Sc. student) in the Department of Earth Sciences at Simon Fraser University, and Mike Wei (Hydrogeologist) at HydroGeoLogic.

References

Allen, D.M. 2017. Risk of Flowing Artesian Wells in the Okanagan. Phase 1. Research report submitted to B.C. Ministry of Forests, Lands and Natural Resource Operations, March 2017, 8 pp.

Project Contacts

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Acknowledgements:
Groundwater Science Program
FLNRORD South Coast Authorizations

Groundwater Modelling, Nicola and Coldwater River Valleys, Merritt B.C.

Project Description

The Nicola Watershed project was undertaken as a multi-year, three-phase project to improve knowledge of the hydrogeology and groundwater-surface water interactions within the Nicola and Coldwater River Valleys at Merritt, B.C. Previous work included aquifer characterization and mapping (Phase I, completed in 2017-2018), and data compilation and development of a conceptual hydrogeologic model (Phase II, completed in 2017-2018). Phase III of the project was conducted between 2018-2020 and has led to the completion of a preliminary 3D regional scale, numerical flow model to support resource management. The model domain spans the Nicola River Watershed below Nicola Dam to the confluence with the Thompson River, including portions of the Coldwater River, Guichon Creek, and Midday Creek.

Nicola River hydrometric station below Nicola Dam.
Photo: J. Goetz

Summary of Project Outcome

The steady-state numerical flow model was constructed using FEFLOW, a 3D finite element model capable of simulating variably saturated flow. Groundwater flow is modeled in valley bottom unconsolidated sediments, which are bound vertically and laterally by the estimated bedrock surface. The model domain covers an area of 140 km^2 and is divided vertically into 14 geological layers. The model was calibrated to average static groundwater levels reported in the GWELLS database and to average measured baseflows for two reaches of the Nicola River and one reach of the Coldwater River. The calibrated model was used to conduct groundwater budget analyses for four sub-regions, and to explore groundwater response and vulnerability of streamflow under three pumping scenarios.

Relevance

There is considerable interest in the Nicola and Coldwater River valleys regarding groundwater, particularly in how river flows contribute to the aquifers and how pumping from local wells may impact flows in the rivers. Recurring drought conditions and low flows in the Coldwater River has required the Province to consider restricting water withdrawals in the watershed. Recent research and water budget projects have raised questions of aquifer sustainability. These issues have prompted a need for a better understanding of groundwater resources to assist with water use planning. The numerical groundwater flow model may be used to inform Provincial water management strategies such as water allocation and curtailment decisions. The groundwater model provides a technical basis to identify areas of potential water stress with respect to groundwater availability and baseflow.

Learnings & Recommendations

Absence of data and information leads to model limitations and uncertainties. Hydrogeologic characterization studies are recommended to address data gaps that include the thickness of valley bottom sediments; limited information on bedrock groundwater inflow to the valley bottom sediments; groundwater pumping locations and quantities; and the lack of surveyed water elevation data.

Partners and Linkages

The project was guided by two steering committees of the Nicola Basin Collaborative: 1) Nicola Steering Committee (mostly a non-technical group), and 2) Nicola Research and Technical Committee (mostly a technical group).

References

Golder Associates, 2018. Nicola River Project: Data Compilation Plan to Support Numerical Flow Modeling Strategy.
Golder Associates, 2019. Technical Memo, Nicola Valley Groundwater Flow Modelling Project (Part 1).
Golder Associates, 2020. Technical Memo, Nicola Valley Project Phase 3 (Part 2), Hydrogeological Modelling.

Project Contacts

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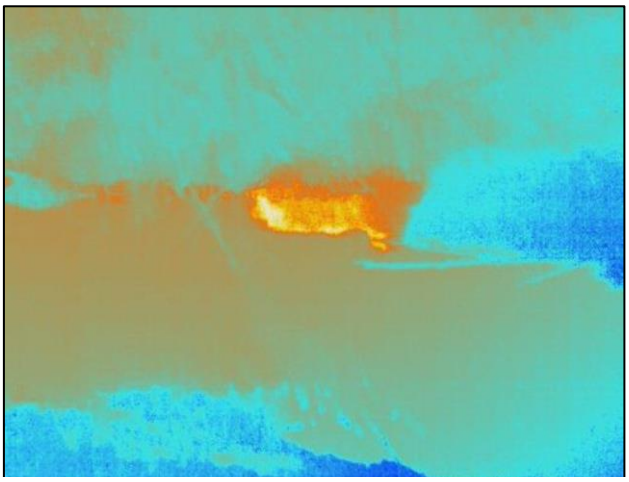
Acknowledgements:
Groundwater Science Program
Fraser Basin Council

Upper Bulkley Groundwater-Surface Water Interaction Research Project, Houston, B.C.

Project Description

Groundwater and surface water are a single system and when groundwater is withdrawn there can be implications for streamflow. The Upper Bulkley River watershed near Houston, B.C. is a classic glacial valley filled with unconsolidated sand and gravel aquifers that exhibit strong hydraulic connections between groundwater and surface water. There is considerable interest around hydraulic connectivity and environmental flow needs (EFN) in the Upper Bulkley River watershed. This interest is due to the propensity for drought, low flow conditions, and high water temperatures in the watershed, the significance of the watershed as critical spawning and rearing habitat for pacific salmon and steelhead trout, and the importance of the river as a source of water supply for a variety of users.



Thermal signature of groundwater discharge into the Upper Bulkley River, Fall 2019.

This project began in 2018 and is intended to be a 3-year study that includes: a desktop and scoping exercise (Phase 1); a field data collection program encompassing thermal imaging using a drone equipped with infrared instrumentation, the monitoring and recording of discharge and water levels, and water quality sampling and analyses for a range of parameters (Phase 2); and report writing and data sharing with stakeholders, First Nations and water management staff (Phase 3).

Summary of Project Outcome

The intended outcome of this project is to increase all levels of government understanding (Federal, Provincial, Regional and First Nations) of the interaction between surface water and groundwater resources in the Upper Bulkley River watershed through strategic collection and synthesis of both groundwater and surface water data.

This project will contribute to a more thorough understanding of groundwater resources, existing allocation pressures, the interplay between groundwater and surface water, and EFNs, which must be considered by water managers in water allocation decisions under the *Water Sustainability Act.*

Relevance

This project will support and inform water management decisions in the Upper Bulkley River watershed and will provide critical water information to a multi-year, multi-stakeholder fisheries research project.

Partners and Linkages

Project development and data sharing partners include: The Office of the Wet'suwet'en; the Wet'suwet'en First Nation; the Upper Bulkley River Streamkeepers; the District of Houston; the Regional District of Bulkley-Nechako; Fisheries and Oceans Canada; and FLNRORD.

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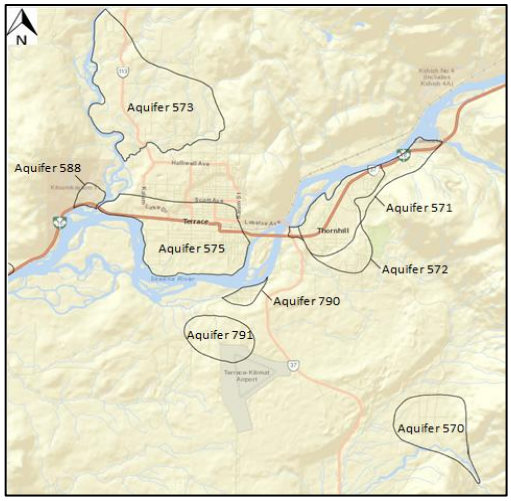
Acknowledgements:
Water Research Portfolio, FLNRORD

Terrace Aquifer Characterization Project, Terrace, B.C.

Project Description

The purpose of this study is to identify approaches to characterize aquifers using water chemistry as the primary information source and to improve the understanding of local aquifers and groundwater resources in the Terrace and Thornhill area. A sampling program was developed to evaluate groundwater and surface water chemistry in order to provide insight into groundwater recharge zones, interactions between surface water and groundwater, and to aid in estimating the mean groundwater recharge.



Mapped aquifers in the Terrace area.

Summary of Project Outcome

The project is in its final year with a focus on collation and interpretation of data. Three rounds of private well sampling (28 sites) and surface water collection (15 sites) have been completed. Water samples were analysed for general chemistry, metals, and isotopes. In addition, a total of 16 groundwater sampling sites were selected for tritium analysis during the summer 2017 sampling event. Ongoing collection of precipitation and isotope analyses is occurring to establish a local meteoric water line for data comparisons; however, sampling restrictions due to Covid-19 may limit the completeness of this dataset. Data analysis is underway with support from contractors. Project completion is expected in the fall of 2020.

Relevance

There is a lack of hydrogeological knowledge/understanding regarding the aquifer recharge areas and the interactions between groundwater and surface water bodies (i.e., Skeena River). Due to an increase in industrial activities and the potential for future development around Terrace, improved characterization of groundwater resources is needed to support effective and sustainable allocation of groundwater, as well as to inform the overall management and protection of the groundwater and aquatic resources. The groundwater characterization methods developed in this project (i.e., natural isotopic tracer) can be applied throughout B.C.

Learnings & Recommendations

Water chemistry was successfully used as the primary tool for characterizing groundwater flow patterns, aquifer boundaries, and groundwater surface water interactions in the Terrace Area. Analysis of water samples for tritium isotopes provided useful information about aquifer recharge zones and groundwater flow paths, but also requires establishment of a local meteoric water line.

Partners and Linkages

Access to groundwater sampling wells was provided voluntarily across the region, including wells from City of Terrace, Regional District of Kitimat-Stikine, First Nations (Kitselas and Kitsumkalum), and private home owners.

References

A final report will be produced documenting the results of the research.

Project Contacts

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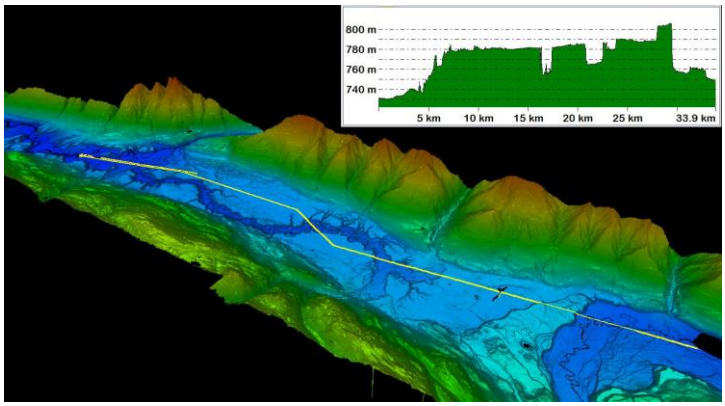
Acknowledgements:
Water Research Portfolio, FLNRORD

Surface Water and Groundwater Interaction, Valemount, B.C.

Project Description

This study examines a buried valley aquifer system in the Rocky Mountain trench near Valemount B.C., which spans the Fraser and Columbia River watersheds. The main objective is to develop a better understanding of the deeper aquifer system and its interaction with surface water and the shallow aquifer system. The study approach uses geochemical and isotopic analyses of groundwater and surface water samples to evaluate and quantify groundwater recharge and to support development of a conceptual model of groundwater interaction with surface waters in the Kinbasket Reservoir and the upper Fraser River.



Cross section of study area from the upper Fraser River to the Kinbasket Reservoir.

Summary of Project Outcome

Analysis will mainly be carried out using geochemical data of both surface water and groundwater samples that are collected during the fall and spring. More than 30 groundwater and surface water samples were collected and analysed in the 2019 fall season. However, the scheduled 2020 spring sampling plan was postponed due to Covid-19 restrictions. A three-dimensional hydrostratigraphic model is being developed to enhance the conceptual understanding of the groundwater flow systems. This model will be refined and validated using the geochemistry data.

Relevance

This project will provide water managers and proponents with an improved understanding of groundwater recharge rates and the interaction between groundwater and surface water in this complex stratigraphic setting. This knowledge will support and inform natural resource management decisions, including groundwater allocation and licensing decisions under the *WSA*, which must include the consideration of potential impacts to environmental flow needs in hydraulically connected surface waters. The study results can also support the long-term evaluation of climate changes in the current regional weather patterns, which are expected to impact the local hydrologic cycle in Robson Valley at Valemount.

Learnings & Recommendations

Initial water chemistry results indicate the water chemistry in the deeper wells (buried valley aquifer) is distinct from the chemistry in the shallower wells (surficial aquifers) and surface water. This suggests that groundwater in the deeper aquifers has limited interaction with both the shallow aquifer and surface waters. However, these project results are tentative. A more comprehensive analysis of the system will be undertaken once the hydrostratigraphy model is established, and a second round of samples are collected and analysed.

Partners and Linkages

The project is being conducted by researchers from the University of Northern British Columbia and the Geological Survey of Canada with support from FLNRORD.

Project Contacts

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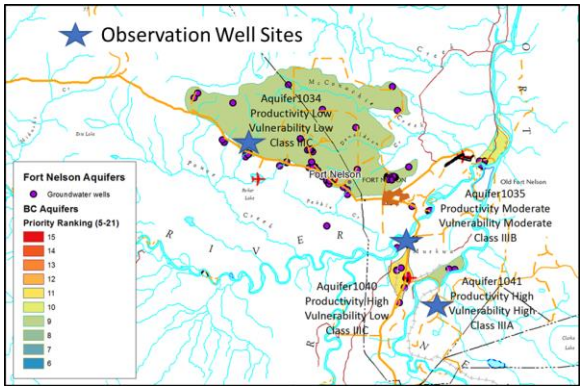
Acknowledgements:
Water Research Portfolio, FLNRORD

Provincial Groundwater Observation Well Network Expansion in the Fort Nelson Area

Project Description

British Columbia and Northwest Territories have entered into a bilateral water management agreement in Liard and Petitot River sub basins, including management of trans-boundary groundwater resources. However, there is limited understanding of groundwater resources in the transboundary area due to a scarcity of groundwater development and hydrogeological data. To address this deficiency, the Liard and Petitot sub-basins transboundary groundwater resources assessment project was completed in 2018 to compile and analyze available data and propose priority transboundary areas for field-based hydrogeologic characterization studies. The current project implements recommendations in the 2018 report through the expansion of the Provincial Groundwater Observation Well Network (PGOWN) in the Fort Nelson area.



Approximate location of groundwater observation wells in the Liard and Petitot Rive sub-basins.

Summary of Project Outcome

Three provincial observation wells were drilled in high priority basins identified in the 2018 Liard-Petitot groundwater assessment study. The first well was drilled into the shallow unconfined Fort Nelson River alluvial aquifer system (AQ1041); a second well is in a confined glaciofluvial aquifer system between the Fort Nelson and Muskwa River valleys (AQ1040); and a third well is in a fractured shale bedrock aquifer (AQ1034). All wells will be integrated into the PGOWN for long-term monitoring of groundwater levels and water quality. The Fort Nelson First Nations have agreed to manage and maintain the observation wells through a partnership agreement.

Relevance

Due to active oil and gas development in the region, the need for more hydrogeological data and observation wells in the Northern Peace Region has been a common interest of various groups including: Fort Nelson First Nation, Peace River Regional District; various regulatory authorities (FLNRORD, EMPR, OGC); and, private industry. Monitoring information resulting from this project will support implementation of the Mackenzie River Basin Bilateral Water Management Agreement, groundwater licensing under the *Water Sustainability Act*, and the Northeast Water Strategy. Long-term observation well data can also support evaluation of climate change related impacts.

Learnings & Recommendations

Exploratory drilling and pumping tests form the background of hydrogeologic investigations. The drilling program and associated analyses conducted under the Fort Nelson groundwater study project informs aquifer characterization, groundwater resource assessments, and potentially surface water-groundwater interaction studies within this major transboundary river system. Recommendations for additional hydrogeological investigations will be developed.

Partners and Linkages

The project was implemented in collaboration with FLNRORD, EMPR and the Fort Nelson First Nation.

References

Levson, V.M., H. Blyth, T. Johnsen and M. Fournier. 2018. Liard and Petitot Sub Basins Transboundary Groundwater Resources Assessment. Water Science Series 2018-01, Province of British Columbia, Victoria.

Baye, A. et al., 2020. Exploratory drilling, pumping tests and provincial groundwater observation well network expansion in the Fort Nelson area, B.C. Water Science Series, Province of British Columbia, Victoria (in preparation).

Project Contacts

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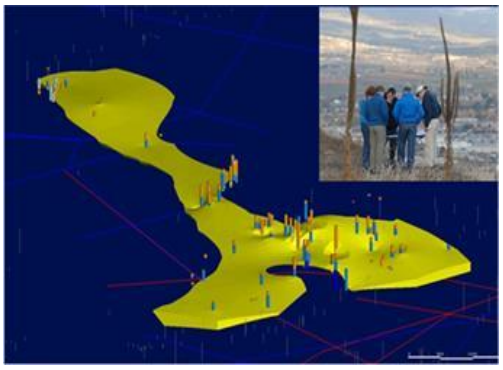
Acknowledgements:
Water Research Portfolio, FLNRORD

Surficial Materials Mapping Project

Project Description

The surficial materials mapping project is a multi-year undertaking expected to be completed in two years, pending funding. The main goal of this project is to bring together several sources of surficial materials data into a single, easily accessible map.



View of water wells within an aquifer.

Summary of Project Outcome

A pilot mapping study was completed for the Vanderhoof area in 2019/2020. Data were extracted from existing surficial geology maps, terrain maps, soil survey maps, and modelled terrain maps to create a single surficial materials map. The pilot project created a map for the Vanderhoof area and refined the surficial materials mapping process. Common mapped surficial material names were created using naming criteria for surficial geology, terrain, and soil survey mapping. This was used to compare mapped polygons in the study area, which were then integrated into a single map. Phase 2 (2020/2021) will further refine the mapping process by including B.C.'s aquifer sub-types, and will test this process in a different part of B.C. with different topography, geology, and depositional history.

Relevance

Understanding the complex distribution of surficial materials throughout B.C. is crucial to the understanding of groundwater and surface water resources. Surficial materials (i.e., unconsolidated deposits of gravel, sand, silt) make up approximately seventy percent of the mapped aquifers in B.C., and there are many that have yet to be mapped. Over 1,200 aquifers have been mapped in B.C. but are generally limited to developed areas where data on subsurface conditions are readily available. Surficial materials mapping will provide additional information about the subsurface conditions in areas of the province where aquifer mapping has not occurred. Improved access to surficial materials mapping throughout the province will improve the understanding of the:

- location and extent of surficial aquifers;
- groundwater quantity and dynamics;
- aquifer vulnerability;
- conceptual-level spatial variability of groundwater-surface water interactions; and,
- enhance the ability to conduct high-level groundwater management planning.

Learnings & Recommendations

The pilot mapping project extracted individual mapped polygons from the various sources which in areas with complex geology led to surficial materials maps with greater detail than was anticipated. In areas with broad complex fills and lowlands (i.e., Prince George Lowlands, Peace area, and Lower Fraser) well logs will be required to assist and refine future mapping. These learnings will be applied in the next phase of the study in which the mapping process will be refined to include B.C.'s aquifer sub-types and to test mapping in a physiologically different part of B.C. with different topography, geology, and depositional history of the Cordillera.

Partners and Linkages

This project was developed and managed in partnership with the Ecosystems Branch, B.C. Ministry of Environment and Climate Change Strategy.

Project Contacts

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Acknowledgements:
Groundwater Science Program

Assessment of Managed Aquifer Recharge and Aquifer Storage and Recovery Potential in B.C.

Project Description

Managed aquifer recharge (MAR) and aquifer storage and recovery (ASR) are related strategies to replenish groundwater stored in aquifers for later recovery and use, or to support various water management objectives. MAR/ASR systems are increasingly used throughout the world for augmenting and managing groundwater supplies. This project was undertaken to assess and support the potential use of MAR/ASR in B.C. by addressing three goals: 1) improving knowledge of technical and regulatory constraints for application of MAR/ASR in B.C.; 2) investigating and recommending regulatory strategies to support use of MAR/ASR; and, 3) identifying areas to conduct further review of MAR/ASR potential in the province.

Summary of Project Outcome

An overview of ASR/MAR concepts, processes and terminology was prepared, including an inventory of uses and water management objectives that have been addressed with MAR/ASR. A review of regulatory policy supporting MAR/ASR focussed on B.C.'s system of water regulation, as well as regulatory approaches used in the USA in Oregon and Washington. This review found that B.C.'s *Water Sustainability Act* (*WSA*) and drinking water regulations broadly accommodate MAR/ASR strategies. Recommendations to consider and support MAR/ASR applications focussed on policy clarifications, regulation development, and consensus on a regulatory process or framework. Workshops were held in B.C.'s four natural resource regions to inform ENV and FLNRORD staff about MAR/ASR science and to solicit information on regional water availability stresses that could potentially be addressed using a MAR/ASR approach. Four locations were recommended for further investigation of MAR/ASR applicability based on identification of key siting factors: water shortages in need of new solutions; potential availability of water sources on a seasonal basis; suitable aquifers; and, partnership opportunities.

Relevance

MAR/ASR has not been successfully applied in B.C. but could potentially provide water managers with additional tools to support resource management and ongoing implementation of the *WSA*. Some of the potential uses of MAR/ASR strategies in B.C. are potable and emergency water supplies, irrigation supply, drought planning and management, migitation of groundwater decline, and enhancement of groundwater dependent ecosystems during critical low flow periods.

Learnings & Recommendations

MAR/ASR strategies use geologic formations as storage reservoirs, similar to surface reservoirs. However, there are limitations to their use because siting, technical, and water quality issues can be more complex than traditional surface water diversions. To limit uncertainties and reduce upfront costs, the development of MAR/ASR projects would benefit from a staged approach following: 1) feasibility assessment and conceptual design; 2) pilot test program; 3) system expansion; and, 4) full scale operation and maintenance.

Partners and Linkages

This project was completed under contract by Western Water Associates, Ltd. and GSI Water Solutions, Inc. with oversight from project partners in ENV and FLNRORD.

Project Contacts

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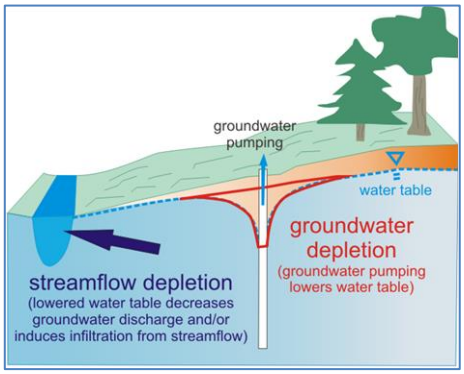
Acknowledgements:
Groundwater Science Program

Analytical Depletion Functions for Groundwater Pumping Impacts on Environmental Flows

Project Description

Groundwater extraction can result in streamflow depletion and associated impacts on aquatic ecosystems that must be considered in groundwater licensing decisions. However, quantifying pumping effects on streamflow is difficult. Analytical depletion functions are tools for rapidly estimating streamflow depletion but can have large variability and uncertainty in model results. This project was undertaken to assess the validity and accuracy of analytical depletion functions by comparing their performance to two numerical groundwater flow models in different landscapes and climatic regions of B.C. including: 1) surficial aquifers in the BX Creek Watershed in the semi-arid southern interior plateau; and, 2) surficial and deeper semi-confined aquifers in the boreal plain in the Peace Region of Northeast B.C.



Schematic showing influence of groundwater pumping on streamflow.

Summary of Project Outcome

Inter-model comparisons showed analytical depletion functions can be an accurate tool for estimating streamflow depletion over annual to decadal timescales, with poorer performance for sub-annual time periods. The model comparisons also demonstrated that analytical depletion functions can conservatively estimate the time for streamflow to drop below a presumptive environmental flow threshold due to groundwater pumping. Differences between analytical and numerical models were greatest within a few kilometers of a streams, in areas where pumping has the most dynamic influence on streamflow depletion. Performance of the analytical depletion functions also varied between the two hydrogeologic settings. For simple stream networks and aquifer types found in BX Creek, analytical depletion functions performed better in regions with highly conductive alluvial aquifers and shallower well depths. For complex hydrogeological settings, as in the Peace region, analytical depletion functions performed better in aquifers with lower hydraulic conductivity and with deeper well depths.

Relevance

This project results can inform groundwater allocation staff who are responsible for assessing streamflow depletion impacts and technical assessment reports associated with license applications. The study provides insights and perspectives on the applicability of analytical depletion functions, and the complexity and limitations of estimating streamflow depletion in the absence of field measurements and calibrated numerical groundwater models.

Learnings & Recommendations

Inter-model comparisons indicate analytical depletion functions are applicable tools for estimating streamflow depletion and the lag time between pumping and streamflow impacts. However, application of analytical depletion functions should be based on thorough understanding of the local hydrogeologic conditions. Both numerical and analytical depletion functions can lead to biased results if not properly constructed, tested, or applied.

Partners and Linkages

This multi-year research project was completed by the Groundwater Science and Sustainability (GSAS) research group in the Department of Civil Engineering at the University of Victoria with partners from ENV and FLNRORD.

References

Li, Q., S.C. Zipper, and T. Gleeson. 2020. Analytical Depletion functions and Response Times of Groundwater Pumping Impacts on Environmental Flow. Department of Civil Engineering, University of Victoria, Victoria, B.C.

Project Contacts

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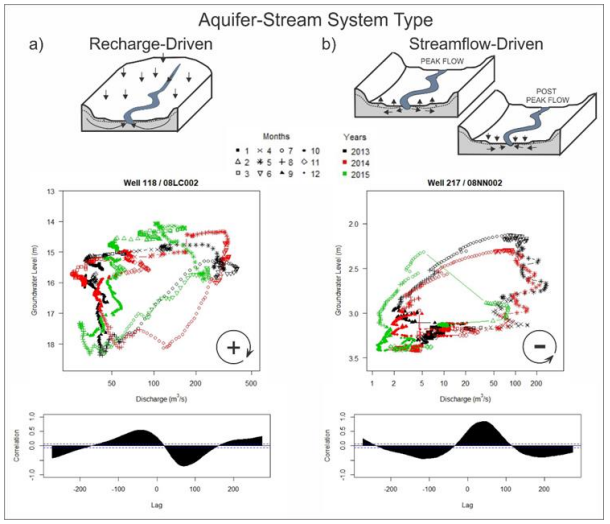
Acknowledgements:
Groundwater Science Program

Identifying Drought Susceptible and Drought Resilient Aquifer-Stream Systems in B.C.

Project Description

Drought can lead to reduced water availability of both surface water and groundwater and can change the nature of their interactions. Understanding how drought affects the linkages between groundwater levels and flows in nearby streams is central to decision-making surrounding water use and the protection of water resources during periods of drought. The main purpose of this project is to develop approaches for determining the susceptibility of aquifer-stream systems to drought in B.C., and to test this approach in the Okanagan Basin. This multi-year project aims to: 1) develop quantitative drought indicator thresholds for groundwater levels; 2) evaluate these indicators and regulatory tools used during water scarcity in the Okanagan Basin; and, 3) to ultimately identify the susceptibility of aquifers to drought in the Okanagan Basin and across B.C.



Paired hydrometric station streamflow and observation well water level relationships.

Summary of Project Outcome

During the first year of the multi-year project, various annual, seasonal, and monthly groundwater level metrics from provincial observation wells in the Okanagan Basin were compared to known drought years to assess potential groundwater response to drought. Wells were also paired with nearby hydrometric stations to define aquifer-stream types, as per Allen et al. (2010), to determine patterns of surface water and groundwater interactions. Future work will evaluate the "drought response" for different aquifer-stream types based on the co-analysis of climate, hydrometric, and groundwater level data. Depending on the strength of these drought responses, groundwater indicators of drought and susceptibilities of these systems will be developed.

Relevance

Groundwater indicators and aquifer-stream system susceptibilities to drought developed in this project will inform drought and water management in the Okanagan Basin and across B.C. and will additionally broaden our knowledge in groundwater-surface water interactions in the province.

Partners and Linkages

Dr. Diana Allen of the Department of Earth Sciences at SFU supervised an honours undergraduate student (April Gullacher) to undertake this research. Project funding was provided by the Canadian Mountain Network and the BC ENV Groundwater Science Program. Project support was provided by the BC River Forecast Centre, ENV Water Protection and Sustainability and Knowledge Management Branches, FLNRORD, the Okanagan Basin Water Board, the Okanagan Nation Alliance, and the University of Victoria.

References

Allen, D.M., P.H. Whitfield, and A. Werner. 2010. Groundwater level responses in temperate mountainous terrain: regime classification, and linkages to climate and streamflow. *Hydrological Processes*, 24: 3392–3412. doi:10.1002/hyp.7757.

Project Contacts

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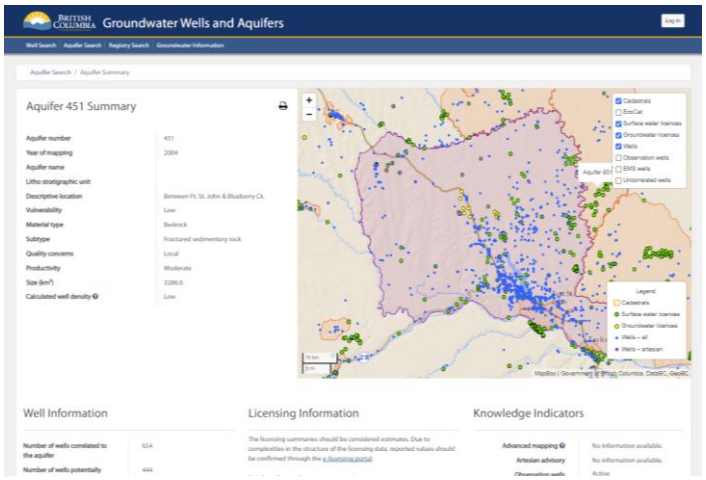
Acknowledgements:
Groundwater Science Program

GWELLS Maintenance and Enhancements

Project Description

The Groundwater Wells and Aquifers (GWELLS) application is an interactive web-based platform for locating and accessing groundwater related information, including Provincial well records, aquifer and hydrogeologic information, and the registry of certified well drillers and pump installers. This project is a continuation of ongoing work to maintain, update, and enhance features and functionality of GWELLS.



Screen capture of aquifer search tab in GWELLs.

Summary of Project Outcome

This project is a multi-year endeavour. Work completed this year includes aquifer map review and data clean-up, improvements to well and aquifer data management (bulk upload of well records, aquifer publish status, well drillers and pump installers registry data export functionalities) and improvements to the aquifer search and summary page (map functionalities). Upgrades to GWELLS were implemented to streamline and facilitate the upload of GIS-based aquifer information and improve the accuracy and review of the GIS spatial layers.

GWELLS provides information on more than 120,000 well records, 1,200 mapped aquifers, and 500 well drillers and pump installers. The well search tab includes data from public well records, including the location, well construction details, and hydrogeologic information (lithology, productivity). The aquifer search tab includes an interactive and searchable Mapbox showing aquifer locations and overlays selectable spatial information including the location of registered wells, observation wells, artesian wells, surface and groundwater licenses, and wells with chemistry data in the Environmental Monitoring System (EMS) database. The aquifer search tab also provides general information about the aquifer characteristics, groundwater licensing information, and links to mapping reports, relevant groundwater studies, and an aquifer factsheet. The registry tab includes information on all the qualified well drillers and pump installers operating in B.C.

Relevance

Locating and accessing groundwater information is essential to informing groundwater licensing under the *Water Sustainability Act,* as well as to groundwater resource management in general. GWELLS is intended to simplify groundwater data compilation and will be useful to both proponents who are preparing groundwater license applications and to allocation staff who are evaluating the applications.

Learnings & Recommendations

This project has demonstrated the efficiency of using R-scripts to work with large datasets in a manner that is reproducible, easily updateable and can be done in an automated fashion. The scripted output is also effective for highlighting database errors and streamlining data clean-up efforts.

Partners and Linkages

GWELLS enhancements were completed under contract with oversight from partners in ENV and FLNRORD.

Project Contacts

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Acknowledgements:
Groundwater Science Program

Guidance for Technical Assessments in Support of an Application for Groundwater Use in B.C. – Version 2.0

Project Description

Applications for a water licence and associated water rights for new groundwater use are typically supported with technical analyses to assist the Statutory Decision Maker (SDM) in adjudicating the licence application. A Technical Assessment Guidance Document (Version 1) is available to groundwater licence applicants so they may proactively engage a professional and provide the appropriate level of analysis to the SDM. The goal of this project was to update the Technical Assessment Guidance (Version 2) to incorporate feedback from regional staff and the groundwater community.

Examples of groundwater development.
Photo: Michele Lepitre

Summary of Project Outcome

Version 1 of the Technical Assessment Guidance Document was published in 2016 shortly after enactment of the *Water Sustainability Act*, which established groundwater regulation in B.C. Subsequently, the Province solicited feedback on Version 1 from both internal Provincial government staff and external groundwater professionals. Common themes of feedback were to provide clarity around groundwater quality issues (i.e., saltwater intrusion), climate change, cumulative effects, the Environmental Assessment process, environmental flow needs, and to update Appendix B as a concordance table/checklist. The working group also engaged with the Engineers and Geoscientists of British Columbia (EGBC) to add wording outlining the Professional's duty and obligation under the *Engineers and Geoscientists Act* and forthcoming *Professional Governance Act*. Version 2 of the guidance document provides a more transparent process by identifying four different levels of technical assessment, where the analysis level and study scale are based on site specific information. The guidance document is expected to result in better quality applications and more clarity for the public and groundwater professionals.

Relevance

With the introduction of groundwater authorizations in 2016, it was recognized that standardized guidance was needed to inform applicants of the authorization process and the expectations for supporting documentation by the SDMs. It was further noted in 2016 that subsequent updates to the guidance document would be needed to address operational realities that emerge from the licensing process. Version 2 of the Technical Assessment Guidance Document provides this update. It details the minimum assessment and documentation requirements typically requested by SDMs in adjudicating water licence applications for new use groundwater users and provides a concordance table/checklist. The document also identifies factors and conditions that should be considered by professionals in preparing field studies and reports. Pre-application research and/or pre-drilling assessment work is encouraged to help determine the likelihood of an authorization approval and to reduce risks in the construction of works or wells that may not be approved.

Learnings & Recommendations

This guidance document is intended to provide clear and provincially consistent guidance to prospective water licence holders, professionals, and internal government staff in meeting regulatory requirements for adjudicating water licences for new groundwater users.

References

Todd, J., M. Lepitre, D. Thomson, J.A. Ishikawa, M. Wade, C. Beebe, 2020. Guidance for Technical Assessments in Support of an Application for Groundwater Use in British Columbia. Water Science Series, WSS2020-01. Province of British Columbia, Victoria.

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Acknowledgements:
ENV Water Protection and Sustainability Branch
FLNRORD South Coast & South Area Regional Operations

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- B.C. River Forecast Centre
- Canadian Mountain Network
- Fisheries and Oceans Canada
- Geological Survey of Canada
- Ministry of Environment and Climate Change Strategy
- Ministry of Forests, Lands, Natural Resource Operations and Rural Development
- Ministry of Transportation and Infrastructure
- Okanagan Basin Water Board
- Simon Fraser University
- The City of Terrace
- The City of Maple Ridge
- The Cowichan Valley Regional District
- The District of Houston
- The Fort Nelson First Nation
- The GWELLS development team
- The Islands Trust
- The Kitselas First Nation
- The Kitsumkalum First Nation
- The Nicola Basin Collaborative
- The Office of the Wet'suwet'en
- The Okanagan Nation Alliance
- The Regional District of Bulkley-Nechako
- The Regional District of Kitimat-Stikine
- The Regional District of Nanaimo
- The Snaw-naw-as First Nation
- The Te'mexw Treaty Association
- The Township of Langley
- The Upper Bulkley River Streamkeepers
- The Village Point Improvement District
- The Wet'suwet'en First Nation
- University of Northern British Columbia
- University of Victoria