

List of British Columbia's 20 Priority Areas for Aquifer Characterization

SUMMARY

The BC Office of the Auditor General (OAG) in its December 2010 report: [*An Audit of the Management of Groundwater Resources in British Columbia*](#) brought forward seven recommendations to better sustain the groundwater resources in British Columbia.

The OAG's first recommendation covered three areas. They recommended that the ministries responsible for groundwater ensure that:

- *classification of the province's aquifers is completed for all priority areas;*
- *the WELLS database is kept up to date; and*
- ***aquifers are characterized, starting with those classified as having the highest priority.***

In response to this third area, the Ministry agreed to develop a list of priority areas or aquifers for more in-depth aquifer characterization. This report fulfills the Ministry's commitment to develop this list (see Table 2).

1. BACKGROUND

While surface water supplies the majority of the Province's needs, more than an estimated 1 million British Columbians (25% of the province's population) rely on groundwater for daily use, and this number is growing. As elsewhere in the world, BC's groundwater resources are critical to satisfying drinking water, agricultural and industrial needs, as well as supporting ecosystem viability. In BC, groundwater is a Crown resource and, for the most part, it is the responsibility of the province to protect and manage. Diligent and effective management and protection of groundwater is therefore essential to assure the sustainability of the province's groundwater resources.

The purpose and scope of the Office of the Auditor General's audit

From December 2009 to July 2010, the Office of the Auditor General (OAG) carried out an audit to determine whether the provincial government is ensuring the sustainability of groundwater resources in British Columbia.

The aim of their audit was to answer three main questions:

1. *Is the Ministry of Environment's information about groundwater sufficient to ensure the sustainability of the resource?*
2. *Is groundwater being protected from depletion and contamination and to ensure the viability of the ecosystems it supports?*
3. *Is groundwater access being controlled and do key organizations have the authority needed to take appropriate local responsibility?*

Their interest was in assessing government's overall management of groundwater resources, focusing on the work of the Water Stewardship Division in the Ministry of Environment (MoE). MoE was the lead ministry in this area until October 25, 2010, when a realignment of some of these ministries and their responsibilities took place.

The OAG's overall conclusion was that government was not effectively ensuring the sustainability of the province's groundwater resources. Specifically, in their aim to answer the above 3 questions, they found that the ministry's information about groundwater is insufficient to enable it to ensure the sustainability of the resource or the ecosystems it supports. Further, control over access to groundwater is insufficient to sustain the resource and key organizations lack adequate authority to take appropriate local responsibility.

Recommendations from the OAG's audit

Overall, the OAG expects "the ministry to have sufficient information about groundwater, to monitor the state of groundwater resources and to coordinate the consolidation of groundwater information collected by other stakeholders. They also expect the ministry to use this information to inform a long-term strategy for managing groundwater sustainably."

The OAG's first of seven recommendations was that the ministries responsible for groundwater

"ensure that classification of the province's aquifers is completed for all priority areas and that the WELLS database is kept up to date. The ministry should also ensure that aquifers are characterized, starting with those classified as having the highest priority."

The Ministry's response to the OAG's first recommendation

The Ministry recognized the need to collect, analyze and manage groundwater scientific information to map and characterize groundwater aquifers and noted that a modernized *Water Act* will require aquifer characterization to ensure science-based groundwater management decisions. This report specifically addresses the need for more in-depth aquifer characterization.

The Ministry also noted that characterizing aquifers requires considerable effort because the objective is to obtain comprehensive information on an aquifer to be able to address specific issues (e.g., water availability for allocation, impact of groundwater withdrawals on surface water, etc.) and that characterization requires specialized expertise and periodic updating. Therefore, this work should be undertaken only for the highest priority aquifers. The Ministry agreed to develop a list of priority aquifers or areas for characterization.

2. DEFINITION OF Aquifer Characterization

Defining *aquifer characterization* is important to provide a common understanding for discussion. Aquifer characterization is defined here to mean developing sufficient understanding of an aquifer or group of aquifers (usually within the same area or basin) to support decisions affecting the groundwater resource. Characterizing aquifers usually means (but not limited to) the following:

- Developing a geological model (usually can be displayed visually in a 3-D visual model, maps, cross-sections).
- Developing a water budget (quantifying the inputs and outputs of water through the aquifer(s)).
- Understanding the major hydrologic processes and hydrogeologic properties that govern the occurrence, flow, replenishment of water into, through and out of an aquifer(s) (e.g., boundary conditions, aquifer hydraulic properties, and hydraulic interaction with adjacent surface water bodies).
- Assessing the intrinsic aquifer vulnerability from pollution due to human activities, usually at the land surface (vulnerability is usually displayed visually using maps).

Many of these concepts of characterizing aquifers have already been presented in more depth in the documents: *Groundwater Inventory and Assessment in British Columbia* (1996) and *Ground Water Mapping and Assessment in British Columbia* (Piteau Associates Engineering Ltd. and Turner Groundwater Consultants, 1993a and b). Some examples of aquifer characterization done in the past in BC are included in Table 1.

Table 1. Some examples of aquifer characterization done in the past in BC.

Project	Main Objective	Reference
Characterizing the bedrock aquifer on Mayne Island.	Guide rational groundwater development on Mayne Island.	Foweraker, 1974 ; Heisterman, 1974 ; Moncur, 1974 .
Describing the occurrence of groundwater in the Fraser Lowland.	Provide a geologic framework and describing groundwater conditions – targeted for drillers and groundwater development.	Halstead, E.C., 1986. Groundwater supply - Fraser Lowland, British Columbia National Hydrology Research Institute, Paper No. 26.
Characterizing the aquifer in Grand Forks.	Understand aquifer characteristics to enable local management. SFU (main partner and lead in study) research in assessing impacts of climate change on groundwater in a semi-arid region of BC.	Wei et al, 2010
Regional aquifer vulnerability mapping on Vancouver Island.	Guide local government land use planning decisions.	Liggett et al, 2010 ; Newton and Gilchrist, 2010
Developing a numerical groundwater model for the Deep Creek watershed in the Okanagan Basin.	Quantify water budget in the Deep Creek watershed to gain insight into current and future groundwater resources.	Ping et al, 2011
Estimating the water budget in the Westwold Valley, near Salmon Arm.	Assess how groundwater extraction affects flow in the Salmon River.	Kevin Bennett, (in draft)

Characterizing an aquifer allows much greater understanding of the aquifer, as well as the surrounding watershed and recharge area, than can be obtained through aquifer classification alone. Aquifer classification basically provides a prioritized inventory, to use as a coarse provincial screening tool and to increase general public understanding (see [Berardinucci and Ronneseth, 2002](#)). In contrast, characterizing aquifers in more detail provides a greater understanding of an aquifer’s characteristics and if this understanding is represented in an analytical or numerical groundwater model, the model can potentially be used as a quantitative decision-support tool, for example, helping to identify critical thresholds for management targets.

As identified in the OAG’s audit and the Ministry’s response, limited resources and the need to risk manage means that all developed aquifers in the province need not be characterized to this greater degree; characterizing should be undertaken only for the highest priority areas and aquifers.

3. CHARACTERIZATION OF GROUNDWATER IS ISSUE DEPENDENT

Although the bullets in Section 2 show that there is a basic level of work common to characterizing aquifers, the business area and groundwater related issues in specific areas will also dictate the specific objectives and emphasis of aquifer characterization. It is expected that licensing of groundwater extraction and use will be a main business driver in aquifer characterization work for the province. Specifically, a focus on understanding how an aquifer's characteristics may have an effect on groundwater availability and interaction with surface water and how groundwater extraction may affect surface water availability would be important objectives. Another business driver is protection of groundwater quality from growth and other human activities, which is important for both the province and local governments. Mapping the vulnerability of aquifers may be an important objective in this case. More generally, aquifer characterization should support decision-making related to:

- Exercising sound groundwater management and licensing decisions and rational regulation of water use during times of scarcity and other conflict issues;
- Informing actions where water availability is becoming limiting;
- Informing actions to address cumulative impacts;
- Establishing water quantity and quality objectives for an aquifer; and
- Informing regional and local land use planning decisions that consider the protection of the groundwater resource; and
- Informing actions to protect drinking water sources.

4. SCALE OF CHARACTERIZATION

In developing a prioritized list of areas for aquifer characterization, it was clear early on that choice of scale was a major decision point. Should characterization occur on a basin-scale level (e.g., Okanagan Basin, Nicola Basin)? Would that scale of understanding be most useful in supporting decisions? Would understanding characteristics of specific aquifers or groups of aquifers within a basin be more useful? The scale of a study dictates the amount, type and detail to which groundwater information can be portrayed.

With future licensing and allocation of groundwater likely becoming a high priority in the province and conflicts expected in generally smaller tributary stream basins (as streams become fully recorded and groundwater use increases), plus the fact that many of the surficial aquifers in BC are of limited extent (generally 10s of km² in areal extent), the optimum scale for more in-depth characterization of groundwater are priority aquifers and any adjoining aquifers that have a significant hydraulic connection with each other; including any adjoining upland area that contributes to recharge.

5. WHAT ARE THE HIGH "PRIORITY AREAS OR AQUIFERS"?

Where groundwater is heavily used, the area may be designated as a priority area and be characterized to a higher level of understanding. A priority area could be a geographic area or an aquifer:

- that is subjected to heavy extraction and use relative to the supply available;
- where the supply is used by many and groundwater is a sole or primary source of supply for drinking water – especially the more extensive and productive sand and gravel aquifers supplying larger populations and diversity of users; and

- where there is known or suspected quantity concerns –areas with limited water availability (e.g. reported conflicts, low yielding aquifer, declining groundwater level, saltwater in coastal aquifers);
- that is believed to be in direct hydraulic connection with surface water and where over pumping may negatively impact the surface water source.

The inventory of classified and mapped developed aquifers, which consists of more than 900 aquifers across the province, provided a starting point for developing the list of priority aquifers/areas. The 900+ aquifers have also been categorized into general types (see [Wei et al, 2010](#)), which gave an indication of their likely connection with adjacent surface water bodies. Based on the above criteria, aquifers were ranked and a list of the highest priority ones developed. Professional judgment was then applied to this list. Some aquifers were grouped together (e.g., the aquifers of one island combined, a group of islands in the same region combined, similar surficial aquifers along the same stream, aquifers within the same geological deposit adjacent to each other, aquifers where significant hydraulic connectivity between them was likely) or re-ordered.

The locations of the 20 highest priority areas in the province are shown in Figure 1 and listed in Table 2. Table 2 identifies the type of aquifer (surficial versus bedrock), their approximate size, the likelihood of a quantity concern or possible conflict with surface water, the aquifer’s identifying number(s) and any relevant comments. Clicking on the **Descriptive Location** (left hand column) in Table 2 for any priority aquifer will link to a location map.

Figure 1: Index map showing locations of the 20 highest priority areas in the province.



Table 2. List of priority areas for aquifer characterization.

Descriptive Location	Aquifer Types ¹	Approximate area (km ²)	Extent of known quantity concern	Potential for conflict with surface water uses	Estimated population reliant on groundwater	Classified aquifers in area	Comments
Lower Mainland: Langley to Aldergrove	Surficial; (unconfined and confined)	500	Local & Regional	Likely	> 100,000	16; 24; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 41; 47; 50; 51; 52; 53; 54; 55; 58; 59; 60	Relatively thick sediments, a number of stacked aquifers. Diversity of users and uses.
Lower Mainland: Abbotsford- Matsqui	Surficial; (unconfined)	140	Regional	Likely	> 100,000	15; 22; 23	Trans-boundary issues with water availability and nitrate. Diversity of users and uses.
Lower Mainland: Vedder River, Chilliwack-Rosedale	Surficial; (unconfined)	290		Likely	> 100,000	6; 8; 21	Stream with high fisheries value.
Vancouver Island: Parksville-Qualicum Beach	Surficial (unconfined and confined)& bedrock; (sedimentary and crystalline)	240	Local	Likely	30,000-100,000	209; 210; 212; 213; 214; 216; 217; 218; 219; 220; 221; 416; 421; 661; 662; 663; 664; 665	Quadra Sand is the dominant aquifer deposit, occurring between Nanoose Bay (to the south) and Deep Bay (to the north).
Omineca: Lower Nechako River Valley	Surficial; (unconfined)	50		Likely	30,000-100,000	92	Stream with high fisheries value. The main user is City of Prince George.
Vancouver Island: Duncan Area	Surficial (unconfined and confined)	20		Likely	> 30,000	186; 187; 188	Stream with high fisheries value. Significant use for aquaculture and municipal supplies.
Okanagan: Rutland-Kelowna	Surficial; (unconfined and confined)	130		Likely	10,000-30,000	462; 463; 464; 465; 467	Stream with high fisheries value. Significant use for irrigation.
Okanagan: Osoyoos Lake to Vaseux Lake	Surficial (unconfined and confined)	60	Local	Likely	10,000-30,000	193; 194; 195; 254; 255; 256; 257	Stream with high fisheries value. Significant use for irrigation. Nitrate issue. Transboundary aquifer.
Vancouver Island: Cowichan Bay-Mill Bay	Surficial (unconfined and confined)& bedrock; (sedimentary and crystalline)	100			10,000-30,000	197; 198; 199; 200; 201; 202; 204; 205; 206; 207	
Southern Gulf Islands: (e.g., Gabriola, Thetis, Hornby, Denman, Mayne, Galiano, etc)	Surficial (unconfined and confined)& bedrock; (sedimentary)	200	Isolated, Local, Regional		10,000-30,000	320; 435; 436; 437; 438; 447; 619; 620; 632; 706; 709; 710; 711; 712; 720; 729; 730; 731; 732; 733; 734; 735; 736; 737; 738; 739; 740; 741; 742; 750	

Descriptive Location	Aquifer Types ¹	Approximate area (km ²)	Extent of known quantity concern	Potential for conflict with surface water uses	Estimated population reliant on groundwater	Classified aquifers in area	Comments
Gulf Island: Saltspring Island	bedrock; (sedimentary and crystalline) & Surficial (confined)	180	Isolated		3,000-10,000	155; 156; 157; 721; 722; 723	
Vancouver Island: Cassidy-Cedar	Surficial (unconfined and confined) & Bedrock (sedimentary)	140		Likely	3,000-10,000	160; 161; 162; 163; 164; 165	Stream with high fisheries value. This area has significant public interest.
Quesnel	Surficial (unconfined and confined)	40		Likely	10,000	115; 116; 370; 371	Significant use for municipal and industry
Kootenay: Grand Forks	Surficial (unconfined)	40		Likely	2,000 - 5,000	158; 811	Stream with high fisheries value. Significant use for irrigation. Nitrate issue. Transboundary aquifer.
Similkameen: Princeton to U.S. Border	Surficial (unconfined)	120		Likely	2,000 - 5,000	259	Stream with high fisheries value. Significant use for irrigation. Transboundary aquifer.
Nicola Basin: Merritt	Surficial (unconfined)	10		Likely	3,000-10,000	74; 75	Stream with high fisheries value. Main user is City of Merritt.
Vancouver Island: Chemainus	Surficial (unconfined)	10		Likely	3,000-10,000	172	Stream with high fisheries value. Increasing dependence on groundwater use.
Whistler	Surficial (unconfined and confined)& bedrock; (sedimentary and crystalline)	130		Likely	10,000	387; 388; 389; 390; 391; 392; 393; 394; 395	Stream with high fisheries value.
Salmon River Valley	Surficial (unconfined and confined)	100		Likely	2,000 - 5,000	97; 98; 289	Stream with high fisheries value. Significant use for irrigation.
Okanagan: Armstrong	Surficial (unconfined and confined)	140		Likely	2,000 - 5,000	111; 348; 353; 354; 356; 849	Significant use for irrigation.

² For an explanation of the aquifer classification and ranking value, refer to Berardinucci and Ronneseth, 2002

Discussion of Priority List for Aquifer Characterization

The priority list above shows that many of the top priority aquifers fall within four primary geographic areas:

1. The Lower Fraser Valley (covered by the municipalities of Surrey, Langley City, the Township of Langley, Mission, Abbotsford, and Chilliwack);
2. The more arid portions of the southern interior (covered by the regional districts of Thompson-Nicola, Columbia-Shuswap, Okanagan-Similkameen, Central Okanagan);
3. The East Coast of Vancouver Island (covered by the Regional District of Nanaimo and Cowichan Valley Regional District); and,
4. The Gulf Islands (covered by the Islands Trust and several regional districts).

These geographic areas have known concerns with water availability and, with the exception of the individual Gulf Islands and some smaller interior communities, are areas with sizeable populations and high volume groundwater uses. All these areas have high dependency on groundwater.

In Table 2, the majority of the priority areas for characterization are comprised of more than one aquifer. In many instances, to effectively characterize an individual aquifer, the hydraulic interconnectedness of the adjacent aquifers, either vertically or laterally, needs to be taken into account. In the Lower Mainland south of the Fraser River, where the sediments are thick in the west, there are many stacked aquifers and the effect of groundwater withdrawals from one aquifer may not stop at an aquifer's boundary – or an administrative boundary. For example, to understand the groundwater conditions of the Hopington aquifer in Langley will also require understanding the relationship with its adjacent and underlying aquifers.

The east coast of Vancouver Island is also a region with high priority areas for greater aquifer characterization. Growing population and development continues to place increasing demands on the groundwater resource outside the greater Victoria region, primarily in the Mill Bay to the Cowichan Valley and in the Parksville-Qualicum Beach area.

The population of Gulf Islands reliant on groundwater is low relative to the other high priority aquifers. However, the low yielding fractured bedrock, coastal setting, small recharge area, and other known concerns have elevated some of the islands as a priority area. Table 2 shows Saltspring Island as one priority area and combined as a second priority area are: Gabriola, Hornby, Denman, N & S Pender, and Mayne Islands. Other Gulf Islands will likely be added to this list if demand continues to increase relative to supply.

This priority list of aquifers for characterization is a Provincial List – not a regional list. It is based on the most important aquifers in the province as a whole, regardless of the degree of characterization already completed or currently being undertaken and, as objectively as possible, reflects current demand and dependence on groundwater and pressures on the aquifer, as they may have implications on future groundwater licensing decisions. Other criteria, such as more localized issues and emerging concerns, such as potential impacts on shallow aquifers from fracking of deep, shale gas formations in the Peace River area are not explicitly considered. These other issues may be important enough to warrant study of those aquifers.

Finally, each individual FLNRO region has its own list of top priority aquifers that are locally significant sources of water supply to their community and local ecosystems which did not make this top 20 list, some examples would include:

West Coast Region: Saturna Island (aquifers 735, 736, 737 & 738); Comox-Merville (aquifer 408); Sooke Area (449, 599, 604, 605, 606)

South Coast Region: Bowen Island (aquifers 743, 744, 745, 746, 747, 748, 749); Squamish (396, 397, 398, 399, 400, 401, 402); Maple Ridge area (aquifers 19, 26, 154, 883, 884, 885, 886); Mission to Kent/Agassiz area (aquifers 4, 5, 7, 11, 12, 13, 14, 17, 18, 25, 880, 881, 882, 887, 888, 889, 896)

Cariboo-Thompson-Okanagan Region: Coldstream (aquifer 352); Lumby (Aquifers 314, 315, 316, 317 & 318); Hullcar (aquifers 102 & 103); Malakwa (aquifer 307); Canoe Creek to Shuswap (aquifers 108 & 109); Williams Lake (146).

Skeena Region: South Terrace (aquifer 575).

To date, the characterization work undertaken by or for the province is limited. Many of the aquifers on this list have had some studies undertaken beyond what the aquifer classification process provides. A few of these aquifers have even had numerical models to establish capacity and movement of the groundwater (e.g., Abbotsford (0015), Grand Forks (0158), and Langley-Brookwood (0041)). Other aquifers, like #'s 217, 216 and 664 in the Parksville-Qualicum area of Vancouver Island, are currently being characterized in partnership between the Province, the Geological Survey of Canada and the Regional District of Nanaimo. It is important to know what issue any previous characterization work was attempting to address and to consider if this work is sufficient to meet today's emerging requirements (e.g., proposed licensing of groundwater).

RECOMMENDATIONS/NEXT STEPS

1. Update this list every 5 years.
2. Confirm the basic elements of characterization parameters (e.g., direction of groundwater flow, etc.), that are required to address to increase understanding and support decision making related to water availability and use. These would form a list of minimum characterization products for all priority aquifers. More specifically, confirm the parameters required to produce a water budget to provide the information for more robust licensing decisions and the rational regulation of water use. Identify if the levels of characterization completed for some aquifers are sufficient for sustainable management of the resource.
3. Pursue opportunities for funding to begin to characterize aquifers (partnerships with academic institutions, local governments, Geological Survey of Canada).
4. Developing framework for storing and accessing this results of aquifer characterization.

CONCLUSIONS

A priority list of 20 areas for aquifer characterization has been developed; the list should be considered dynamic. As pressures and demands change over time, and as new issues arise, some areas and the exact order of this list may change. Aquifers within areas on this list will benefit from more in-depth characterization; the few aquifers that have been characterized in the past (e.g., Mayne Island) may need updating, in light of the emerging objective of characterization for licensing and allocation of groundwater. The Province's primary focus for the next decade, regarding aquifer characterization, will be the future licensing and allocation of the Province's groundwater resources. A key benefit of providing the level of characterization required for the allocation of groundwater, is that the type of information generated has significant value-added benefits and will help address many other groundwater issues that exist or may arise in the future.

ACKNOWLEDGEMENTS

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APPENDIX A: LOCATION MAPS OF THE TOP 20 PRIORITY AREAS FOR AQUIFER CHARACTERIZATION.

Figure 2. Lower Mainland: Langley to Aldergrove; 1st priority area of interconnected aquifers.

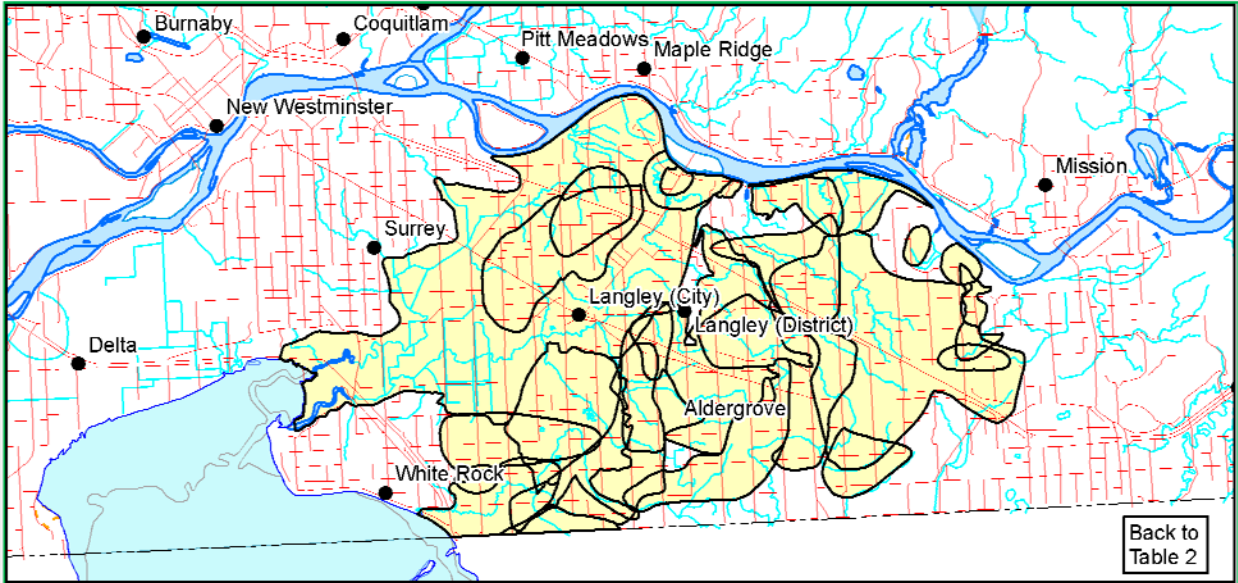


Figure 3. Lower Mainland: Abbotsford- Matsqui; 2nd priority area of interconnected aquifers.

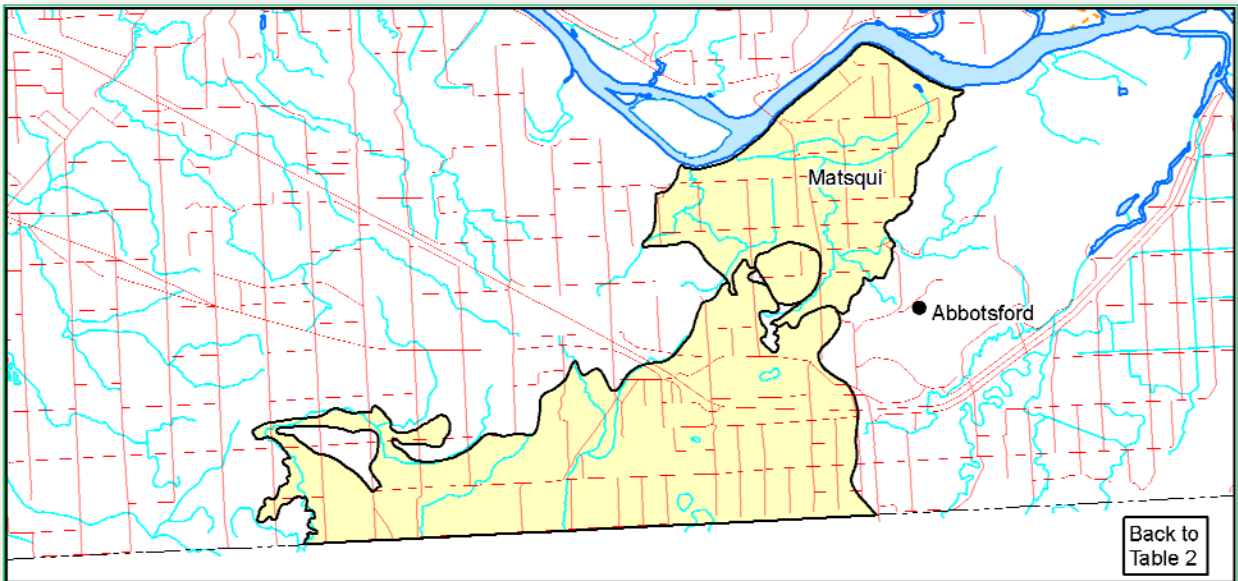


Figure 4. Lower Mainland: Vedder River, Chilliwack-Rosedale; 3rd priority area of interconnected aquifers.

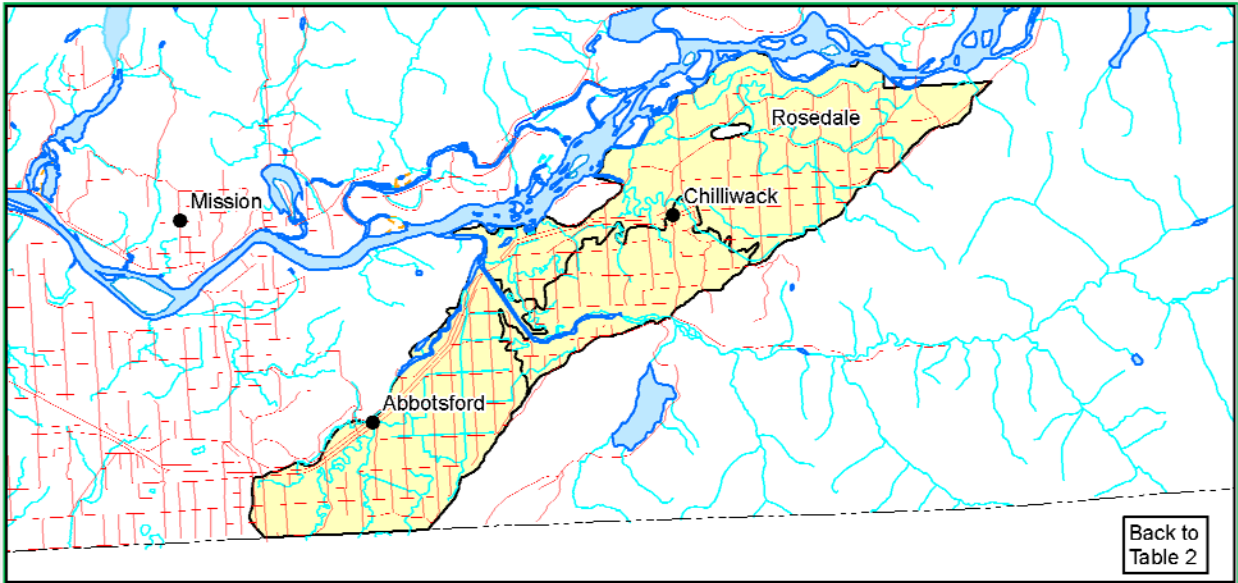


Figure 5. Vancouver Island: Parksville-Qualicum Beach; 4th priority area of interconnected aquifers.

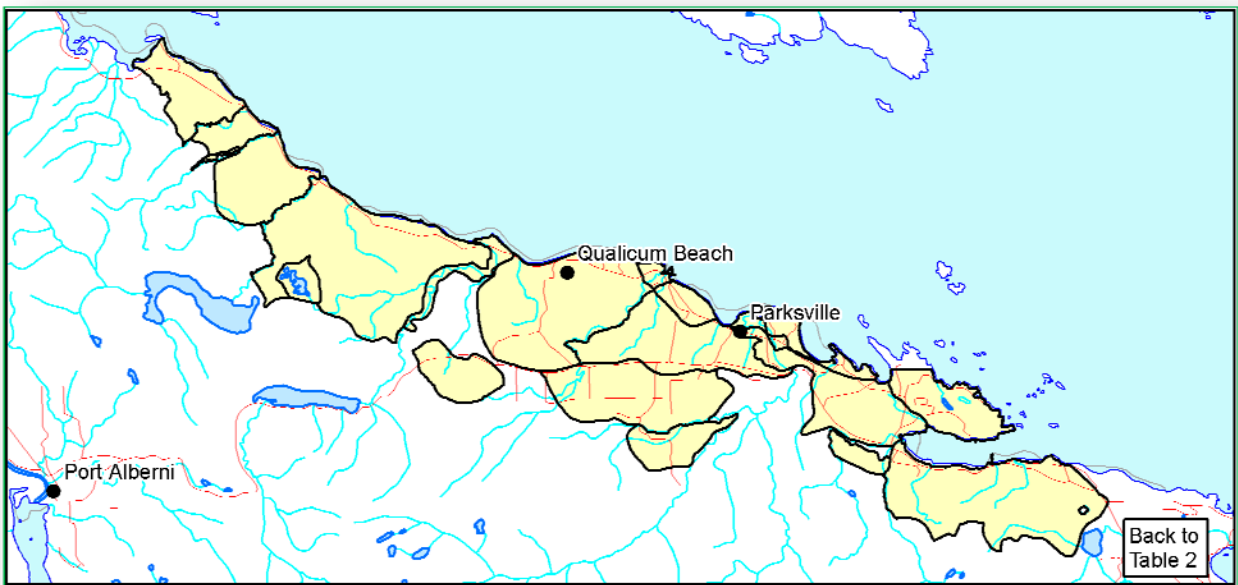


Figure 6. Omineca: Lower Nechako River Valley; 5th priority aquifer.

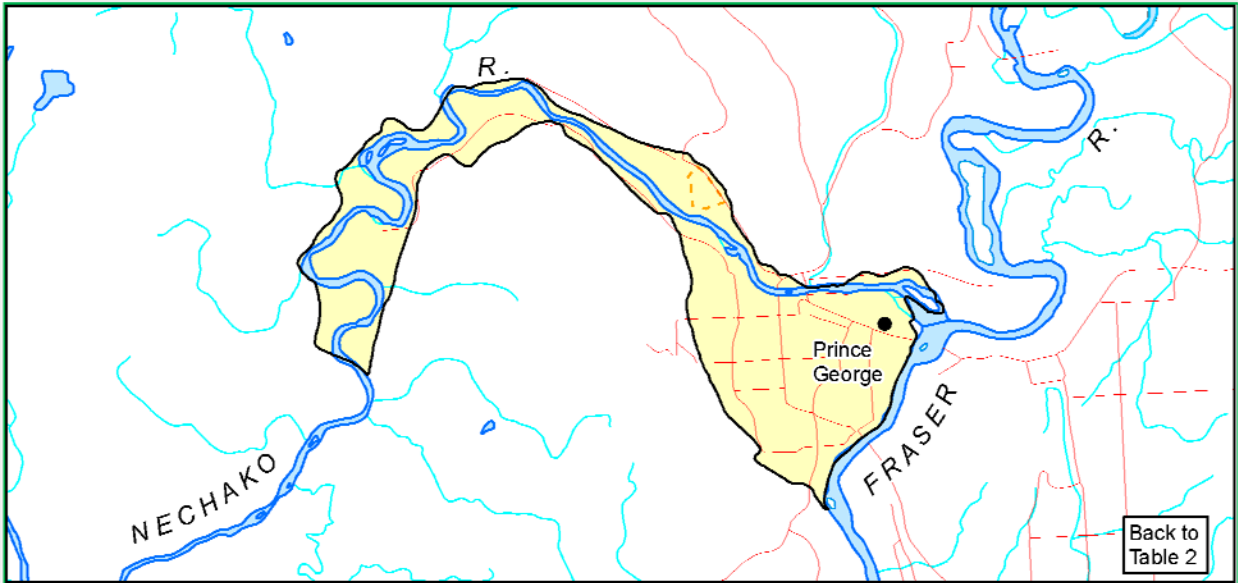


Figure 7. Vancouver Island: Duncan Area; 6th priority area of interconnected aquifers.

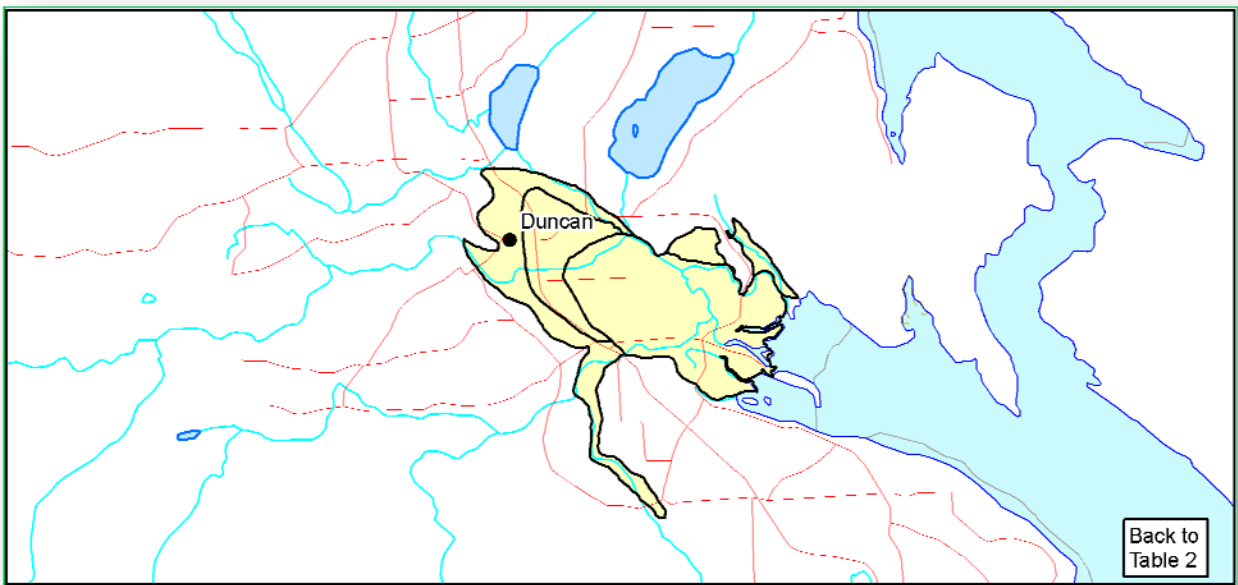


Figure 8. Okanagan: Rutland-Kelowna; 7th priority area of interconnected aquifers.

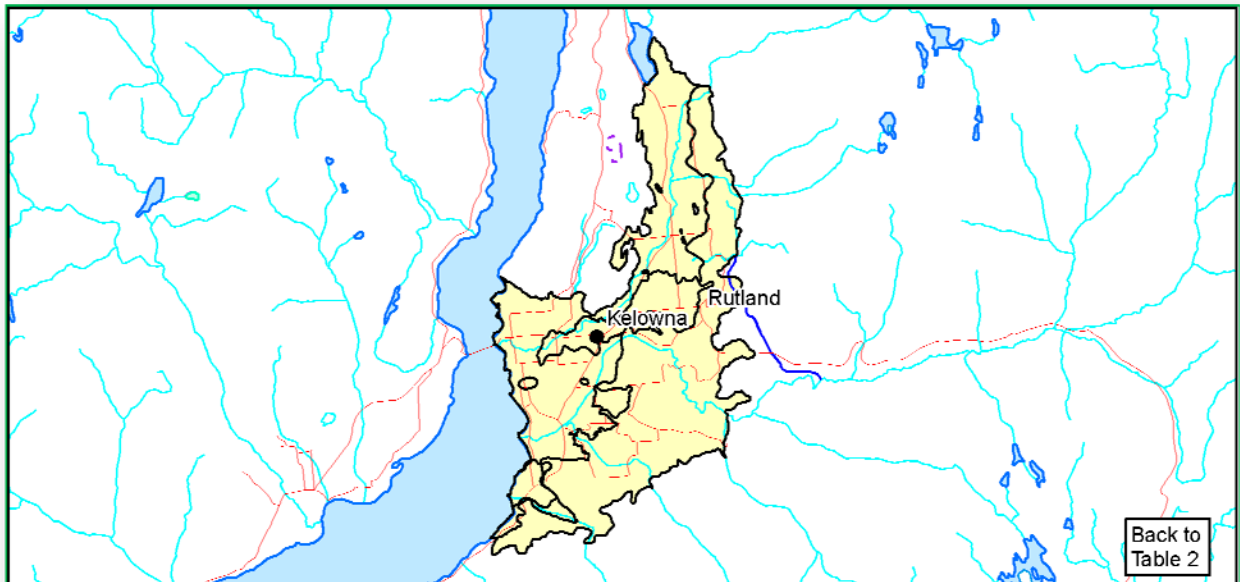


Figure 9. Okanagan: Osoyoos Lake to Vaseux Lake; 8th priority area of interconnected aquifers.

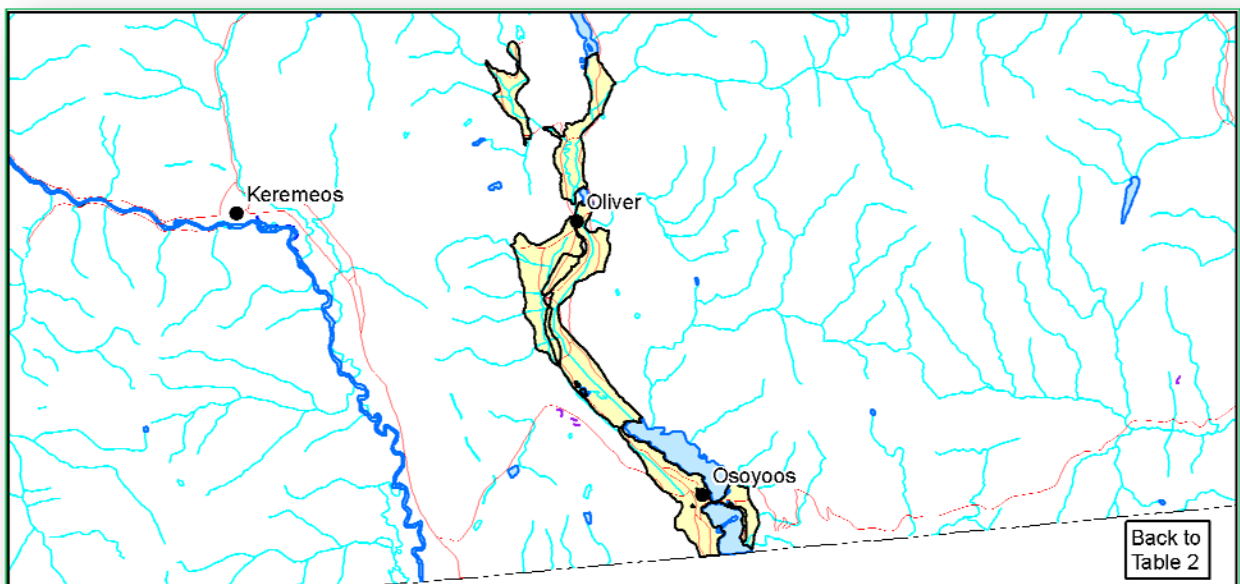


Figure 10. Vancouver Island: Cowichan Bay-Mill Bay; 9th priority area of interconnected aquifers.

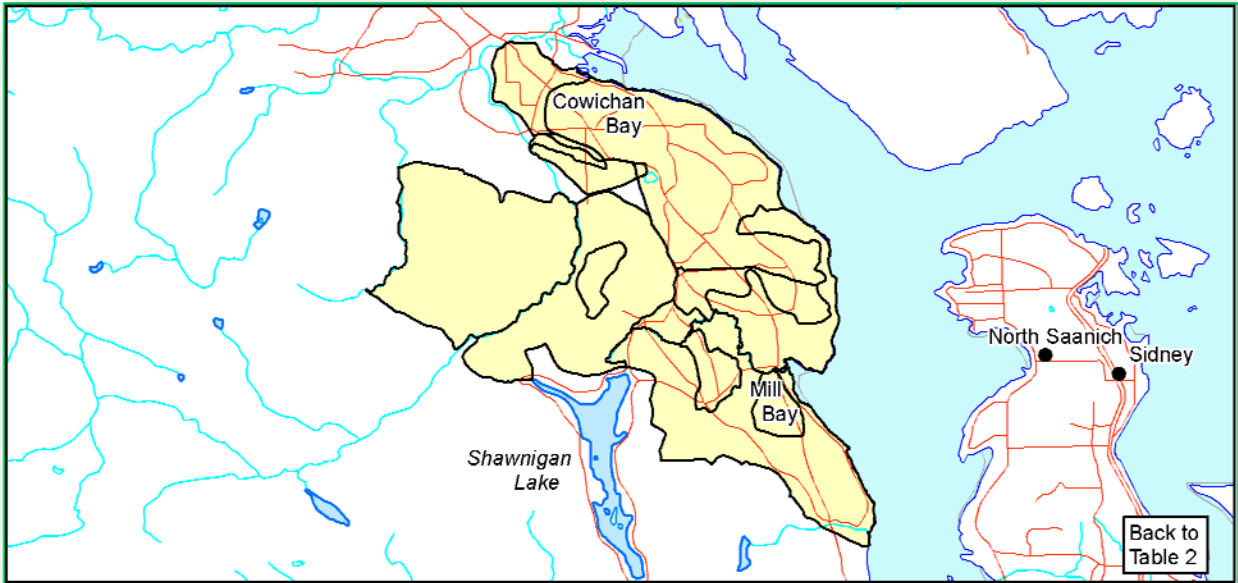


Figure 11. Southern Gulf Islands: (e.g., Gabriola, Thetis, Hornby, Mayne, Galiano, etc); 10th priority area.

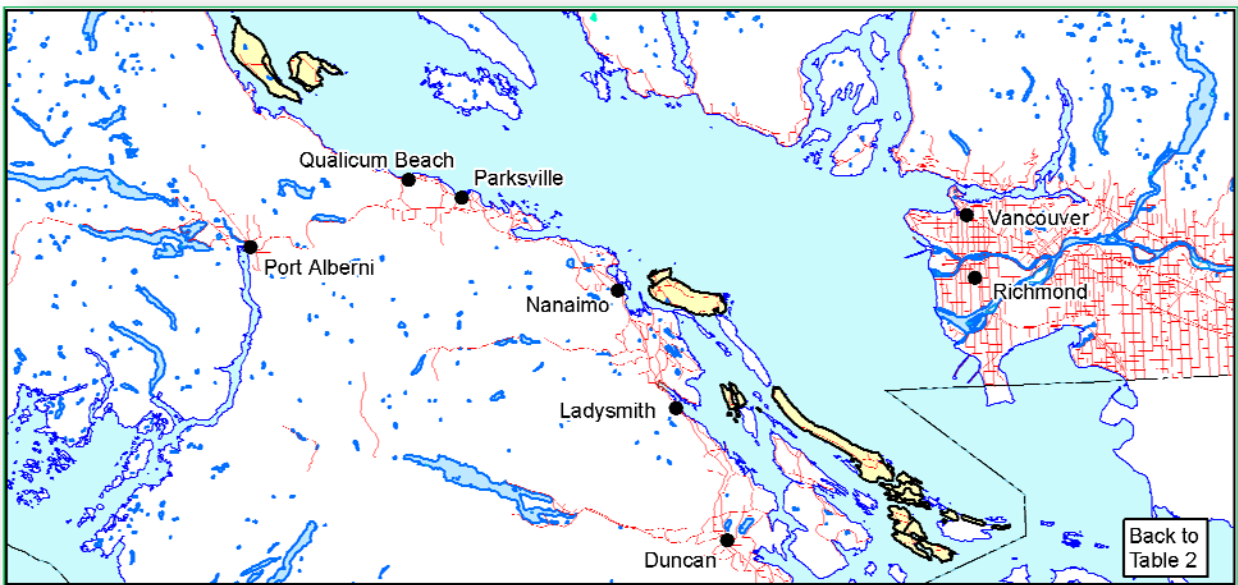


Figure 12. Gulf Island: Saltspring Island; 11th priority area of interconnected aquifers.



Figure 13. Vancouver Island: Cassidy-Cedar; 12th priority area, interconnected aquifers.

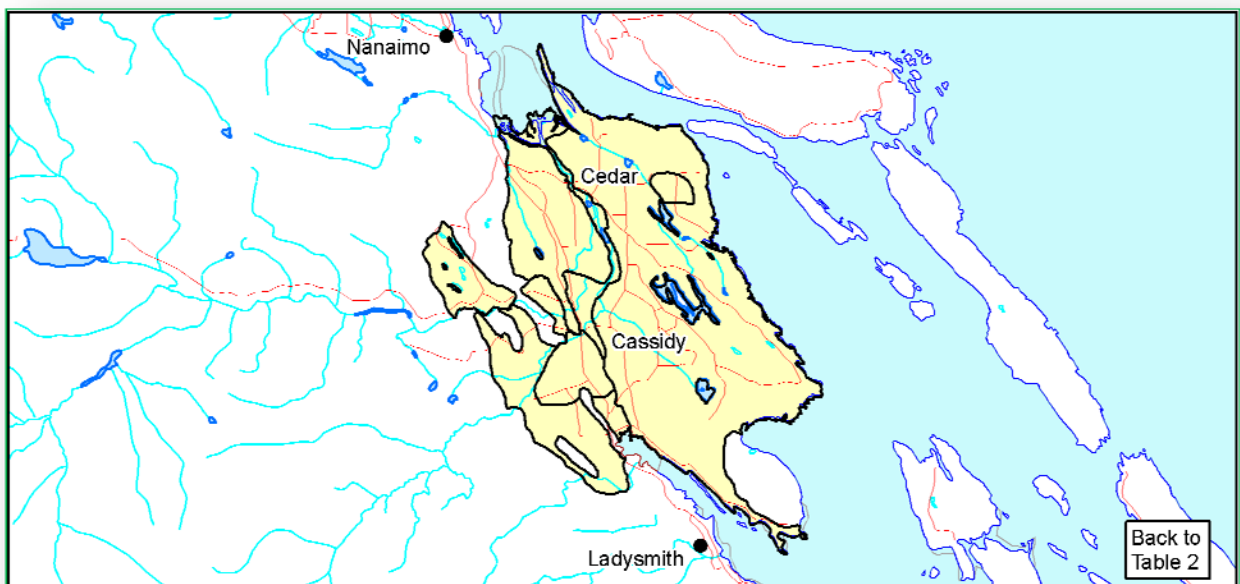


Figure 14. Quesnel; 13th priority area of interconnected aquifers.

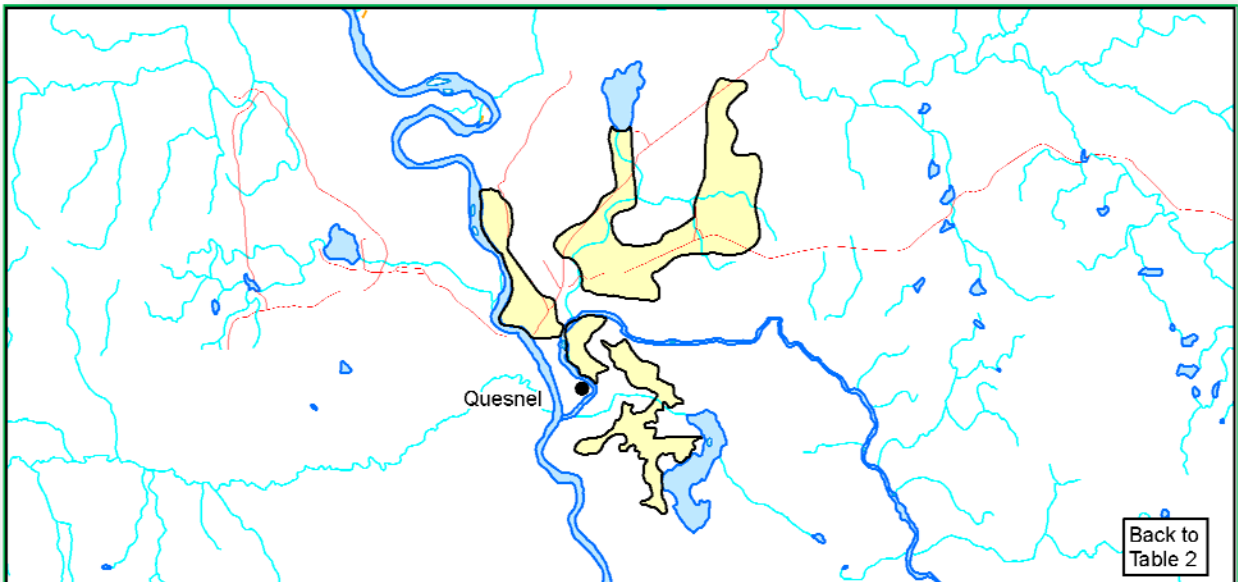


Figure 15. Kootenay: Grand Forks; 14th priority area of interconnected aquifers.

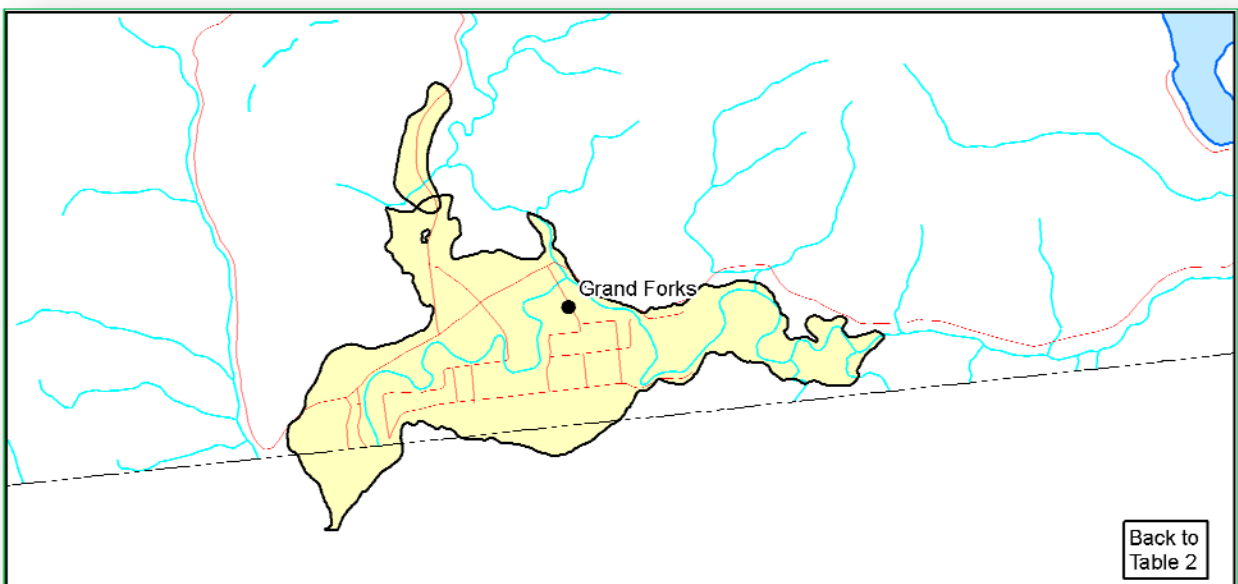


Figure 16. Similkameen: Princeton to U.S. Border; 15th priority aquifer.

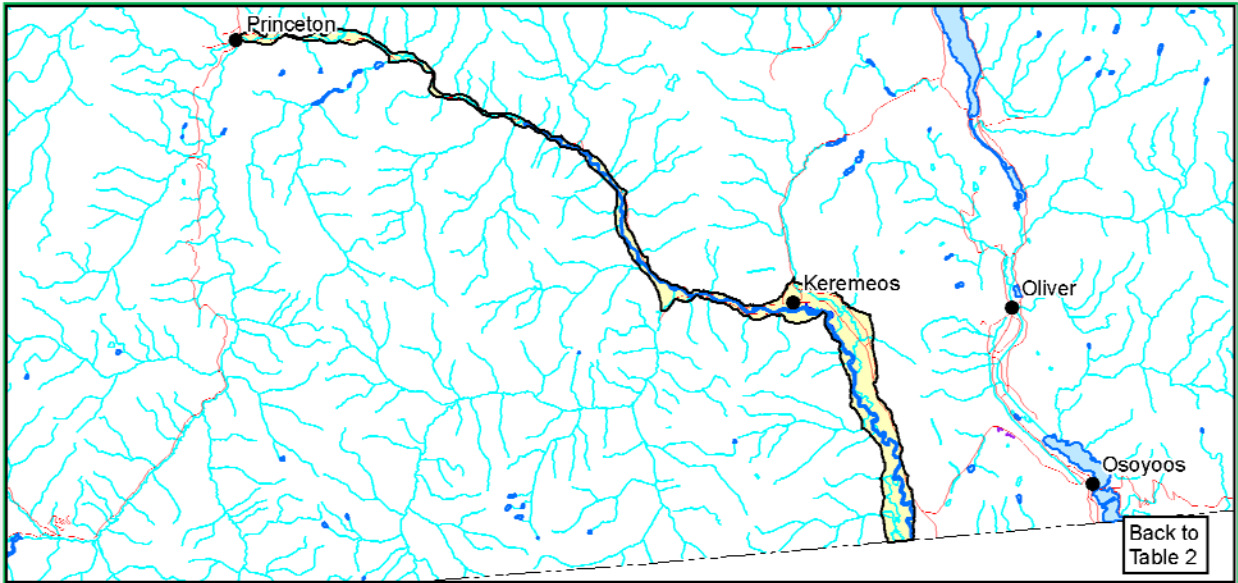


Figure 17. Nicola Basin: Merritt; 16th priority aquifer.

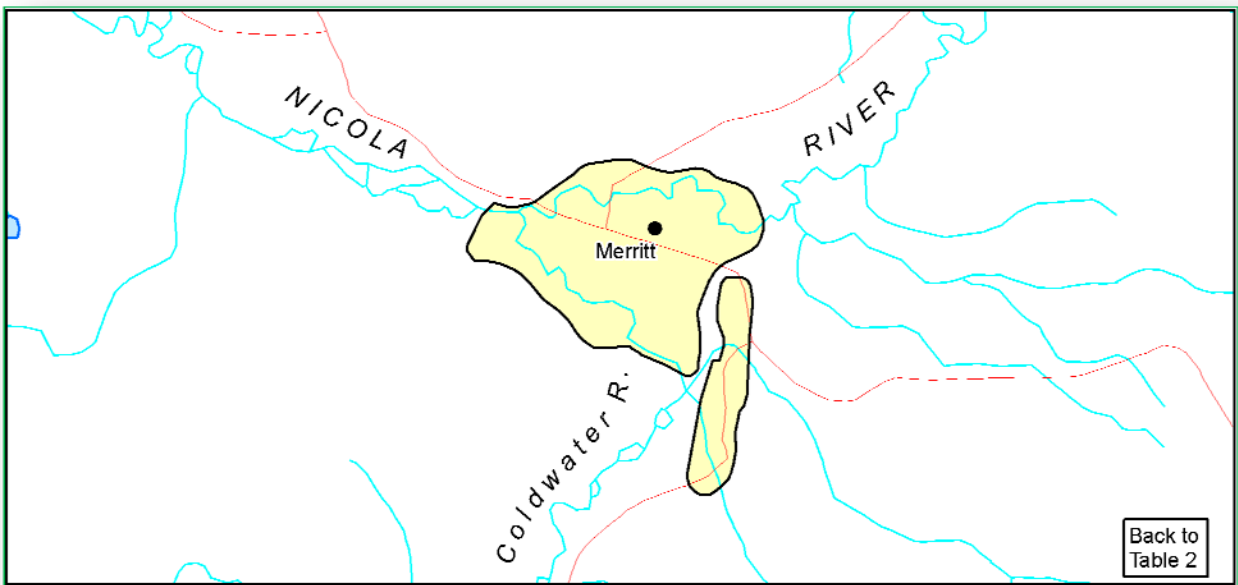


Figure 18. Vancouver Island: Chemainus; 17th priority aquifer.

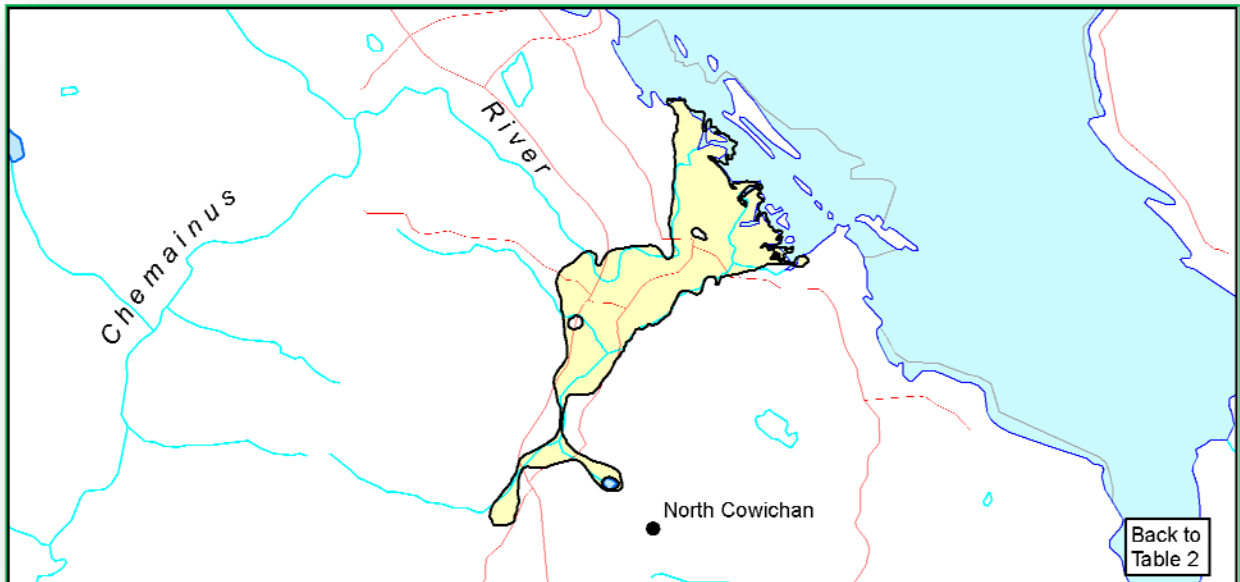


Figure 19. Whistler; 18th priority area of interconnected aquifers.

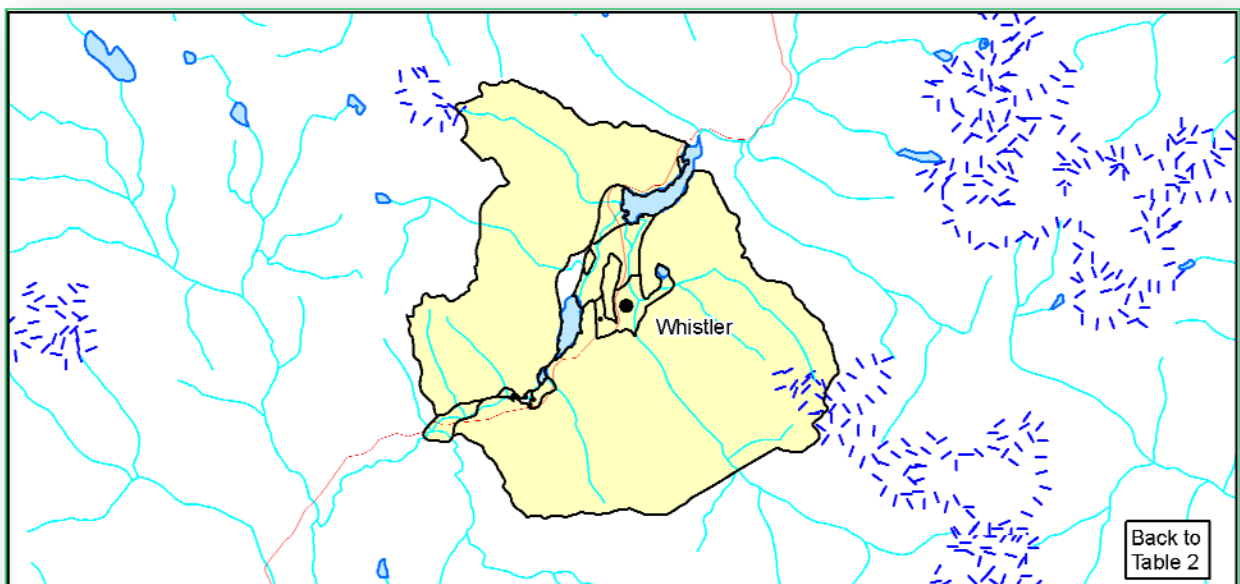


Figure 20. Salmon River Valley; 19th priority area of interconnected aquifers

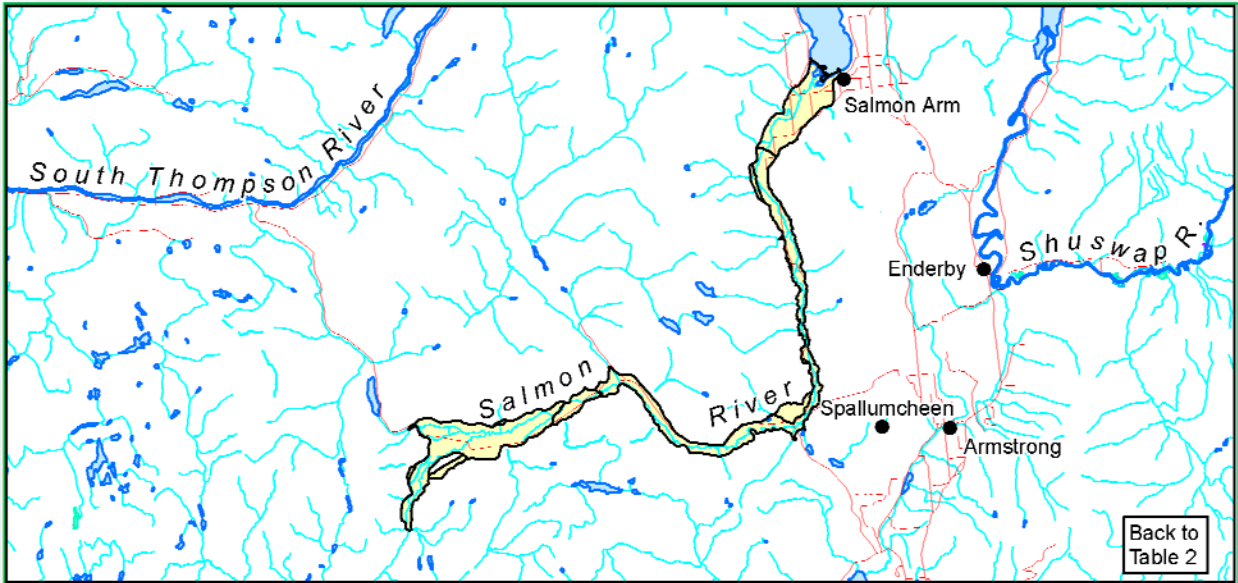


Figure 21. Okanagan: Armstrong; 20th priority area of interconnected aquifers.

