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Zebra and Quagga Mussels Risk Assessment Mapping Summary Report

Prepared for District of Lake Country

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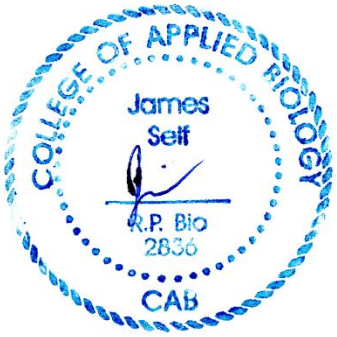


Background

British Columbia remains one of the few major jurisdictions left in North America that does not have invasive zebra or quagga mussels. The Okanagan Basin Water Board (OBWB) has lead invasive mussel prevention programs for over 10 years and recently developed a risk assessment document for British Columbia (Okanagan Basin Water Board, 2024).

District of Lake Country (DLC) operates multiple reservoir lakes within two upland community watersheds: Oyama Community Watershed (Oyama Creek) and Beaver Lake Community Watershed (Upper Vernon Creek). DLC also operates drinking water intakes in Kalamalka Lake at Oyama and Okanagan Lake at Coral Beach, Lakepine, and Lakestone (primary intake). DLC sought to use the new OBWB guide to assess the risk to these lakes from invasive mussels.

Project Scope

This project used available data to compare against an invasive mussel risk matrix that was used to develop a risk assessment map and guidance document for DLCs intakes (Table 1, Okanagan Basin Water Board, 2024). The report currently identifies only the vulnerability of a site to invasive mussels and does not address potential variations in the level of infestation or secondary factors that might influence both the risk and severity of the infestation.

Table 1: Invasive Mussel Survival Risk Matrix

Parameter	At Risk
Calcium/Alkalinity	>12 mg/L
Alkalinity	> 30 mg/L
pH	7.0 to 9.5
Temperature	0 to 33 °C
Salinity	< 10%
Oxygen limit	> 3 mg/L

Modified from (Okanagan Basin Water Board, 2024)

Data Used

Data used in the generation of this report was obtained from DLCs water sample database. These data were layered upon the existing results from mapping produced for OBWB for the development of their new guide. For this study, data from 2021-2023 were considered to ensure the results were reflective of the current status of each site (Table 2).

Table 2: Number of data points for parameters from Table 1 at each watershed site monitored by DLC, 2021-2023

Parameter	Beaver Lake	Upper Vernon Creek	Oyama Lake	Oyama Creek	Damer Lake	Kal Lake at Oyama	Coral Beach (Okanagan Lake)	Lakepine (Okanagan Lake)	Lakestone (Okanagan Lake)
pH*	many	many	many	many	many	3	3	3	3
Total Calcium	1	6	1	6	2	3	3	3	3
Dissolved Oxygen*	-	-	-	-	-	24	21	21	21
Temperature*	many	many	many	many	many	24	21	21	21
Salinity*	-	-	-	-	-	-	-	-	-

* = Routine monitoring data was not available for these parameters at all sites.
Many = annual averages available from online instrumentation

Methodology

This report follows the OBWB guidance document's recommendations and uses an all or nothing approach such that if any of the parameters were unfavourable, a site will be assessed as being "not at risk" to invasive mussels.

The mean value for each parameter at each site was compared against the particular results range in Table 1 and a risk score (0 or 1) was applied (Table 4, Table 3). The sum of these risk scores was calculated for each site to obtain a site-specific cumulative risk value. A value of 5 for a site would flag it as "at risk" while ≤4 meant that at least one parameter was assessed as "not at risk" and therefore the site would be ranked as unsuitable for mussels (Figure 1).

A number of data assumptions were made in preparing this assessment to fill in data gaps:

- Dissolved oxygen information was obtained from Einarson, 2008 for the DLC upland lakes. While the results presented were for the outflows and may have missed bottom water low-DO zones, they indicated that the epilimnion was well oxygenated and could support mussels.
- For Okanagan and Kalamalka lakes, the extensive BC EMS and Kalamalka Lake Study databases was used to augment
- Temperature and salinity data were inferred based on previous experience at other nearby reservoirs
- Downstream chemistry was applied to the upstream reservoirs when data was unavailable. For example, Vernon Creek at the intake had very low calcium. While there was only limited calcium data for Beaver Lake reservoir, it must also be low because it supplies most of the flow to Vernon Creek at the intake.
- Professional judgement was used to apply rankings to those parameters that did not have data
    - Temperature values in Okanagan valley lakes do not ever exceed 30 °C and would therefore be "at risk" for that parameter at all sites
    - Salinity in freshwater Okanagan lakes is far too low to present a challenge to invasive mussels.

Risk Scores

A clear pattern emerged from the risk assessment with upland reservoirs having low average calcium concentrations (4.4 to 6.9 mg/L) and circumneutral pH (6.8 to 7.5; Table 4). While the other parameters were all highly favourable for mussels, the paucity of available calcium, in particular, means that the upland reservoir lakes monitored within the DLC watersheds were ultimately ranked as "not at risk" (Figure 1, Table 3, Table 4). Conversely, the mainstem lake sites ranked as at risk for all parameters with high calcium that would be very favourable for mussels. Okanagan and Kalamalka Lake, therefore ranked as "at risk" for all infrastructure within each (Figure 1, Table 3, Table 4).

Table 3: Summary of risk ratings for each parameter at each site sampled by DLC

Parameter	Beaver Lake	Upper Vernon Creek	Oyama Lake	Oyama Creek	Damer Lake	Kal Lake at Oyama	Coral Beach (Okanagan Lake)	Lakepine (Okanagan Lake)	Lakestone (Okanagan Lake)
pH	1	1	1	1	1	1	1	1	1
Total Calcium	0	0	0	0	0	1	1	1	1
Dissolved Oxygen	1	1	1	1	1	1	1	1	1
Temperature	1	1	1	1	1	1	1	1	1
Salinity	1	1	1	1	1	1	1	1	1
Risk Score	4	4	4	4	4	5	5	5	5
Risk Assessment	Not at risk	Not at risk	Not at risk	Not at risk	Not at risk	At risk	At risk	At risk	At risk

Table 4: Summary of mean values for each parameter during 2021-2023 at each site sampled by DLC

Parameter	Beaver Lake	Upper Vernon Creek	Oyama Lake	Oyama Creek	Damer Lake	Kal Lake at Oyama	Coral Beach (Okanagan Lake)	Lakepine (Okanagan Lake)	Lakestone (Okanagan Lake)
pH	7.3*	7.3*	7.5*	7.2*	7.2*	8.0	8.1	8.1	8.0
Total Calcium	6.8	6.9	4.4	5.5	6.2	41.1	30.6	33.1	20.7
Dissolved oxygen (min)	-	-	-	-	-	10.6 (8.3)	10.9 (8.2)	10.9 (8.2)	10.9 (8.2)
Temperature (max)	13 (19.3)	10 (23)*	10 (19.3)*	14 (24)*	10.8 (19.3)	10.8 (24.3)	7.9 (23.9)	7.9 (23.9)	7.9 (23.9)
Salinity	-	-	-	-	-	-	-	-	-

* = Average temperature data from DLC online instruments

Risk Assessment Map

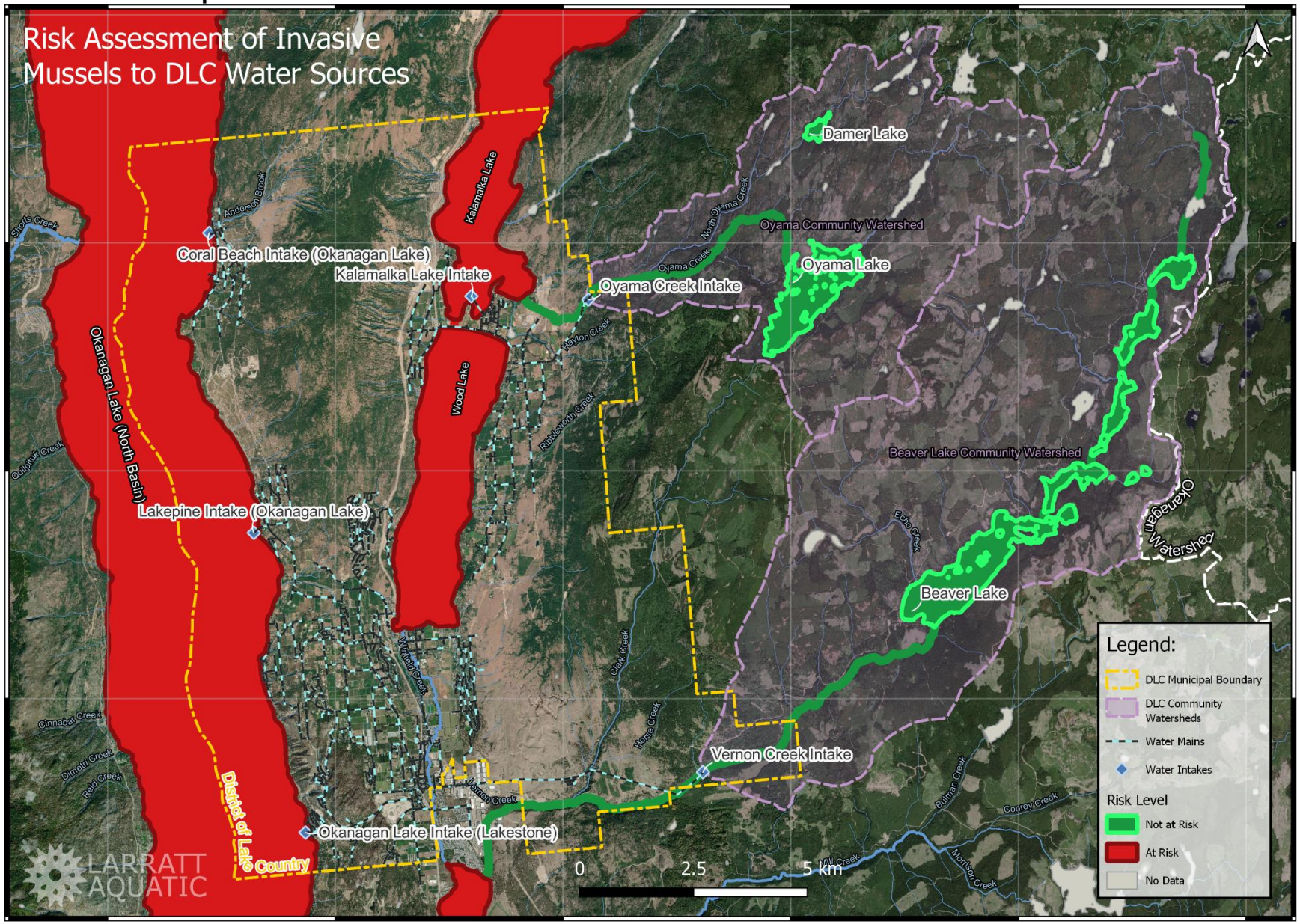


Figure 1: Risk ratings for each lake, colour coded based on the mean risk score

Conclusion

Using the 2024 OBWB risk assessment methodology, the five primary parameters (calcium, pH, dissolved oxygen, temperature, and salinity) were assessed. While temperature, dissolved oxygen, and salinity data all fell within the favourable range for invasive mussels at all sites, the upland storage reservoir lakes had very low calcium that would prevent growth and replication of mussels. Okanagan and Kalamalka lakes, however, ranked as at risk across all parameters with high calcium concentrations that could support intense mussel infestations.

Report prepared by: Larratt Aquatic Consulting Ltd.

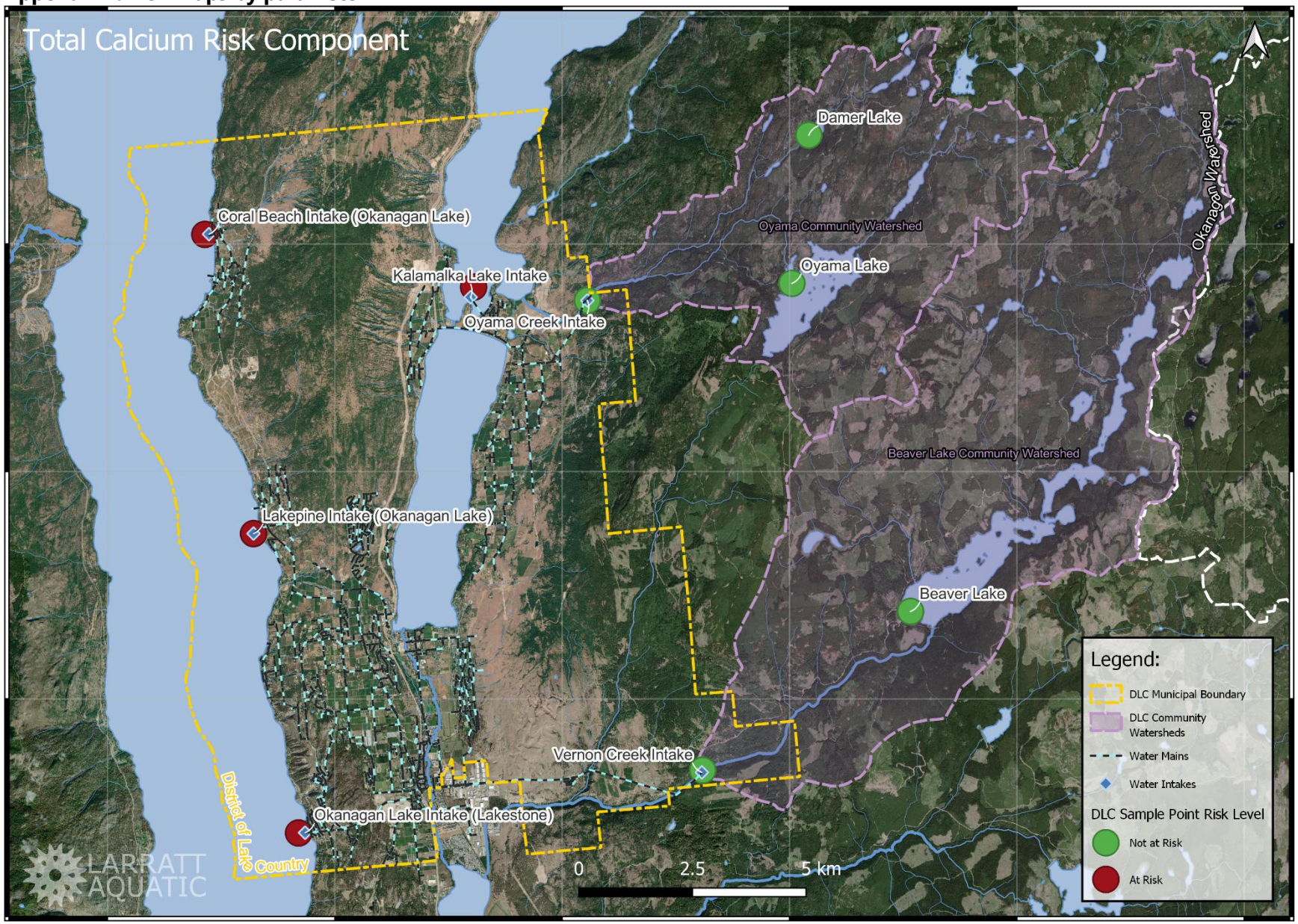
Jamie Self: Senior Aquatic Biologist, R.P.Bio.

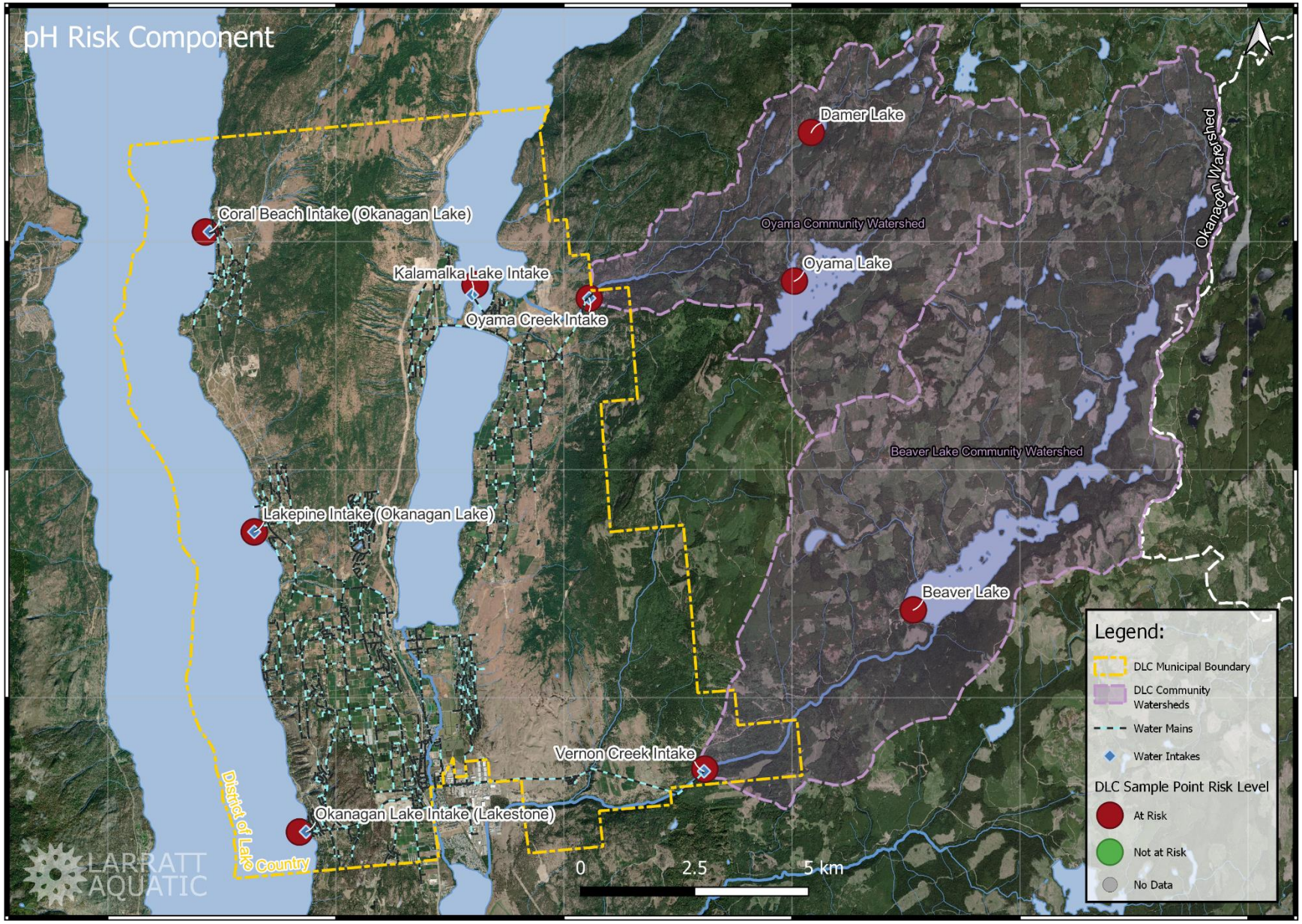
References

Einarson, E. D. (2008). *WATER STEWARDSHIP DIVISION MINISTRY OF ENVIRONMENT WATER QUALITY ASSESSMENT AND OBJECTIVES FOR UPPER VERNON CREEK COMMUNITY WATERSHED TECHNICAL REPORT - DRAFT*.

Okanagan Basin Water Board. (2024). *Preparing for Invasive Mussels: Vulnerability Assessment Guide for Raw Water Infrastructure*.

Appendix 1: Risk Maps by parameter




pH Risk Component
Damer Lake
Okanagan Watershed
Coral Beach Intake (Okanagan Lake)
Oyama Community Watershed
Kalamalka Lake Intake
Oyama Lake
Oyama Creek Intake
Beaver Lake Community Watershed
Lakepine Intake (Okanagan Lake)
Beaver Lake
Vernon Creek Intake
District of Lake Country
Okanagan Lake Intake (Lakestone)
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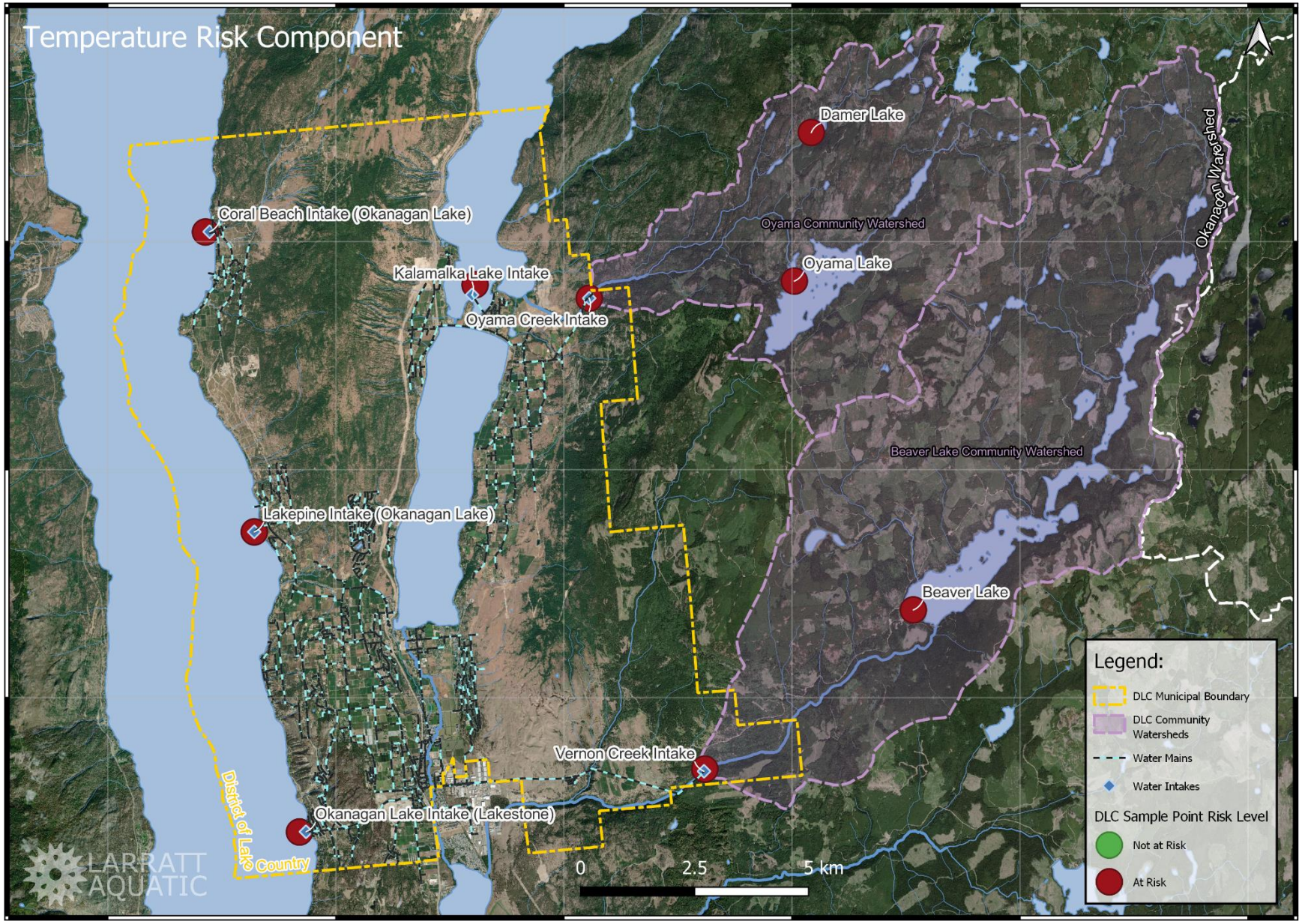
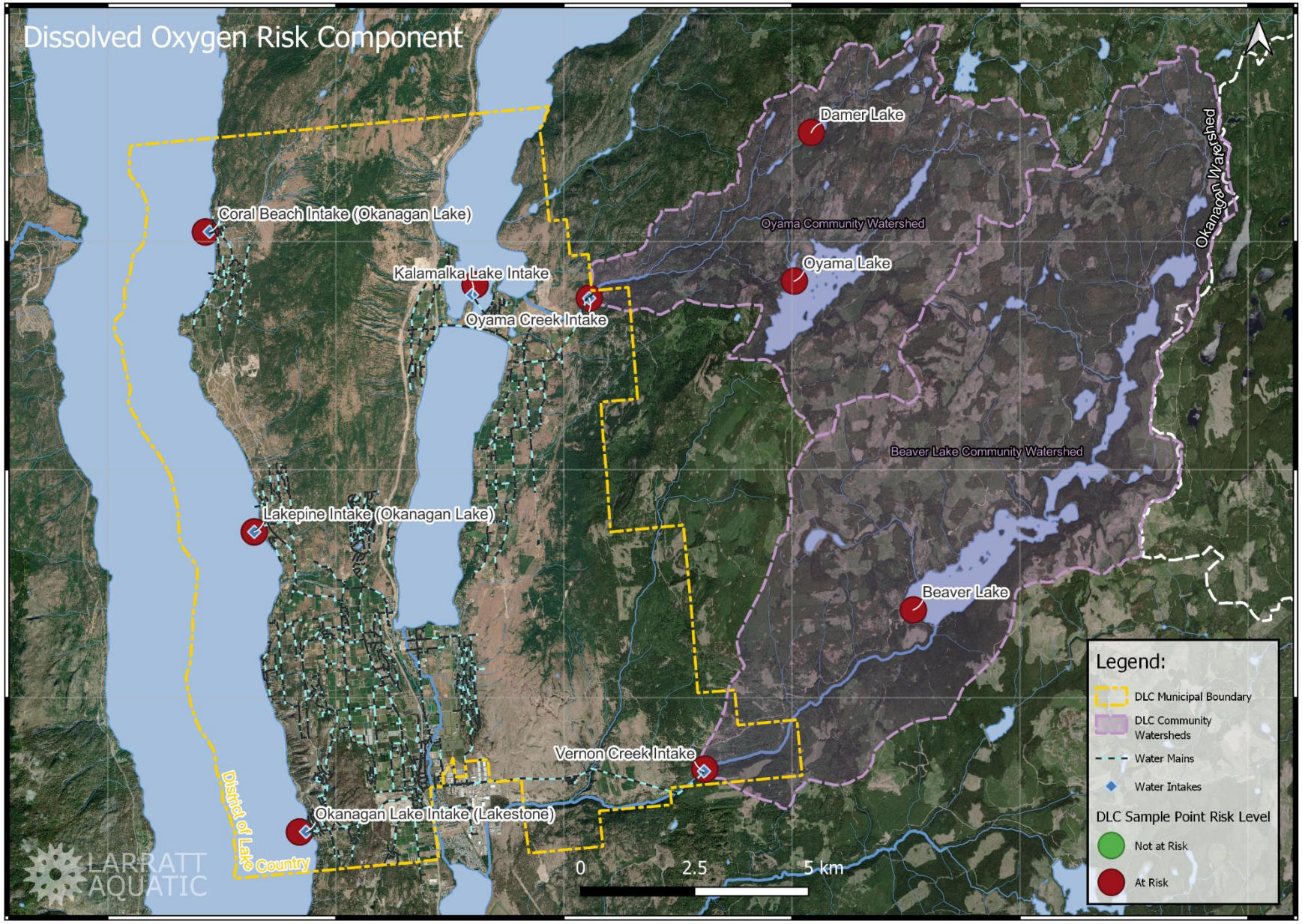
0
2.5
5 km
Legend:
DLC Municipal Boundary
DLC Community Watersheds
Water Mains
Water Intakes
DLC Sample Point Risk Level
At Risk
Not at Risk
No Data


Temperature Risk Component
Damer Lake
Okanagan Watershed
Coral Beach Intake (Okanagan Lake)
Oyama Community Watershed
Kalamalka Lake Intake
Oyama Lake
Oyama Creek Intake
Beaver Lake Community Watershed
Lakepine Intake (Okanagan Lake)
Beaver Lake
Vernon Creek Intake
District of Lake Country
Okanagan Lake Intake (Lakestone)
0
2.5
5 km
Legend:
DLC Municipal Boundary
DLC Community Watersheds
Water Mains
Water Intakes
DLC Sample Point Risk Level
Not at Risk
At Risk


Dissolved Oxygen Risk Component
Damer Lake
Okanagan Watershed
Coral Beach Intake (Okanagan Lake)
Oyama Community Watershed
Kalamalka Lake Intake
Oyama Lake
Oyama Creek Intake
Beaver Lake Community Watershed
Lakepine Intake (Okanagan Lake)
Beaver Lake
Vernon Creek Intake
District of Lake Country
Okanagan Lake Intake (Lakestone)
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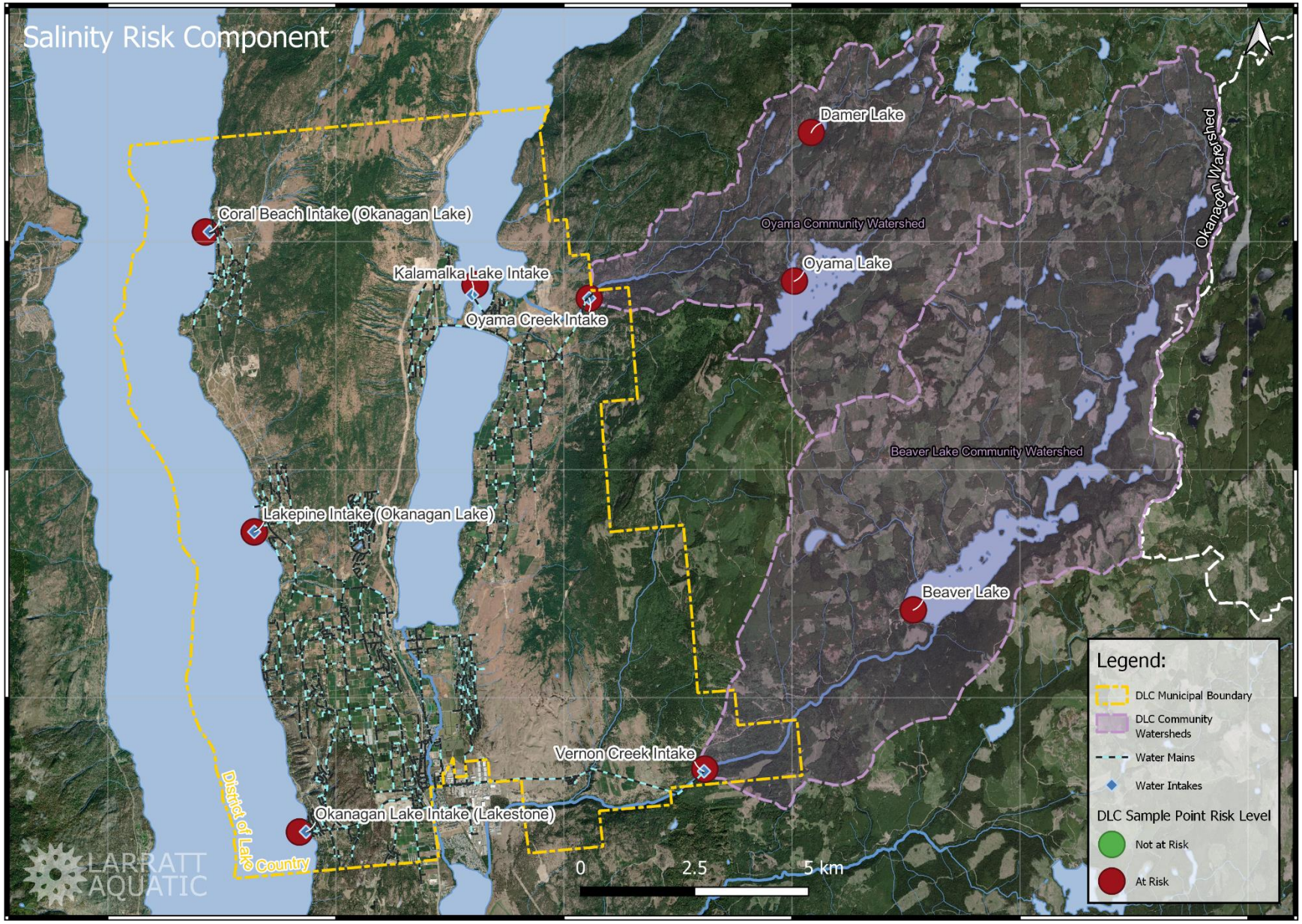
0
2.5
5 km
Legend:
DLC Municipal Boundary
DLC Community Watersheds
Water Mains
Water Intakes
DLC Sample Point Risk Level
Not at Risk
At Risk


Salinity Risk Component
Damer Lake
Okanagan Watershed
Coral Beach Intake (Okanagan Lake)
Oyama Community Watershed
Kalamalka Lake Intake
Oyama Lake
Oyama Creek Intake
Beaver Lake Community Watershed
Lakepine Intake (Okanagan Lake)
Beaver Lake
Vernon Creek Intake
District of Lake Country
Okanagan Lake Intake (Lakestone)
LARRATT AQUATIC
0
2.5
5 km
Legend:
DLC Municipal Boundary
DLC Community Watersheds
Water Mains
Water Intakes
DLC Sample Point Risk Level
Not at Risk
At Risk

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