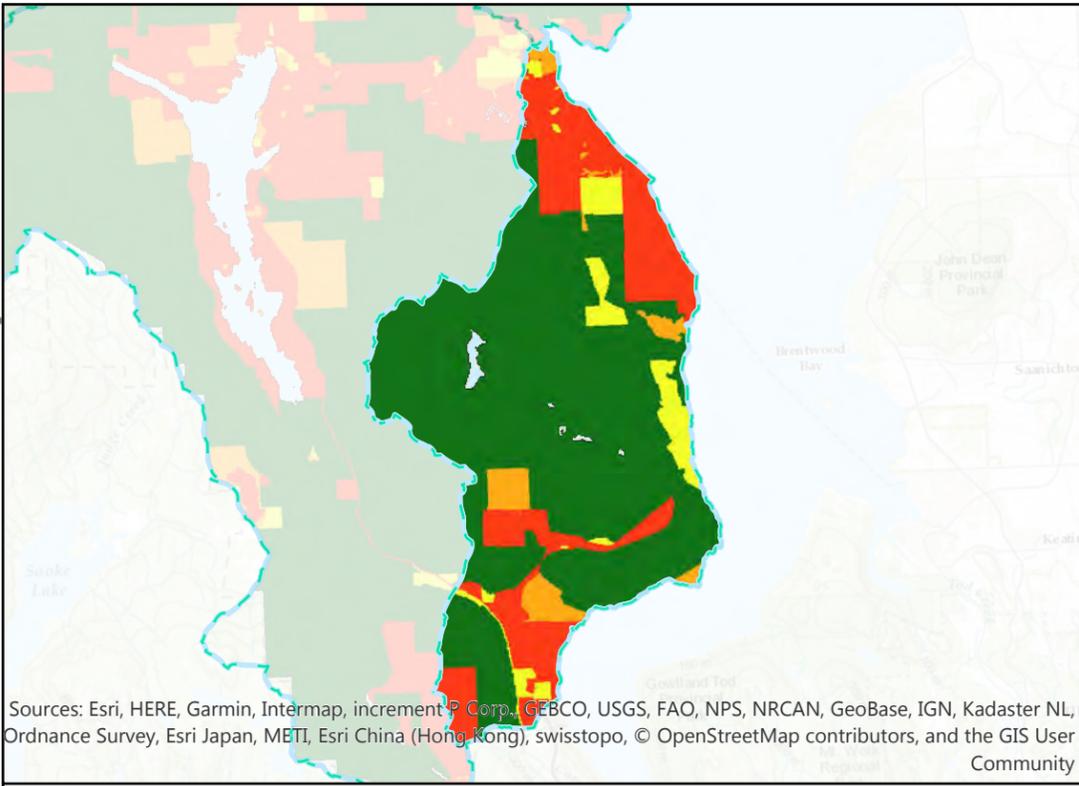
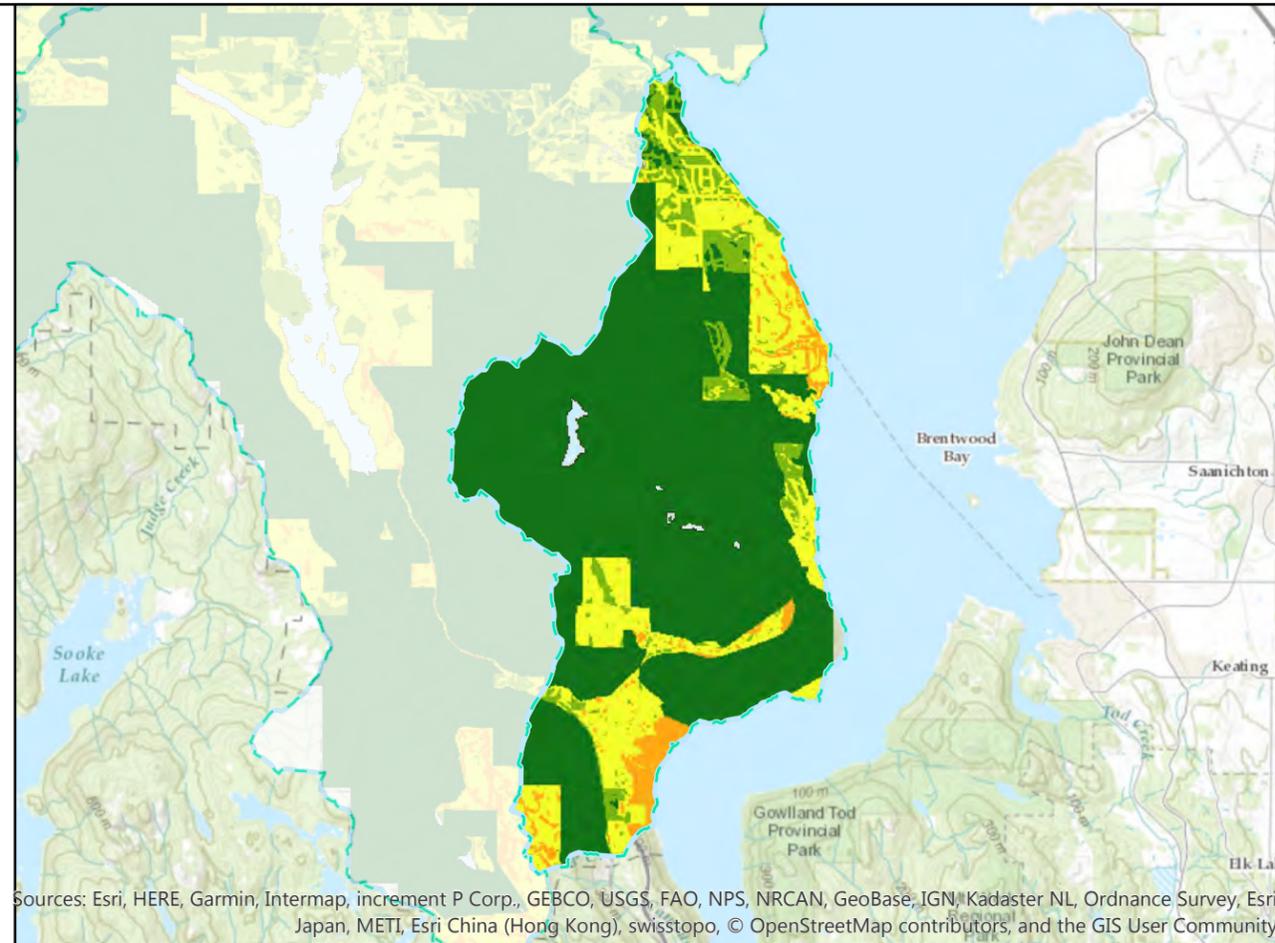


<b>9. Malahat Benchlands</b>	
<b>Topic</b>	<b>Discussion</b>
Slope Failure	<p>Hazard was determined qualitatively at a high level to describe areas based on the degree to which they may be prone to landslides and other mass movements using terrain characteristics. Hazard classifications were generated to show relative comparisons between terrain units within the CVRD watershed study area. Risk ratings derived from this analysis are relative, and should be used to guide prioritization of further detailed studies.</p> <p>The Malahat Benchlands watershed is generally steep and rocky. Hazard is greatest along the east facing slopes extending down to the shoreline from Mount Jeffrey. Consequence is considered moderate to high through the populated areas extending through the central and eastern portion of the watershed. Risk is considered greatest where populated areas are located on relatively steep slopes such as the Mill Bay Ferry and Malahat Indian Reserve 11.</p>
Flooding	<p>Several creeks drain the watershed. Consequence is very low for the majority of the watershed, with relatively higher consequence located at the north-eastern coast at Mill Bay and southern coast at Malahat Indian Reserve 11, and follows Highway 1 and Shawnigan Lake Road. Risk is relatively greater at these locations.</p>
Groundwater Contamination	<p>Hazard is highest at the northern tip of the watershed at Mill Bay. Consequence is highest in the vicinity of municipal water supply wells throughout the watershed. Risk is highest at some of these well locations in the southern half of the watershed, at the Mill Bay ferry terminal, and at Mill Bay.</p>
Surface Water Quality	<p>Hazard is considered moderate for the majority of the watershed's area based on land development, land use type, and coverage of impermeable surfaces. Most of the watershed's area is considered high consequence due to the prevalence of lower order streams that are more susceptible to surface water supply / stream health issues than larger streams. Risk is considered relatively high for most of the watershed's area and is greatest at the mine in Bamberton and at the two homes along Glen Lane by the coast. Relatively rapid population growth is projected for the watershed that may enhance the pressure on surface water quality. The central portion of the watershed is currently considered low or lower in terms of hazard, consequence, and risk, and therefore may be suitable to accommodate growth.</p>
Surface Water Supply	<p>Hazard is overall low in the watershed with one zone of moderate hazard near Mill Bay. Consequence is variable across the watershed and is greatest near Malahat Indian Reserve 11, Bamberton, and Mill Bay. Risk is greatest near Mill Bay, west of the highway, and low to moderate east of the highway near Malahat Indian Reserve 11 and Bamberton. Projected population increase for the watershed is expected to add pressures on groundwater sources that may increase the level of hazard and risk around Mill Bay.</p>
General Data Notes	<p>The Malahat Benchlands has some contribution from surface water quality, a localized high risk at the north end from surface water supply, moderate (and likely overly stated) flood risk due to some stream presence. Slope failure risk is moderate and focused in the north west and south portions of the watershed, with groundwater contamination being a major contributor to overall risk.</p>

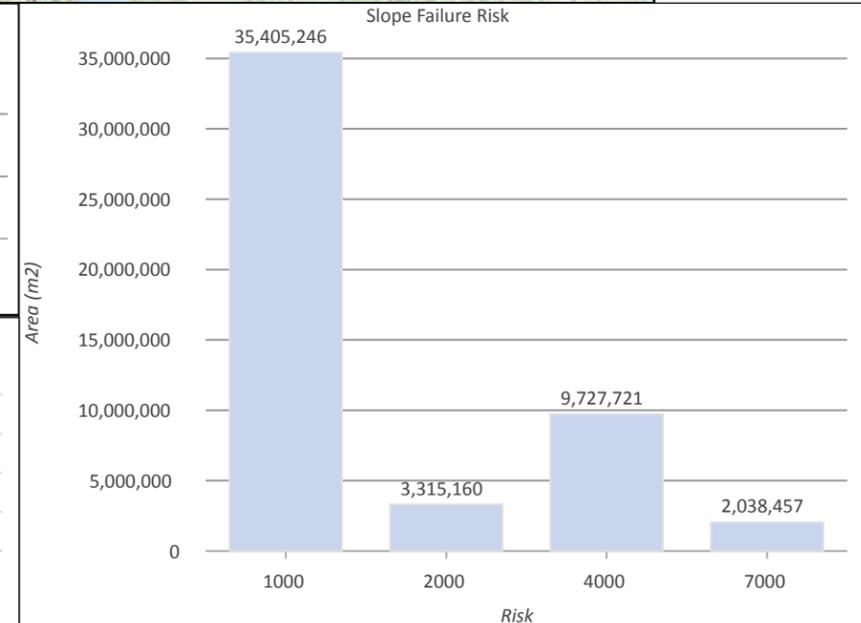
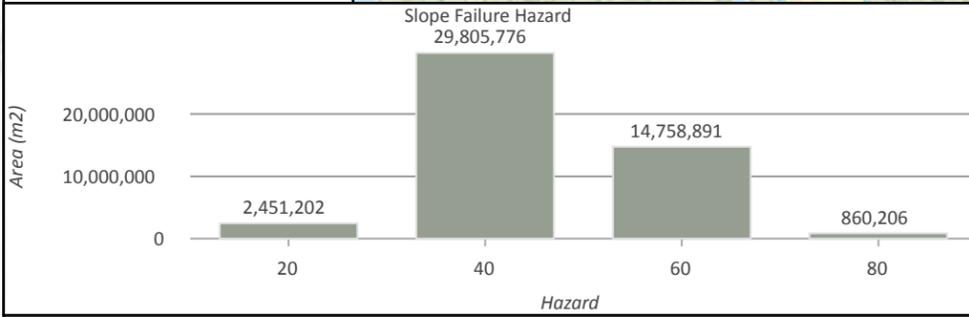
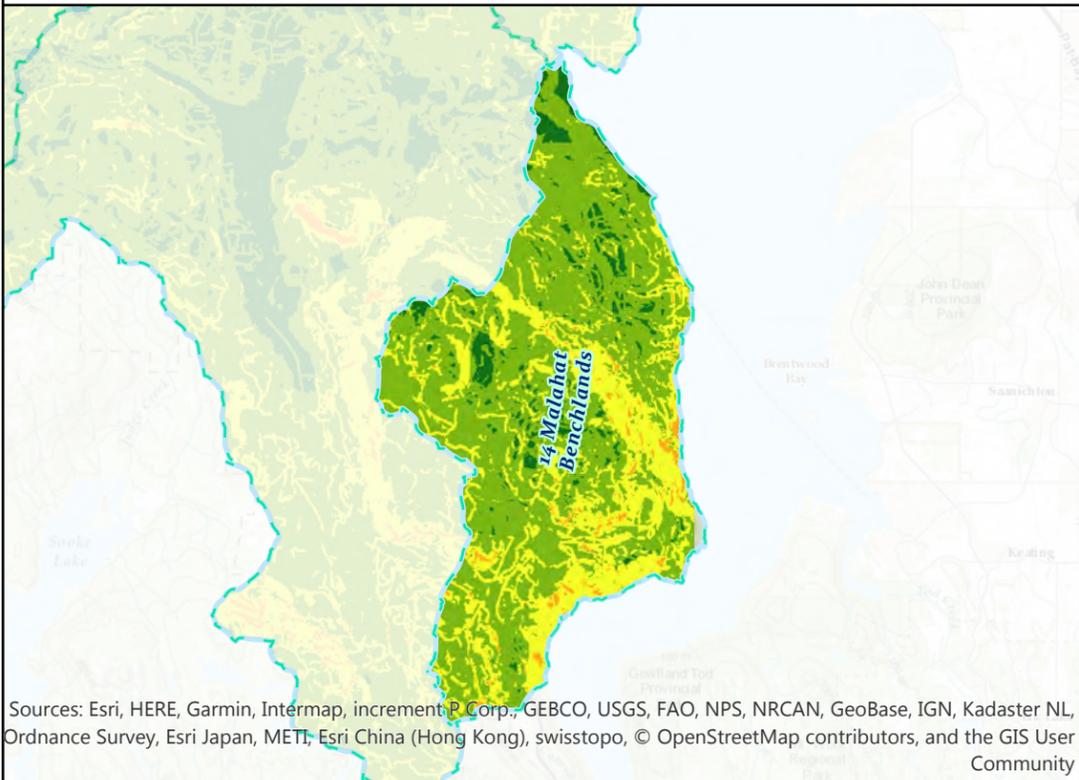
CONSEQUENCE



RISK



HAZARD



**Legend**

WATERSHED BOUNDARIES

**CONSEQUENCES OR HAZARDS**



**RISK**



**REFERENCES:**

1. Risk data compiled from various data sources provided by the Cowichan Valley Regional District. Presentation of data is intended to provide a general guidance on potential issues, rather than a definitive study.

**NOTES:**

1. Original in colour.  
2. Numerical scale reflects full-size print. Print scaling will distort this scale, however scale bar will remain accurate.  
3. Intended for illustration purposes, accuracy has not been verified for construction or navigation purposes.

**REVISIONS:**

0 - CJW - 2018-11-29 - Issued - DK

CLIENT:  
Cowichan Valley Regional District

PROJECT LOCATION:  
Cowichan Valley Regional District  
Malahat Benchlands Watershed



**SNC • LAVALIN**

**Slope Failure Risk Assessment - Malahat**

BY: CJW

SCALE CONS: 1:121,772

DATE: 2019/01/07

REF No:

REV: 0

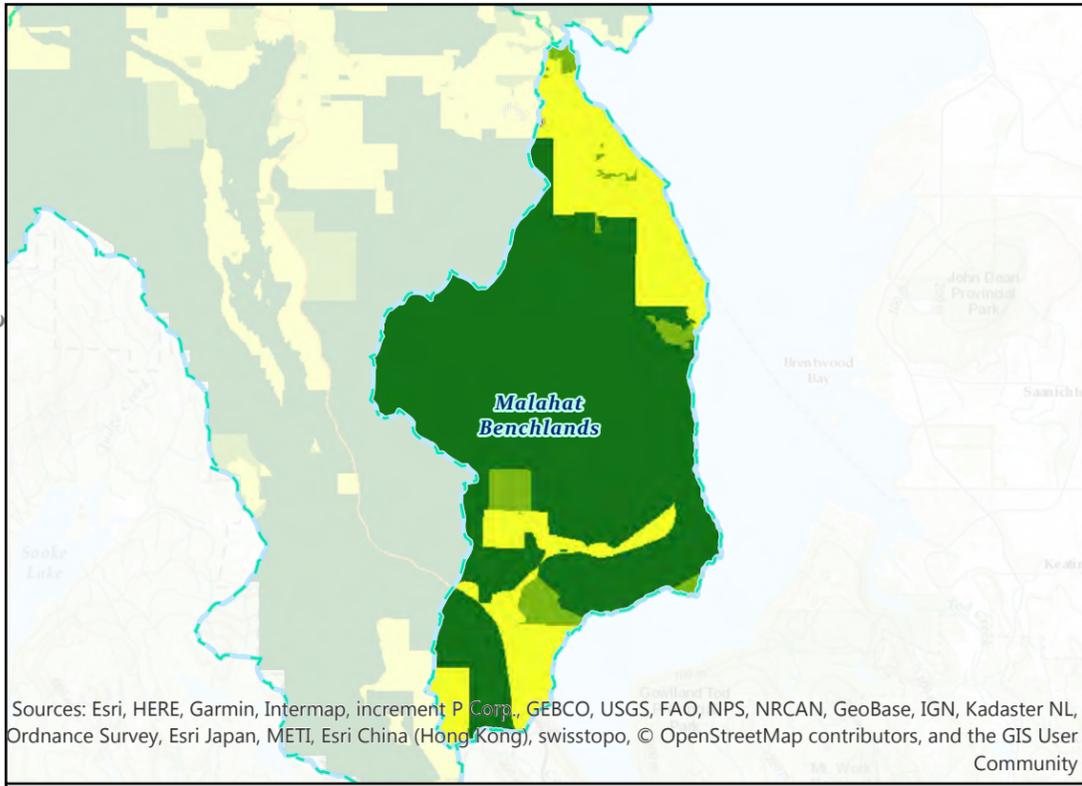
CHKD: DK

Proj Coord Sys: PCS Albers

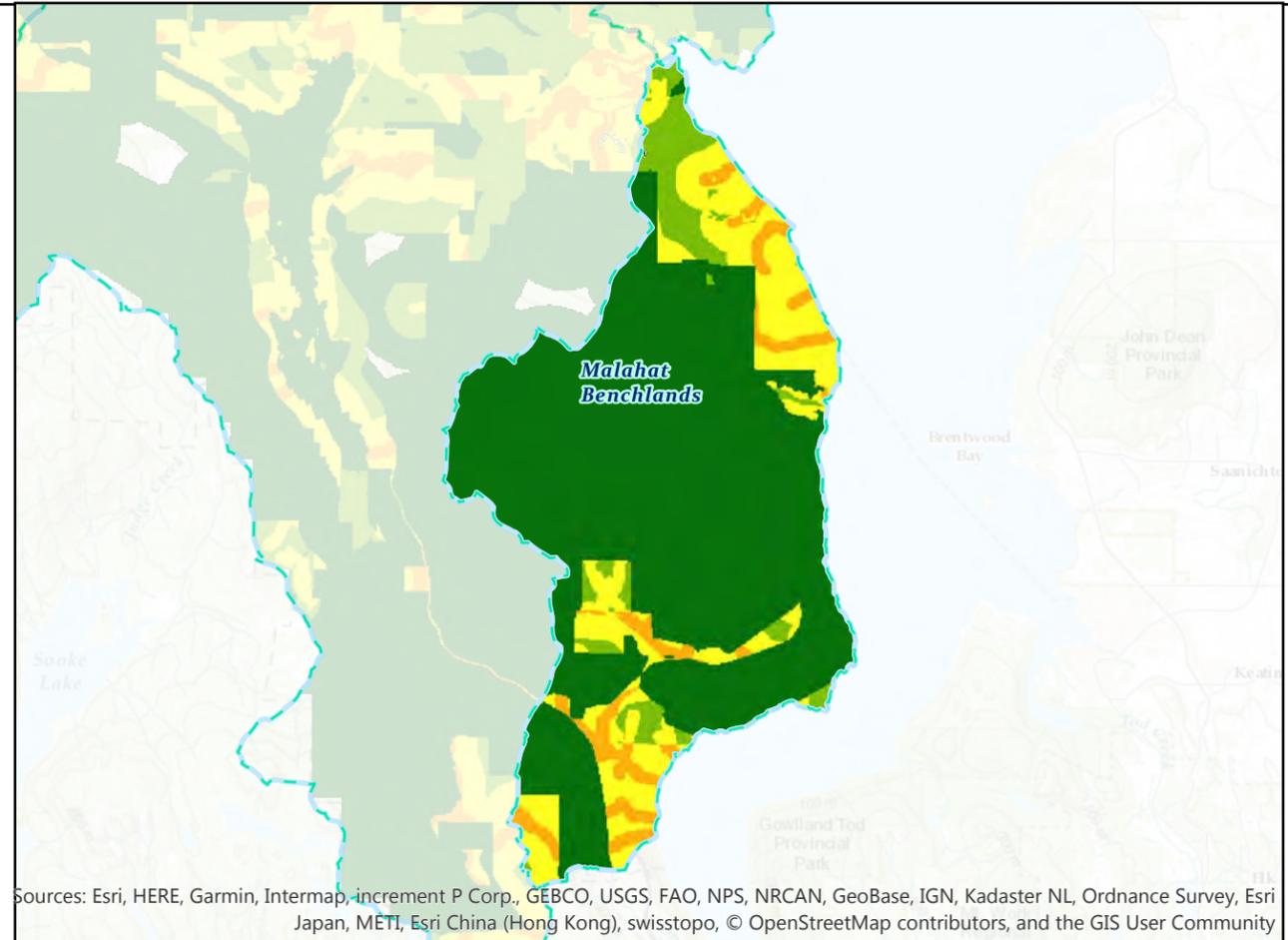
**651957-101-MAL**



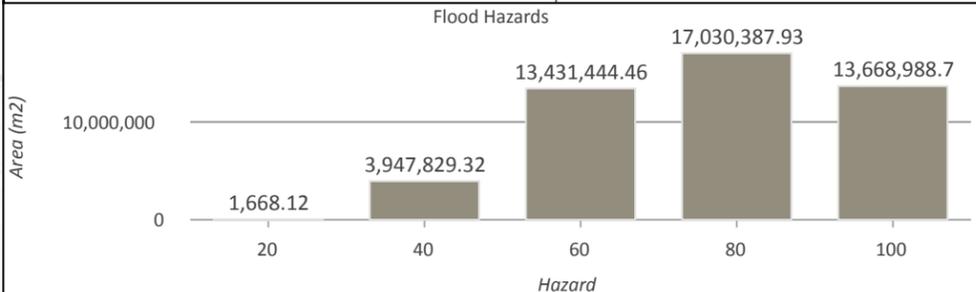
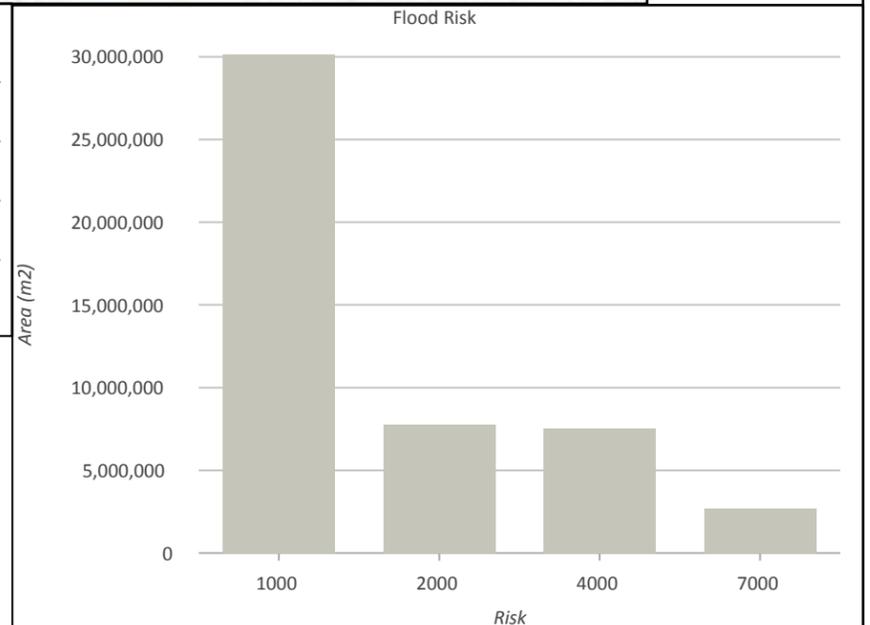
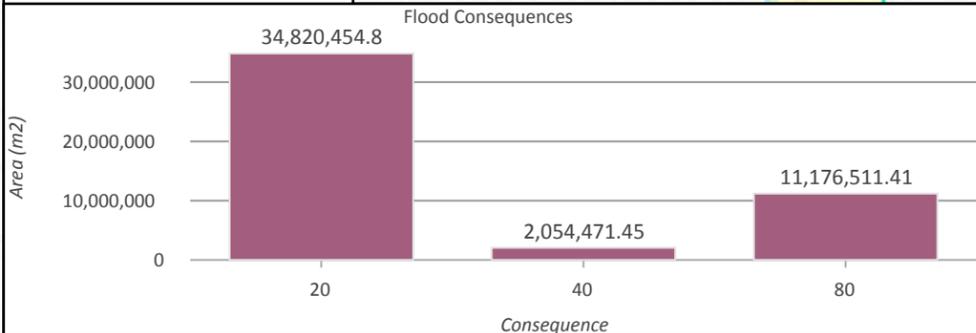
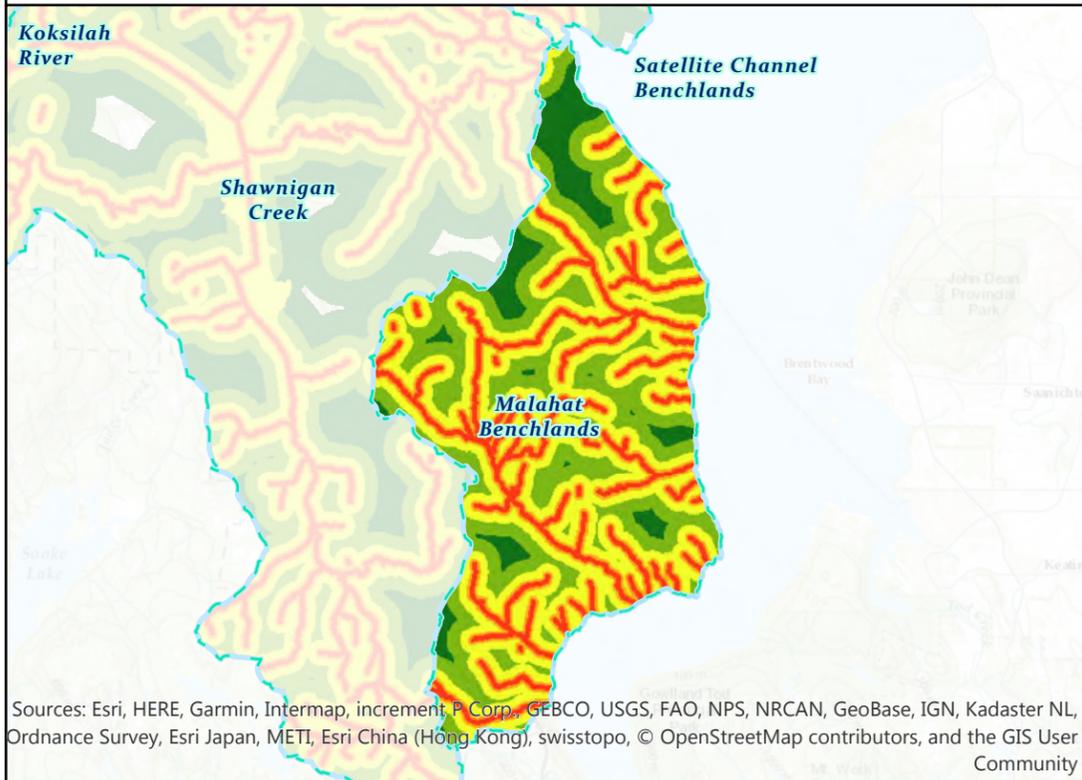
CONSEQUENCE



RISK



HAZARD



**Legend**

WATERSHED BOUNDARIES

**CONSEQUENCES OR HAZARDS**

- ≤ 20
- ≤ 40
- ≤ 60
- ≤ 80
- ≤ 100

**RISK**

- ≤ 1000
- ≤ 2000
- ≤ 4000
- ≤ 7000
- ≤ 10000

**REFERENCES:**

1. Risk data compiled from various data sources provided by the Cowichan Valley Regional District. Presentation of data is intended to provide a general guidance on potential issues, rather than a definitive study.

**NOTES:**

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**REVISIONS:**

0 - CJW - 2018-11-29 - Issued - DK

CLIENT:  
Cowichan Valley Regional District

PROJECT LOCATION:  
Cowichan Valley Regional District  
Malahat Benchlands Watershed

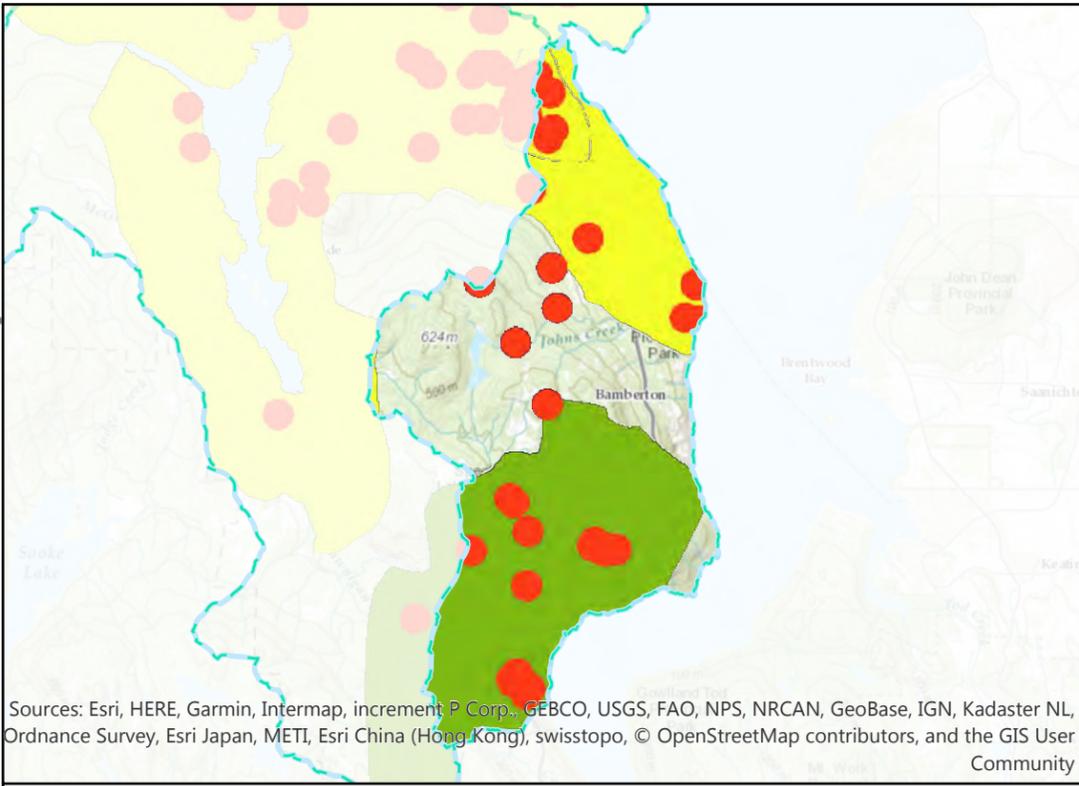


**Flood Risk Assessment - Malahat Benchlands**

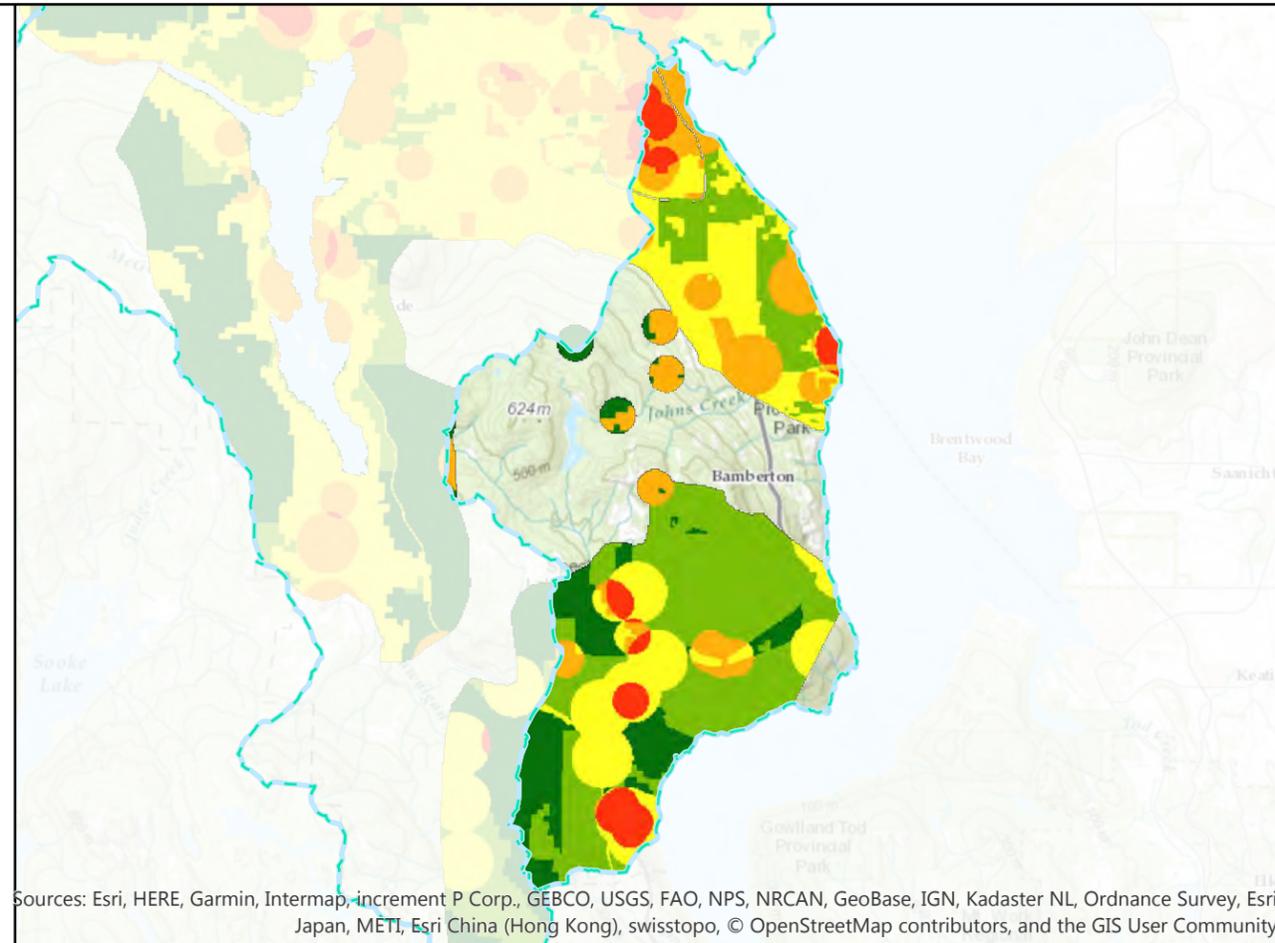


BY: CJW	SCALE CONS: 1:117,314	DATE: 2019/01/08	REF No:	REV: 0
CHKD: DK	Proj Coord Sys: NAD 1983 UTM Zone 10N		651957-102-MAL	

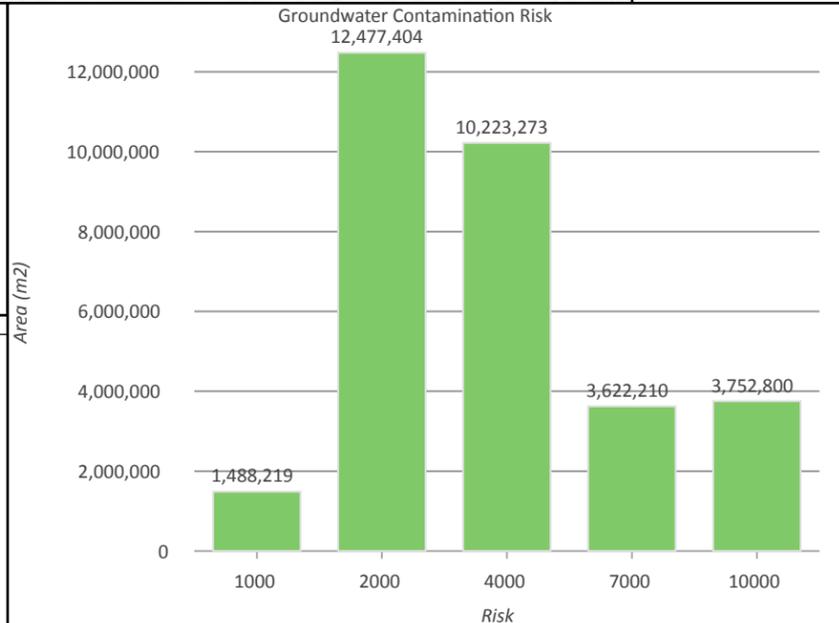
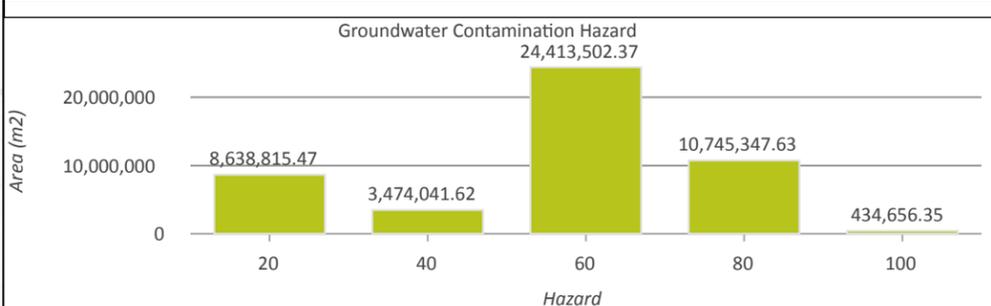
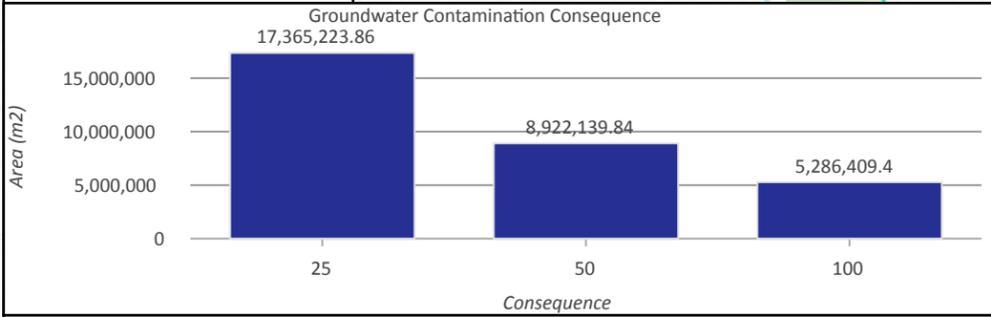
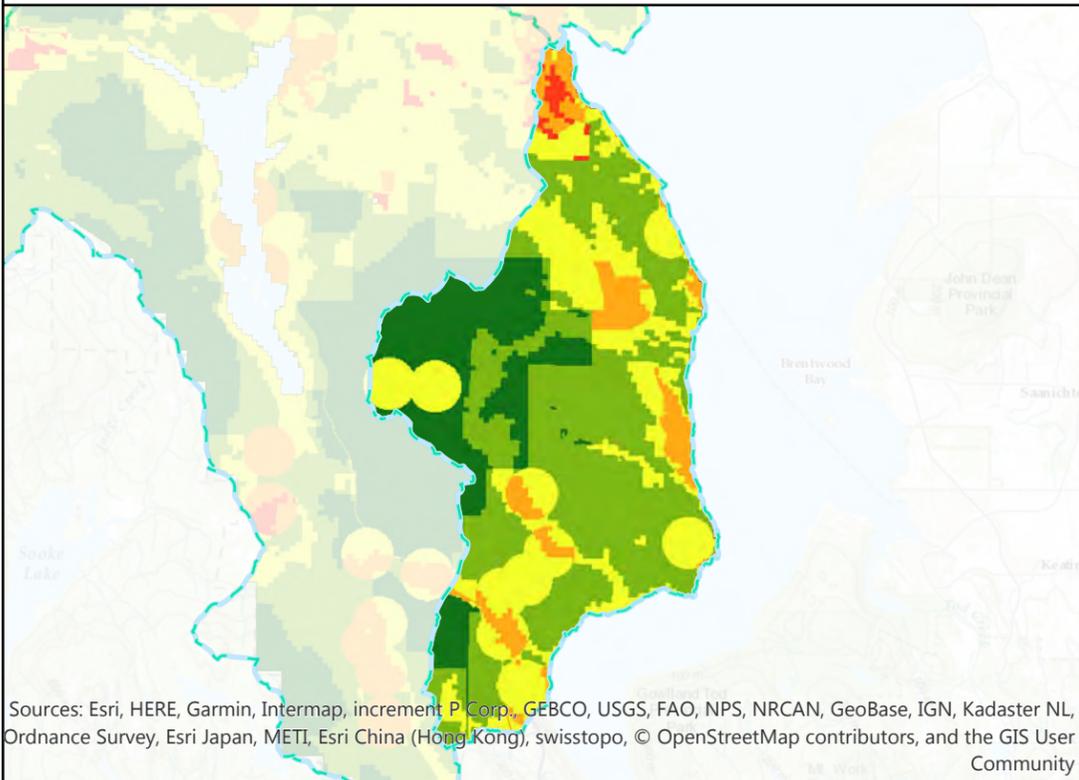
CONSEQUENCE



RISK



HAZARD



**Legend**

WATERSHED BOUNDARIES

CONSEQUENCES OR HAZARDS	RISK
≤ 20	≤ 1000
≤ 40	≤ 2000
≤ 60	≤ 4000
≤ 80	≤ 7000
≤ 100	≤ 10000

**REFERENCES:**  
 1. Risk data compiled from various data sources provided by the Cowichan Valley Regional District. Presentation of data is intended to provide a general guidance on potential issues, rather than a definitive study.

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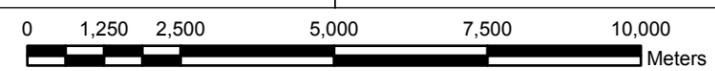
**REVISIONS:**  
 0 - CJW - 2018-11-29 - Issued - DK

CLIENT:  
 Cowichan Valley Regional District

PROJECT LOCATION:  
 Cowichan Valley Regional District  
 Malahat Benchlands Watershed

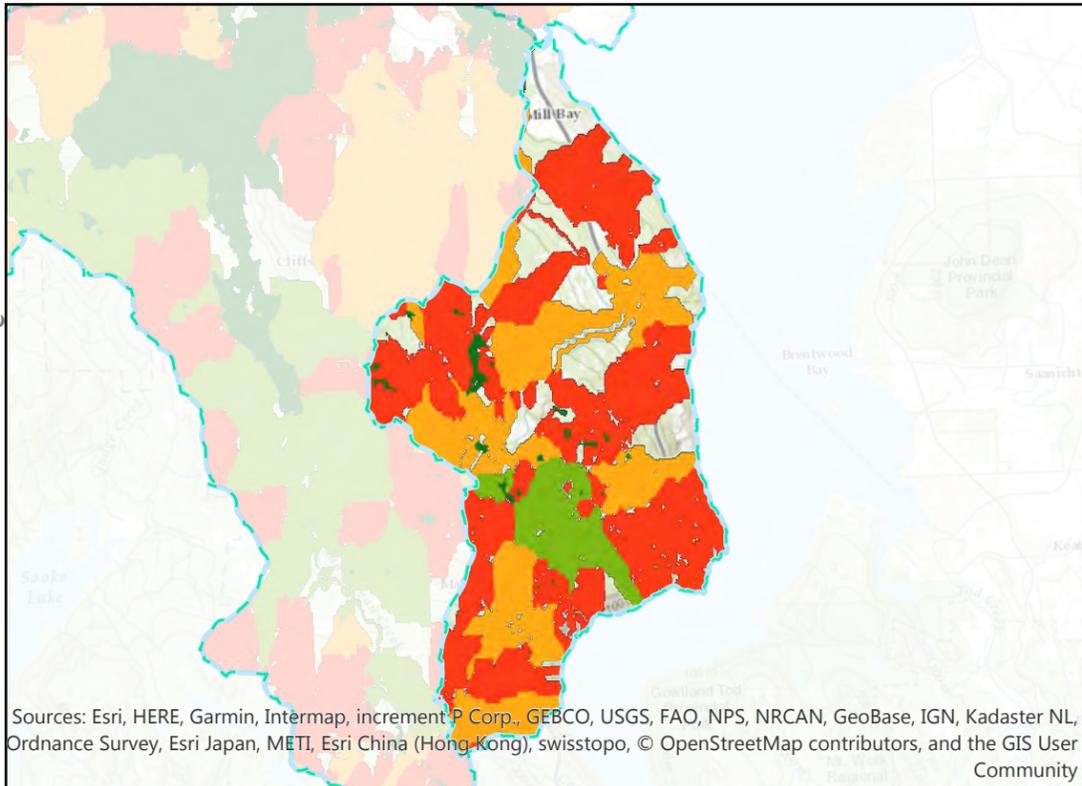


**Groundwater Contamination Risk Assessment - Malahat Benchlands**

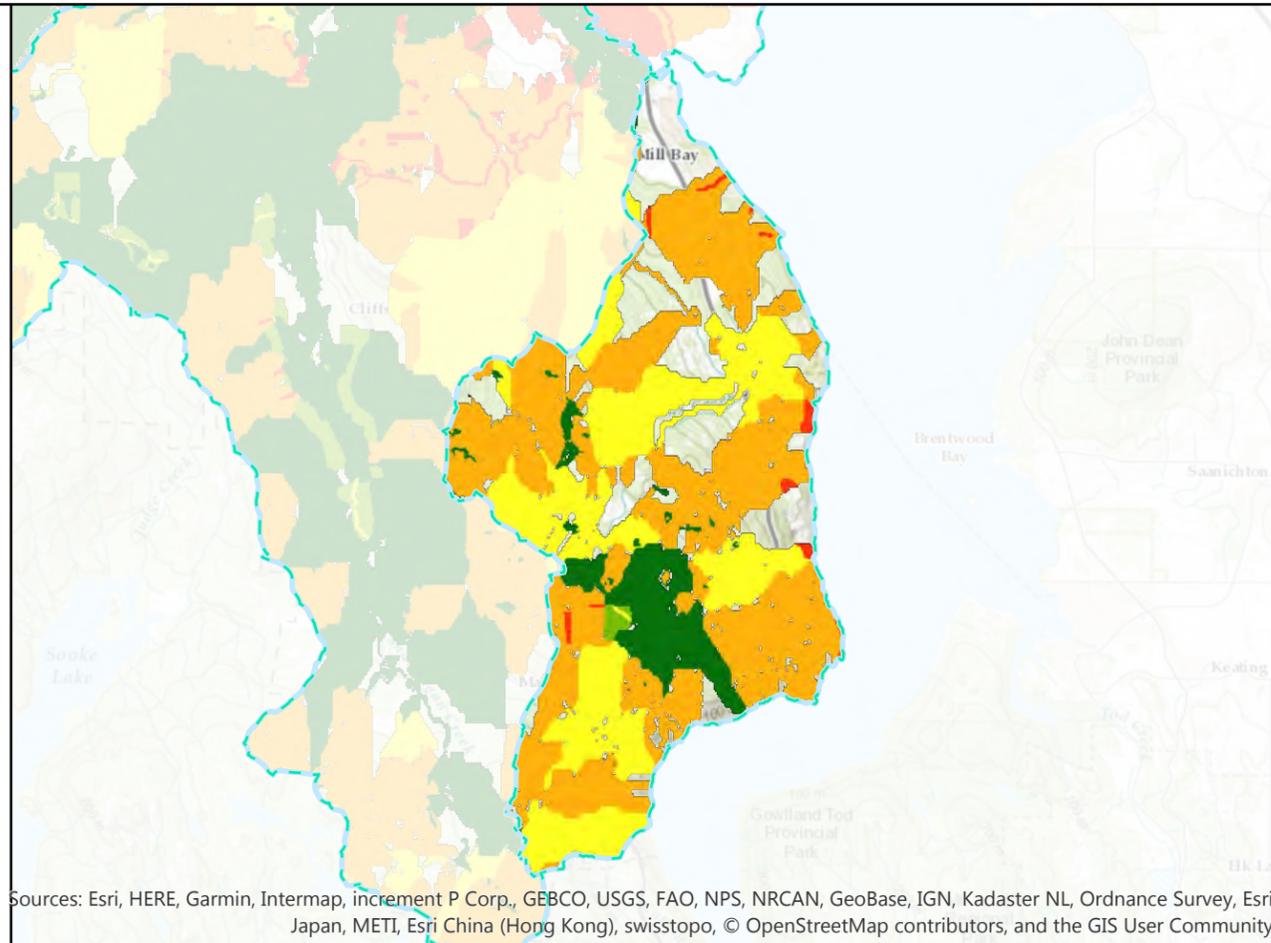


BY: CJW	SCALE CONS: 1:117,314	DATE: 2019/01/08	REF No:	REV: 0
CHKD: DK	Proj Coord Sys: NAD 1983 UTM Zone 10N		651957-103-MAL	

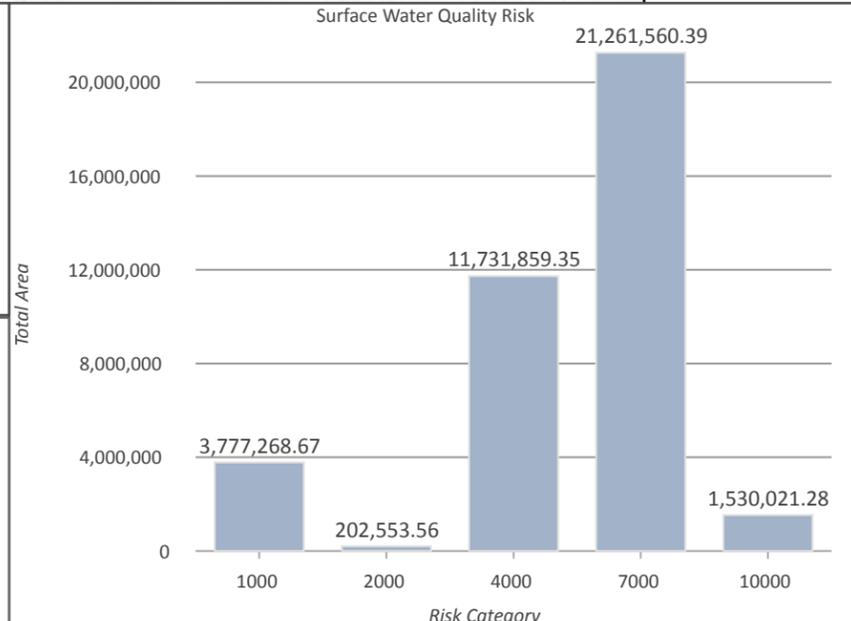
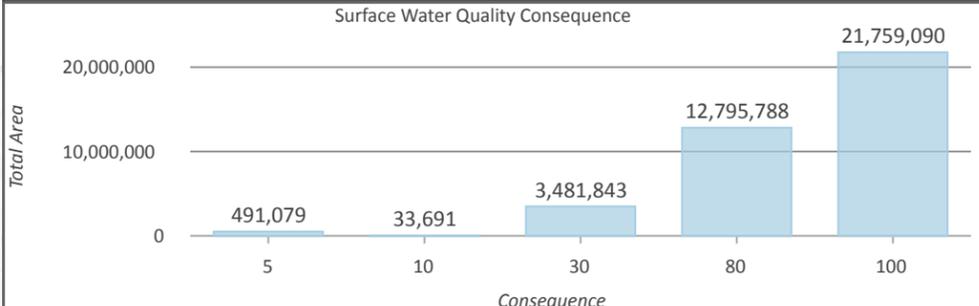
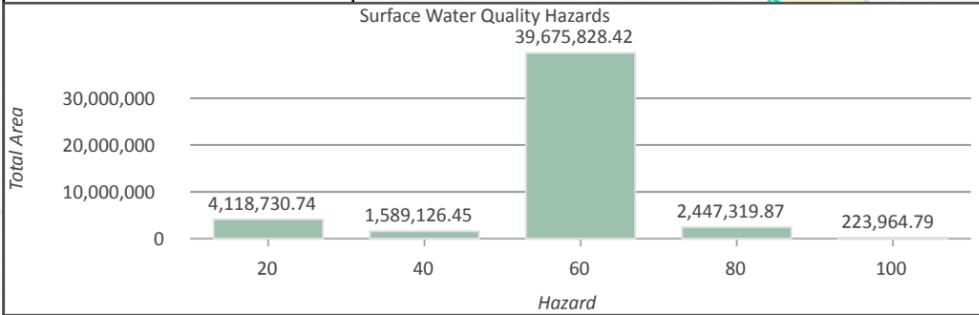
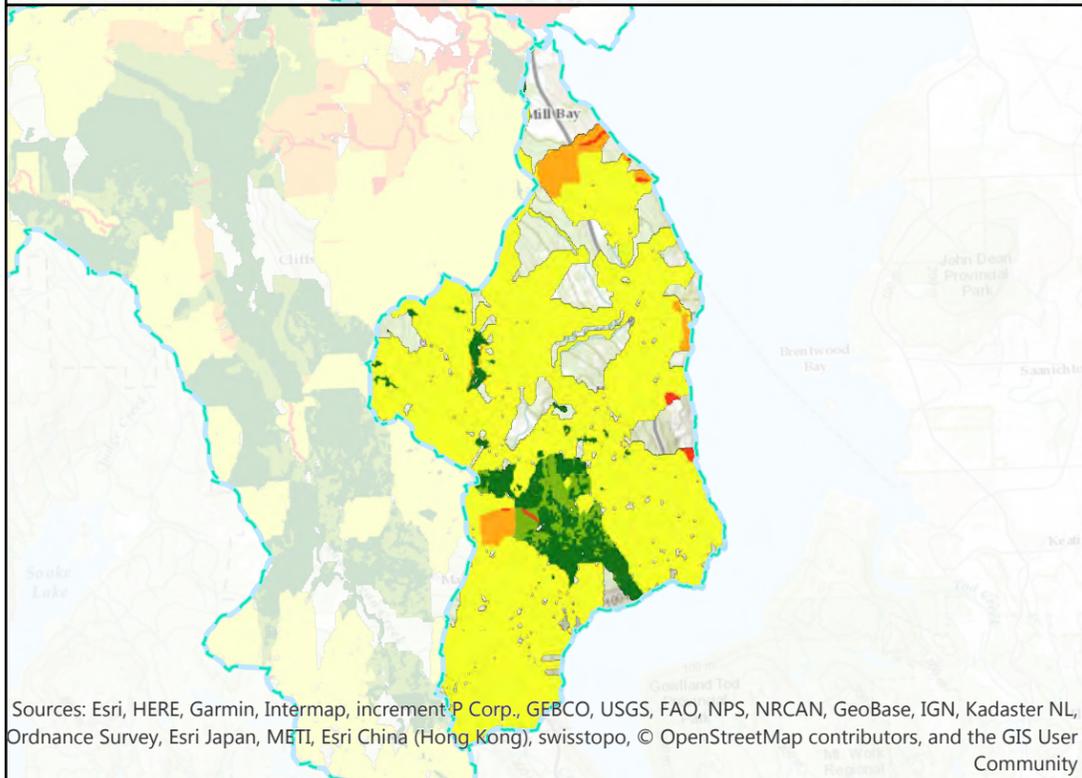
CONSEQUENCE



RISK



HAZARD



Legend

WATERSHED BOUNDARIES

CONSEQUENCES OR HAZARDS



RISK



REFERENCES:

1. Risk data compiled from various data sources provided by the Cowichan Valley Regional District. Presentation of data is intended to provide a general guidance on potential issues, rather than a definitive study.

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REVISIONS:

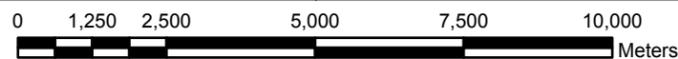
0 - CJW - 2018-11-29 - Issued - DK

CLIENT:  
Cowichan Valley Regional District

PROJECT LOCATION:  
Cowichan Valley Regional District/Malahat  
Benchlands Watershed

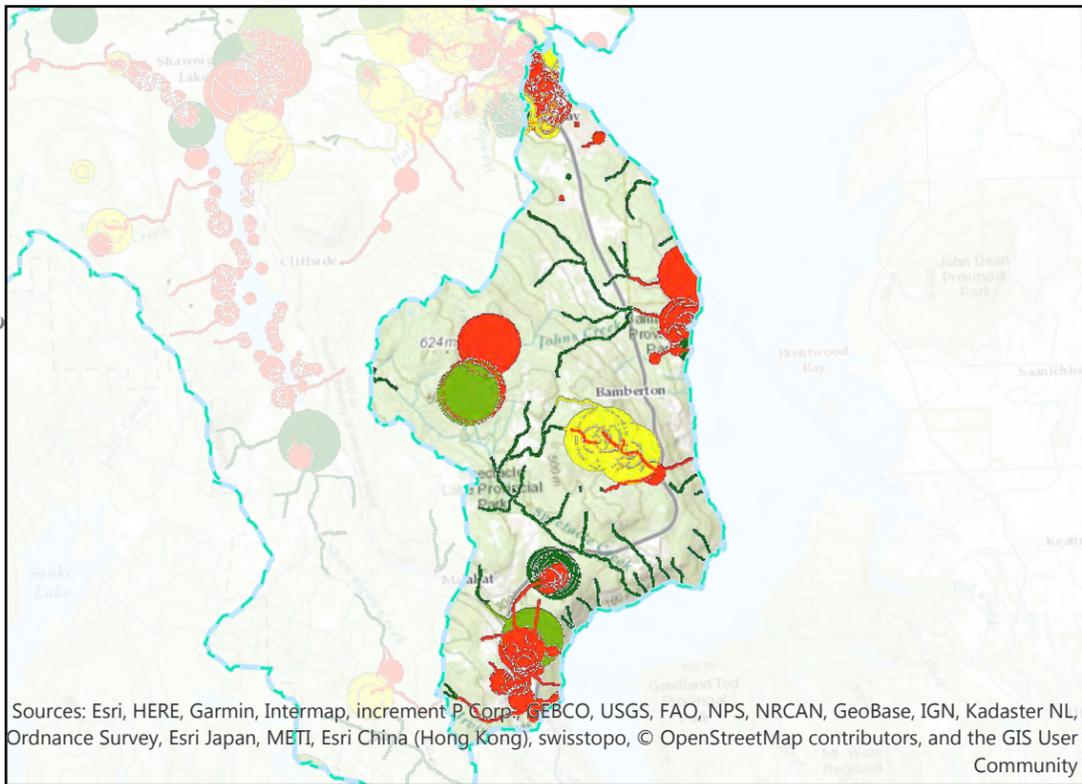


Surface Water Quality Risk Assessment - Malahat Benchlands

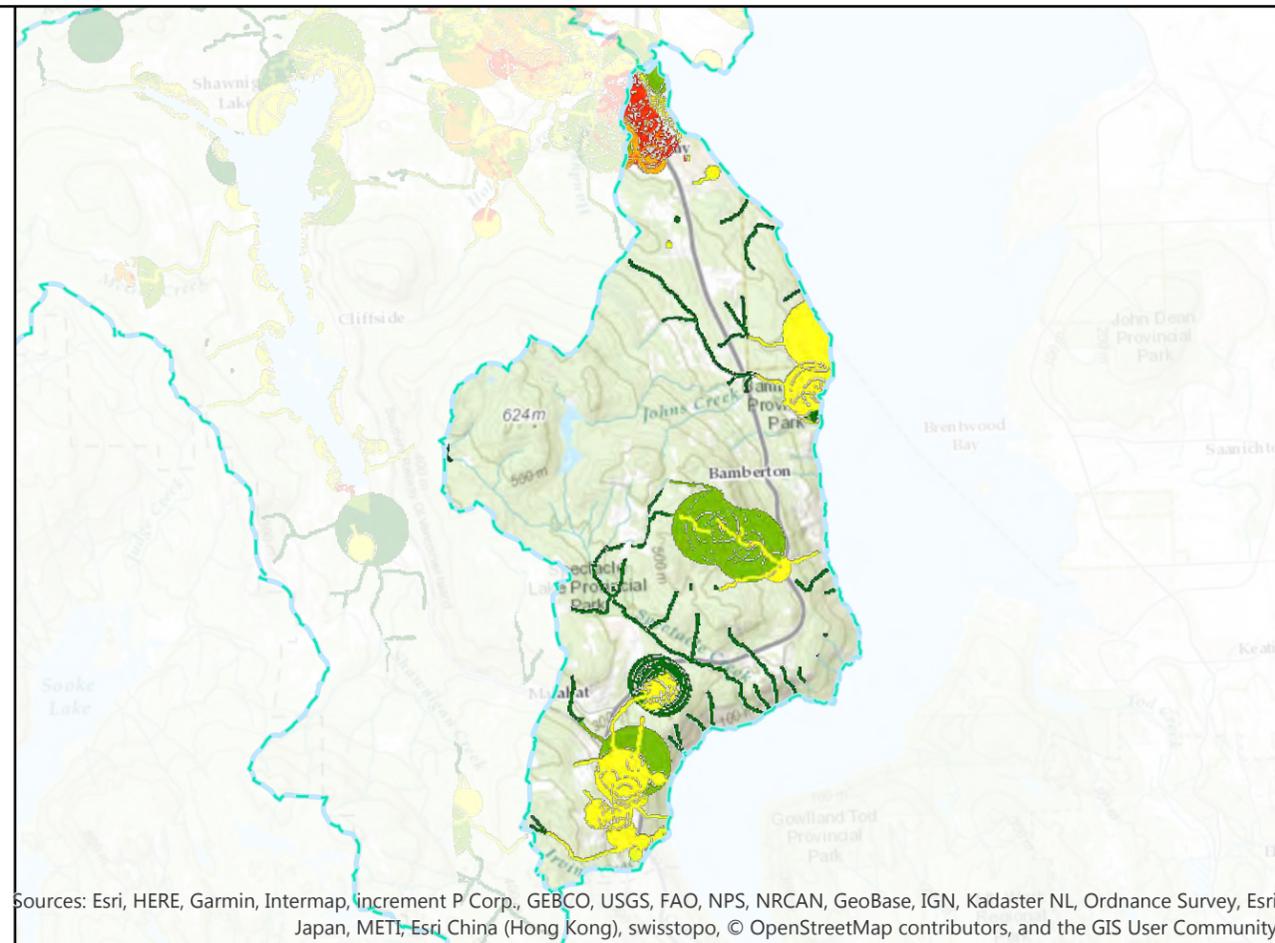


BY:	SCALE: 1:121,104	DATE: 2019/01/08	REF No:	REV: 0
CHKD:	Proj Coord Sys: PCS Albers		651957-104-MAL	

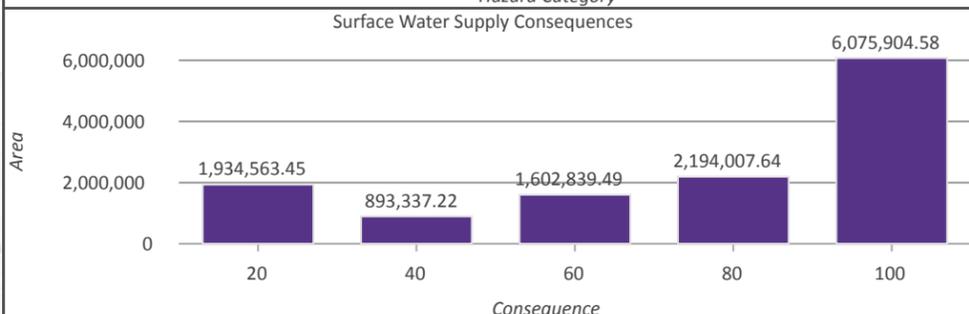
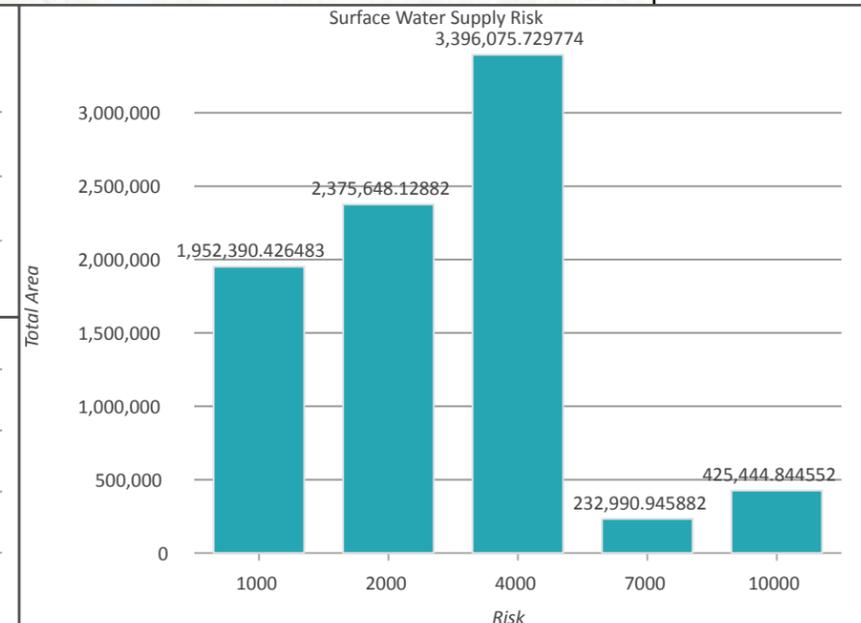
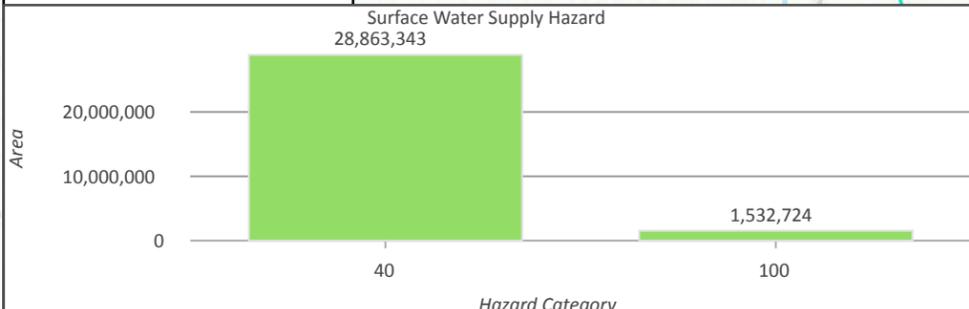
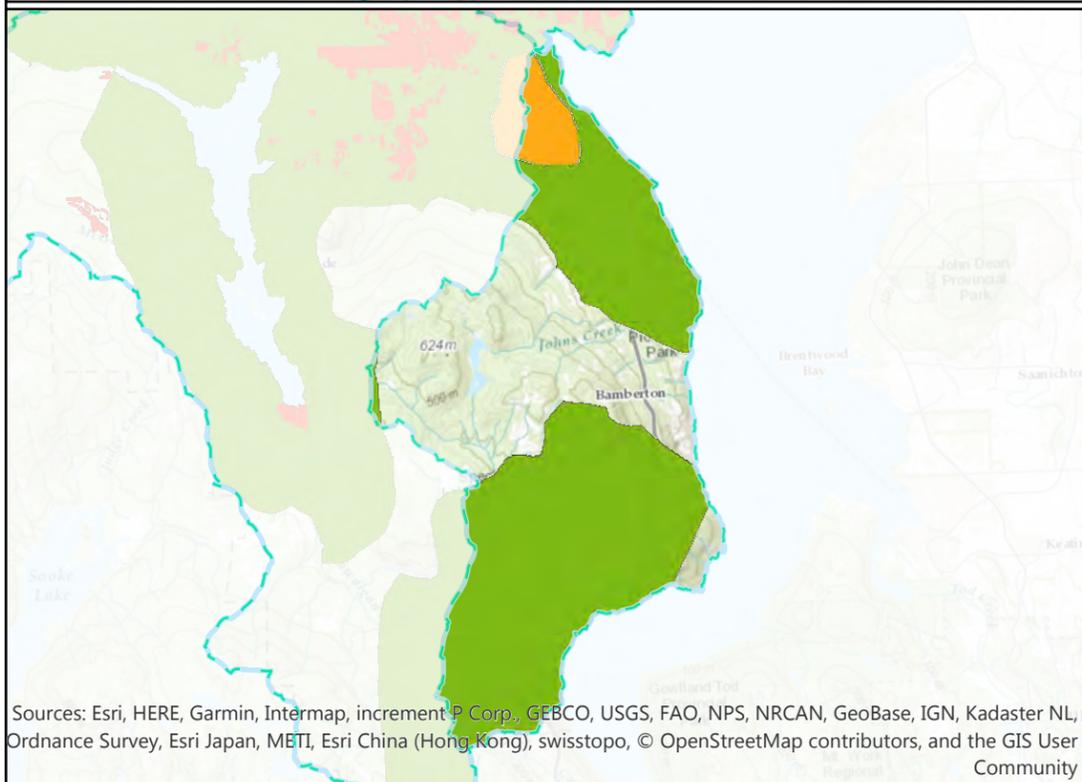
CONSEQUENCE



RISK



HAZARD



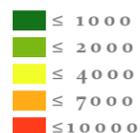
**Legend**

WATERSHED BOUNDARIES

**CONSEQUENCES OR HAZARDS**



**RISK**



**REFERENCES:**

1. Risk data compiled from various data sources provided by the Cowichan Valley Regional District. Presentation of data is intended to provide a general guidance on potential issues, rather than a definitive study.

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**REVISIONS:**

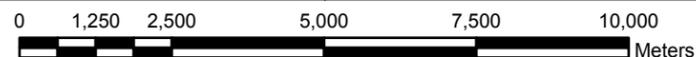
0 - CJW - 2018-11-29 - Issued - DK

CLIENT:  
Cowichan Valley Regional District

PROJECT LOCATION:  
Cowichan Valley Regional District Malahat  
Benchlands Watershed

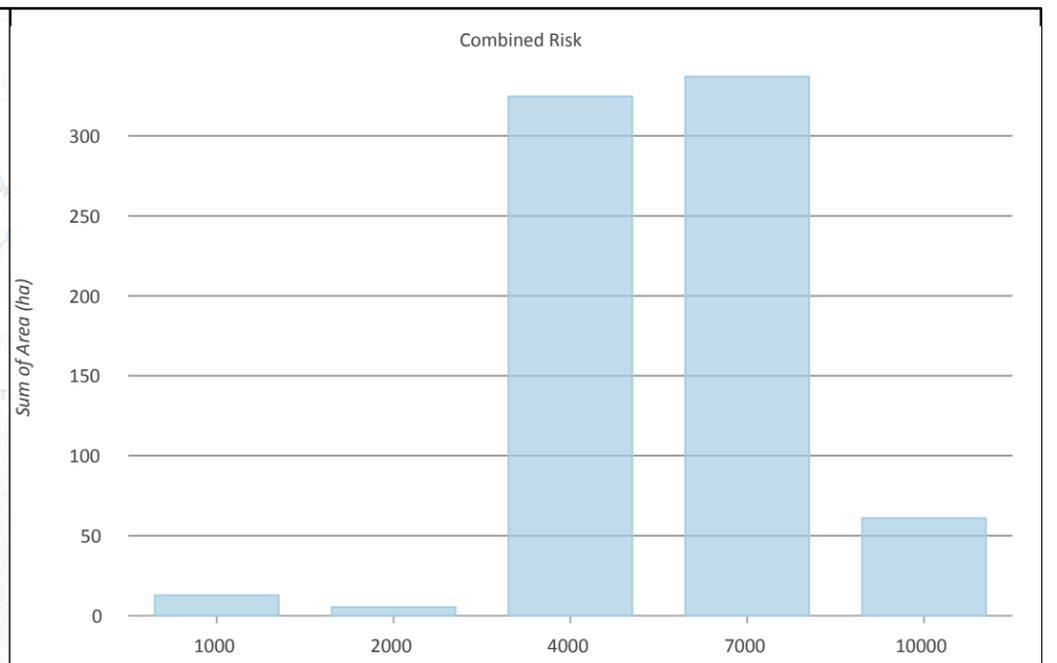
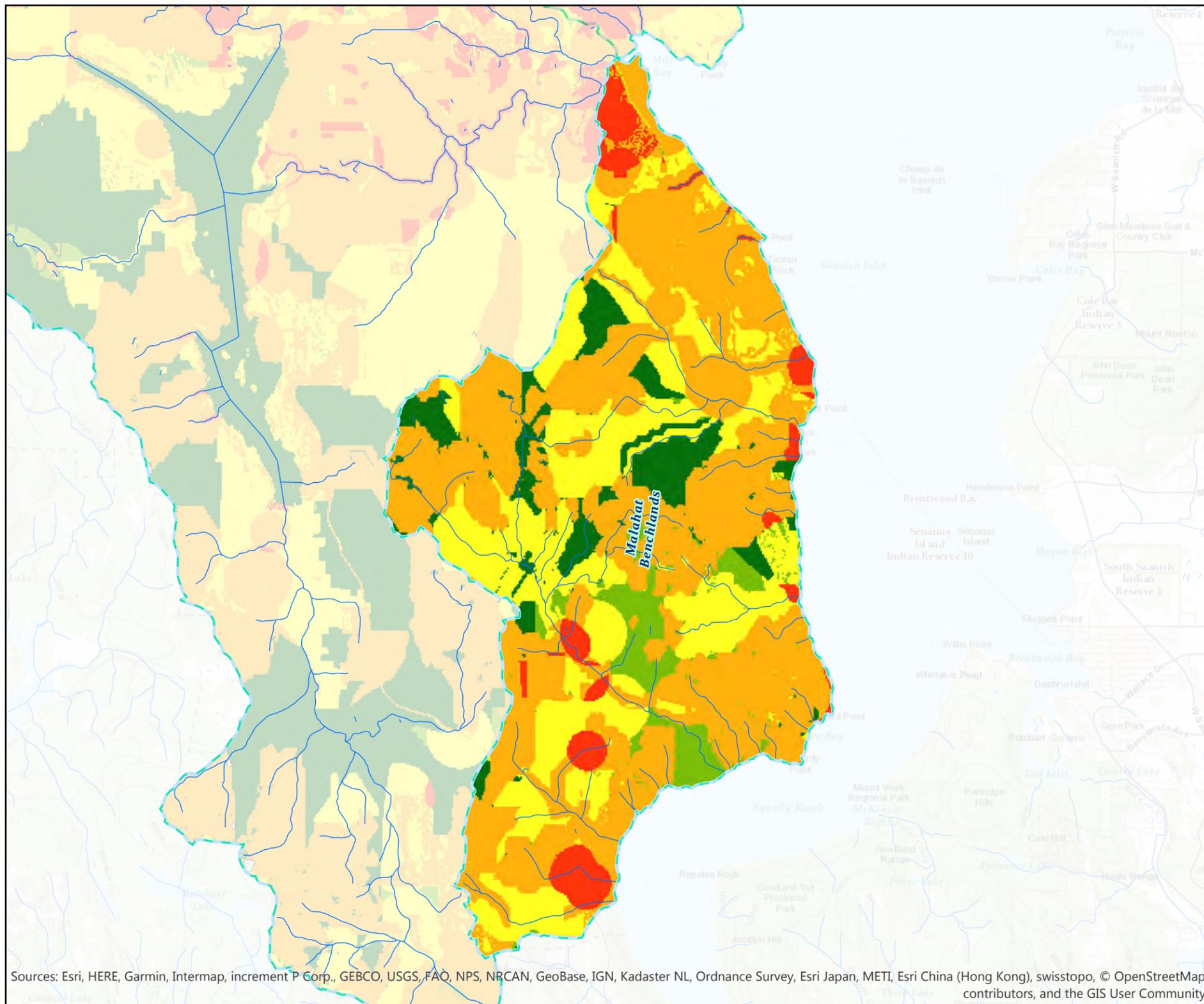


**Surface Water Supply Risk Assessment - Malahat Benchlands**



BY:	SCALE: 1:118,164	DATE: 2019/01/08	REF No:	REV: 0
CHKD:	Proj Coord Sys: PCS Albers		651957-105-MAL	

MXD Path: D:\Local\Projects\651957\_CVRD\GIS\CVRD\Presentation\CVRDPresentation.aprx



NAME	Risk	POP <sub>2021</sub>	POP <sub>2026</sub>	POP <sub>2031</sub>	POP <sub>2036</sub>
SHAWNIGAN CREEK		10047	10760	11613	12598
BUSH CREEK		0	0	0	0
KOKSILAH RIVER		5463	5851	6315	6850
HOLLAND CREEK		1302	1368	1446	1537
BONSALL CREEK		934	974	1019	1073
CHEMAINUS RIVER		1490	1461	1439	1421
COWICHAN RIVER		36368	37905	39683	41766
YELLOW POINT BENCHLANDS		2239	2352	2487	2643
LADYSMITH - SALT AIR BENCHLANDS		8410	8834	9342	9929
STOCKING CREEK		1531	1608	1701	1807
CHEMAINUS BENCHLANDS		3663	3818	3997	4207
SATELLITE CHANNEL BENCHLANDS		4390	4701	5074	5504
SANSUM NARROWS - COWICHAN BAY BENCHLANDS		4941	5150	5391	5674
MALAHAT BENCHLANDS		2829	3030	3271	3548

NAME	POP <sub>2001</sub>	POP <sub>2006</sub>	POP <sub>2011</sub>	POP <sub>2016</sub>
SHAWNIGAN CREEK	6348	8439	8925	9484
BUSH CREEK	0	0	0	0
KOKSILAH RIVER	4555	4808	4954	5157
HOLLAND CREEK	1611	1114	1169	1245
BONSALL CREEK	672	830	815	890
CHEMAINUS RIVER	1423	1395	1497	1514
COWICHAN RIVER	29779	32673	34075	34647
YELLOW POINT BENCHLANDS	1167	1958	2021	2141
LADYSMITH - SALT AIR BENCHLANDS	5275	7488	7541	8042
STOCKING CREEK	1332	1003	1354	1464
CHEMAINUS BENCHLANDS	3177	3129	3085	3490
SATELLITE CHANNEL BENCHLANDS	5425	3902	3989	4144
SANSUM NARROWS - COWICHAN BAY BENCHLANDS	5993	4221	4500	4707
MALAHAT BENCHLANDS	1673	2472	2548	2671

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

**Legend**

WATERSHED BOUNDARIES

**RISK**

- ≤ 1000
- ≤ 2000
- ≤ 4000
- ≤ 7000
- ≤ 10000

**REFERENCES:**

- Risk data compiled from various data sources provided by the Cowichan Valley Regional District. Presentation of data is intended to provide a general guidance on potential issues, rather than a definitive study.

**NOTES:**

- Original in colour.
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**REVISIONS:**

0 - CJW - 2018-11-30 - Issued - DK

CLIENT:  
Cowichan Valley Regional District

PROJECT LOCATION:  
Cowichan Valley Regional District  
Malahat Benchlands Watershed

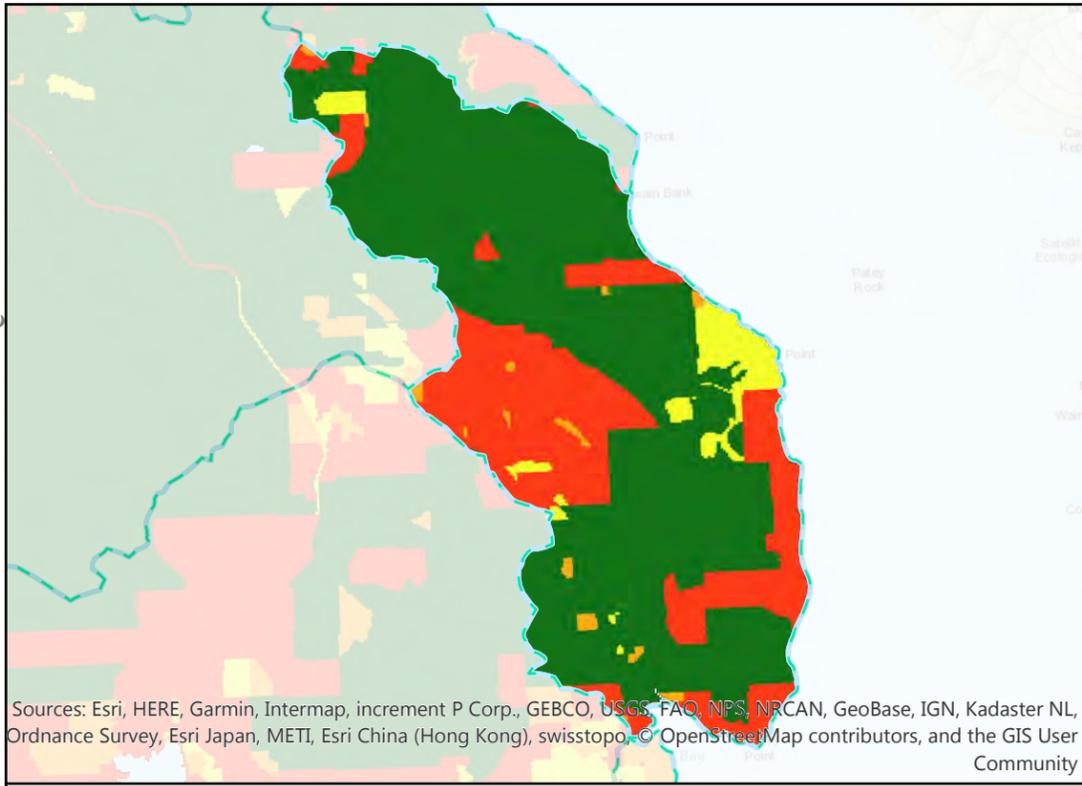
**Combined Risk Assessment - Malahat Benchlands**

BY: CJW    SCALE CONS: 1:69,000    DATE: 2019/01/08    REF No:    REV: 0

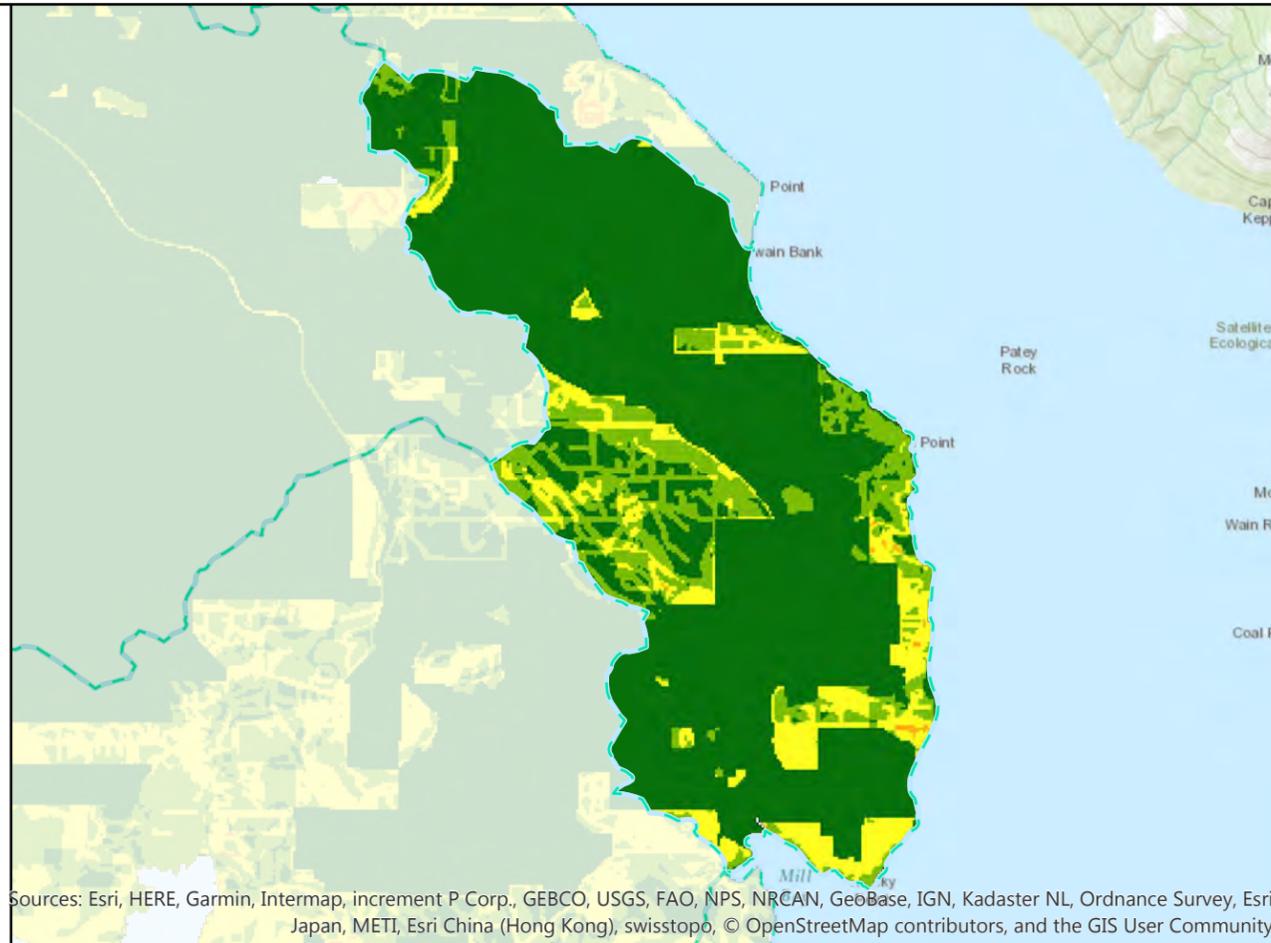
CHKD: DK    Proj Coord Sys: NAD 1983 UTM Zone 10N    **651957-106-MAL**

<b>11. Satellite Channel Benchlands</b>	
<b>Topic</b>	<b>Discussion</b>
Slope Failure	<p>Hazard was determined qualitatively at a high level to describe areas based on the degree to which they may be prone to landslides and other mass movements using terrain characteristics. Hazard classifications were generated to show relative comparisons between terrain units within the CVRD watershed study area. Risk ratings derived from this analysis are relative, and should be used to guide prioritization of further detailed studies.</p> <p>Hazard is generally low throughout the Satellite Channel Benchlands watershed due to the gentle slopes. Consequence is considered moderate to high through the populated areas which are scattered around the watershed. Risk is generally considered low throughout the watershed.</p>
Flooding	<p>Hazard is limited to the creeks and small water bodies within the watershed. Generally, consequence and risk are relatively greater in the residential areas along the west and east ends of the central portion of the watershed, separated by agricultural areas where consequence and risk are relatively lower.</p>
Groundwater Contamination	<p>Hazard is relatively low throughout the watershed. Consequence is focused at municipal water supply wells throughout the watershed, which reflect the locations of relatively higher risk.</p>
Surface Water Quality	<p>Areas of high hazard, consequence, and risk are similar in location and extent. Almost no area in the watershed is considered low or lower in terms of level of hazard, consequence, and risk. Higher hazard, consequence, and risk comprise roughly half of the watershed's total area based on impervious surface cover, land development, land use type, stream order, and the relative locations of each of these factors. The watershed mainly consists of residential and agricultural areas that place overall greater stress on surface water quality. Residential and agricultural areas in the central and south-western portions of the watershed are the largest higher risk zones. Projected population growth in the watershed is likely to place greater stress on stream health due to the prevalence of lower order streams and present dominance of high risk zones.</p>
Surface Water Supply	<p>Hazard is mixed across the watershed and associated with high vulnerability index and the presence of contaminated sites. Consequence is greater where municipal wells are located. Risk is mixed across the watershed with zones of greater risk along several stream segments across the watershed, and a zone near Hatch Point. Projections indicate an increasing population and therefore additional pressures from residential use is expected on groundwater sources.</p>
General Data Notes	<p>The combined risk for the Satellite Channel Benchlands is relatively high. Flood and slope failure risk is a low contributor, while groundwater contamination, surface water supply, and surface water quality are major contributors to overall risk.</p>

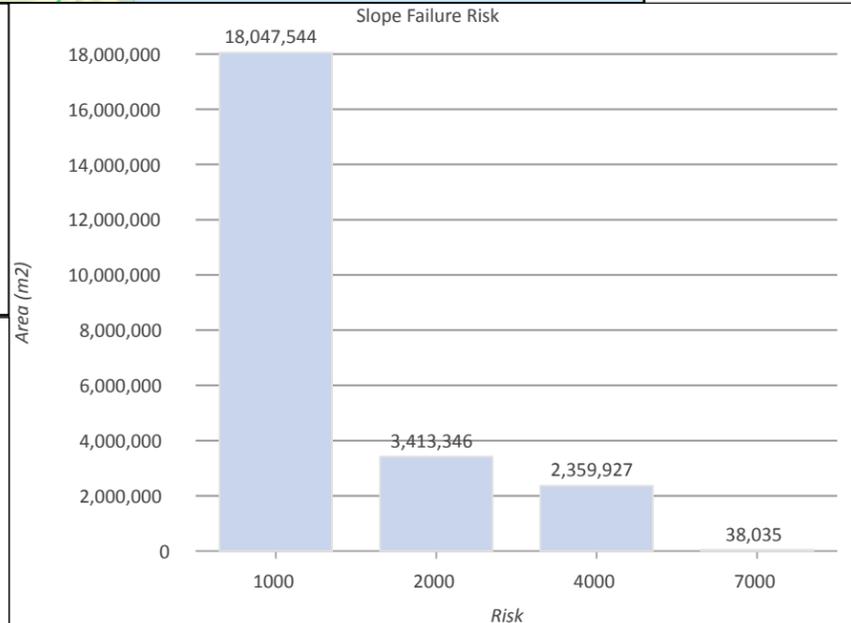
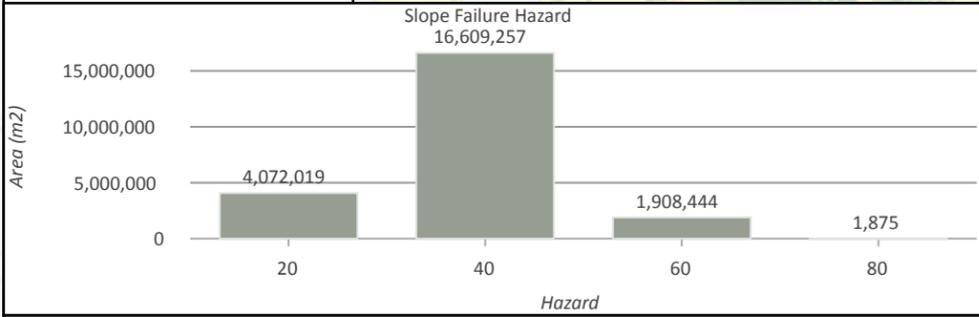
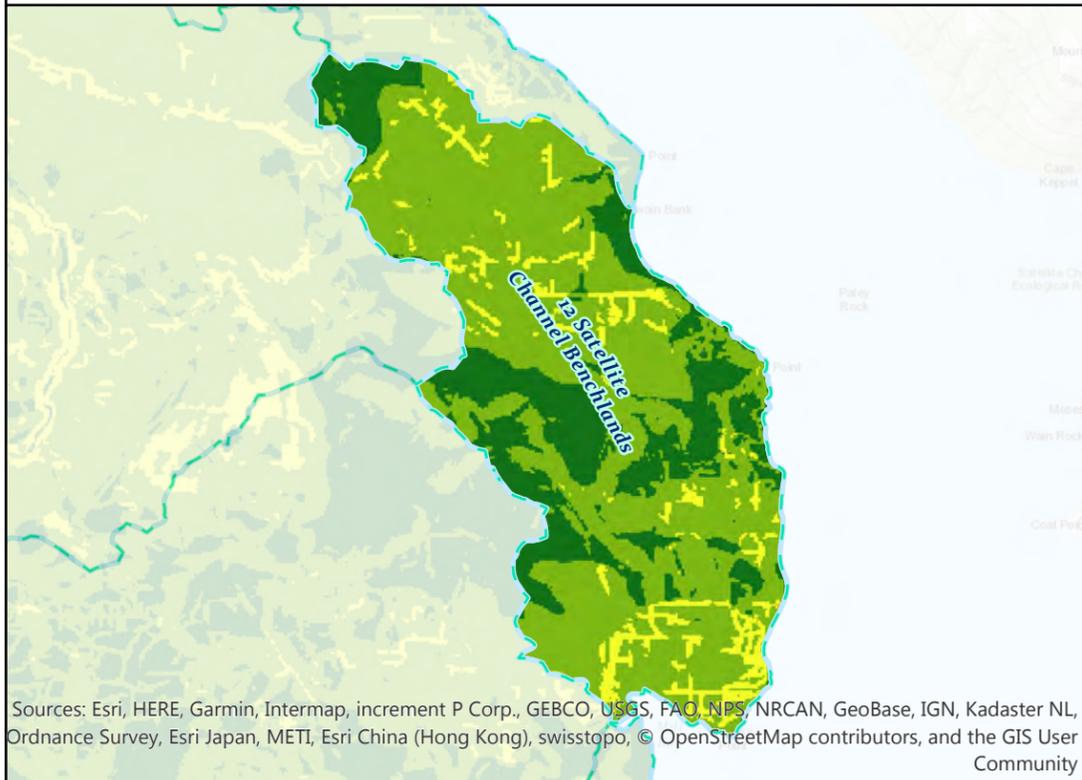
CONSEQUENCE



RISK



HAZARD



**Legend**

WATERSHED BOUNDARIES

**CONSEQUENCES OR HAZARDS**

- ≤ 20
- ≤ 40
- ≤ 60
- ≤ 80
- ≤ 100

**RISK**

- ≤ 1000
- ≤ 2000
- ≤ 4000
- ≤ 7000
- ≤ 10000

**REFERENCES:**

1. Risk data compiled from various data sources provided by the Cowichan Valley Regional District. Presentation of data is intended to provide a general guidance on potential issues, rather than a definitive study.

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**REVISIONS:**

0 - CJW - 2018-11-29 - Issued - DK

CLIENT:  
Cowichan Valley Regional District

PROJECT LOCATION:  
Cowichan Valley Regional District  
Satellite Channel Benchlands Watershed



**Slope Failure Risk Assessment - Satellite Channel**

BY: CJW

SCALE CONS: 1:70,075

DATE: 2019/01/07

REF No:

REV: 0

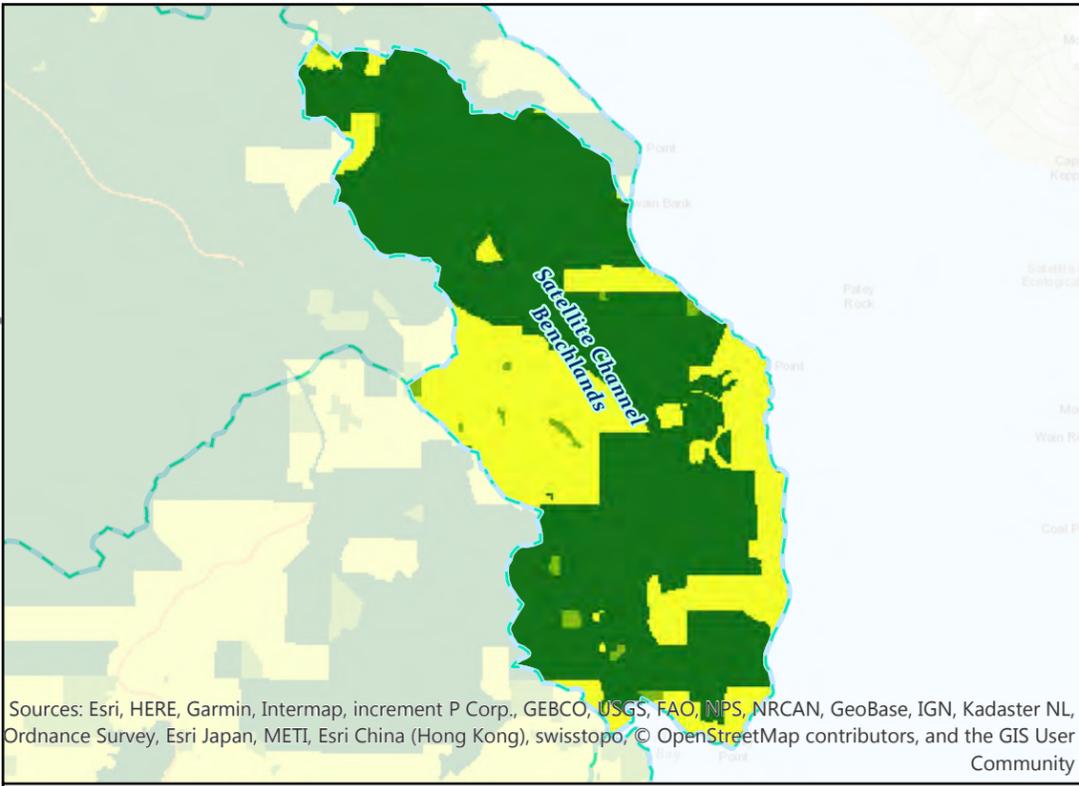
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Proj Coord Sys: PCS Albers

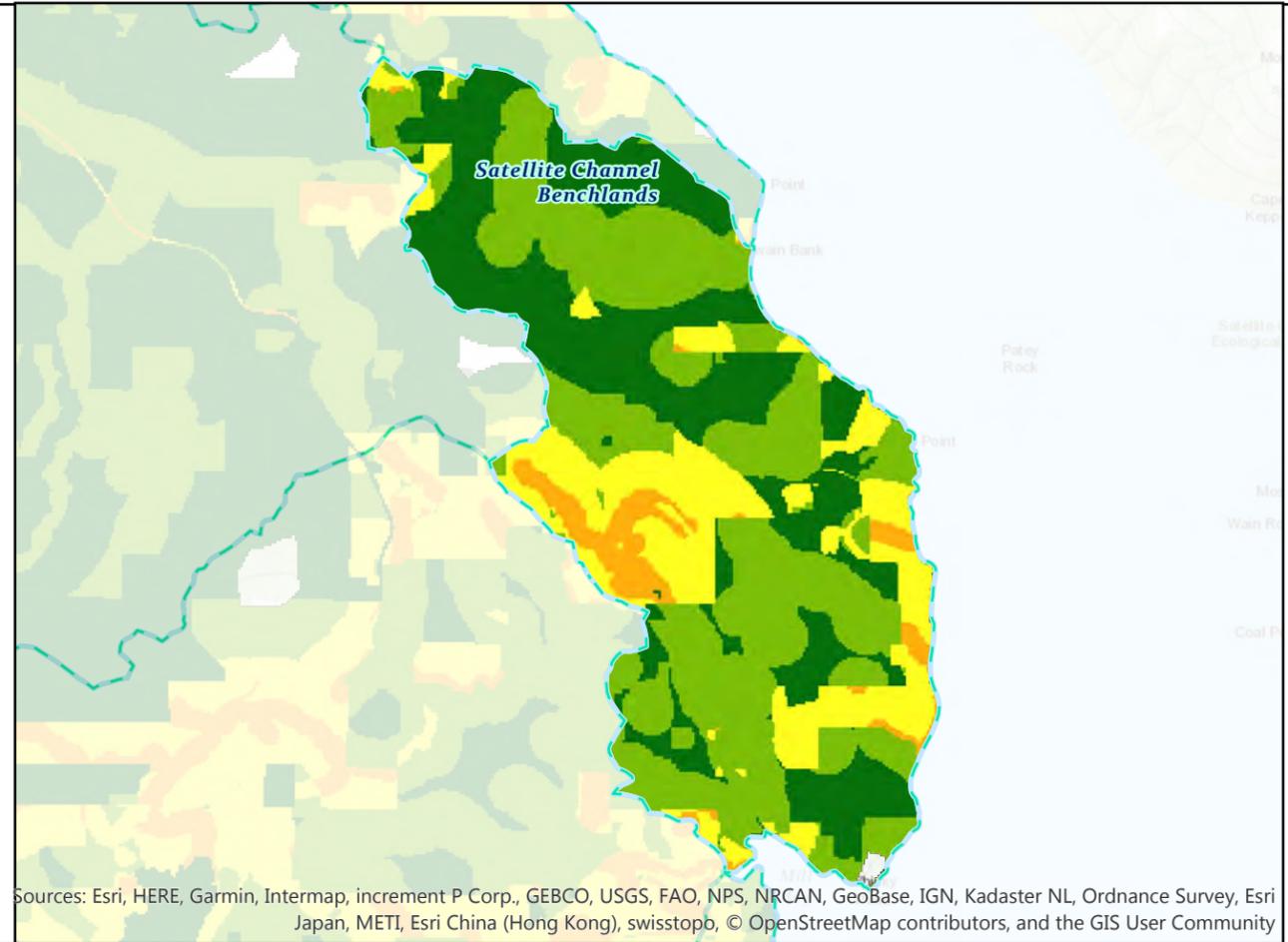
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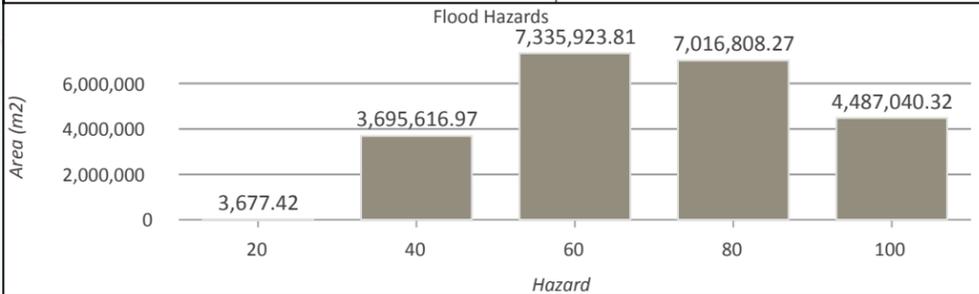
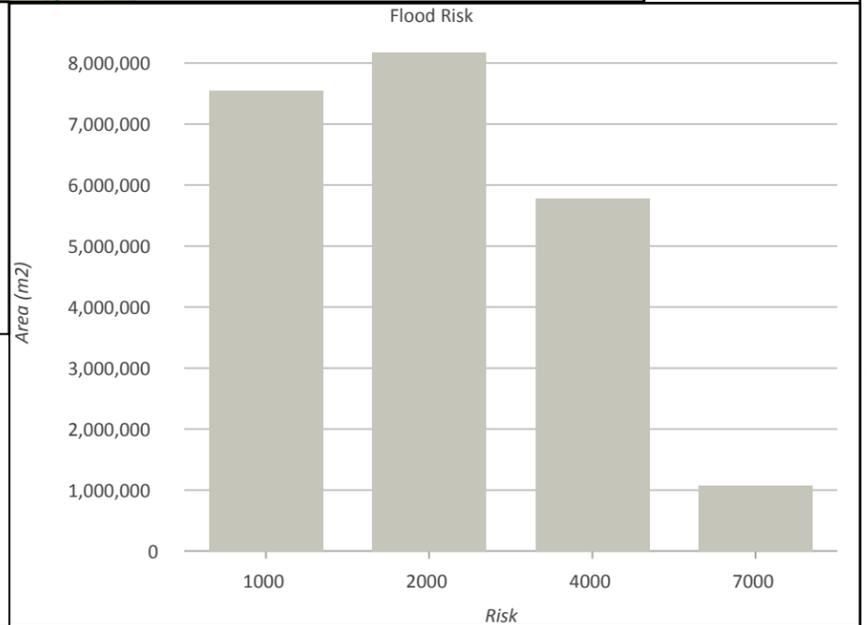
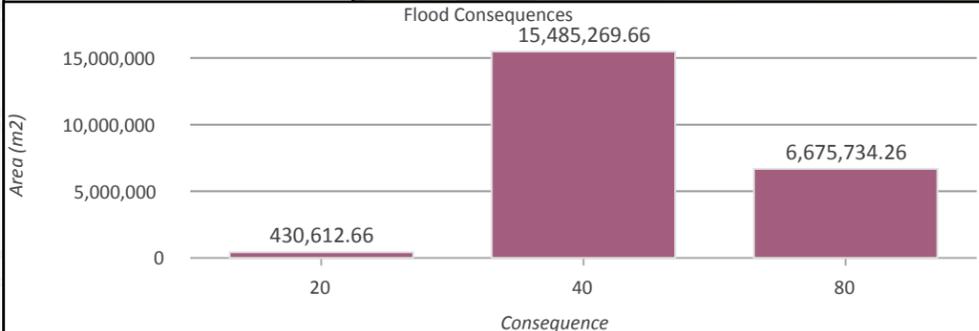
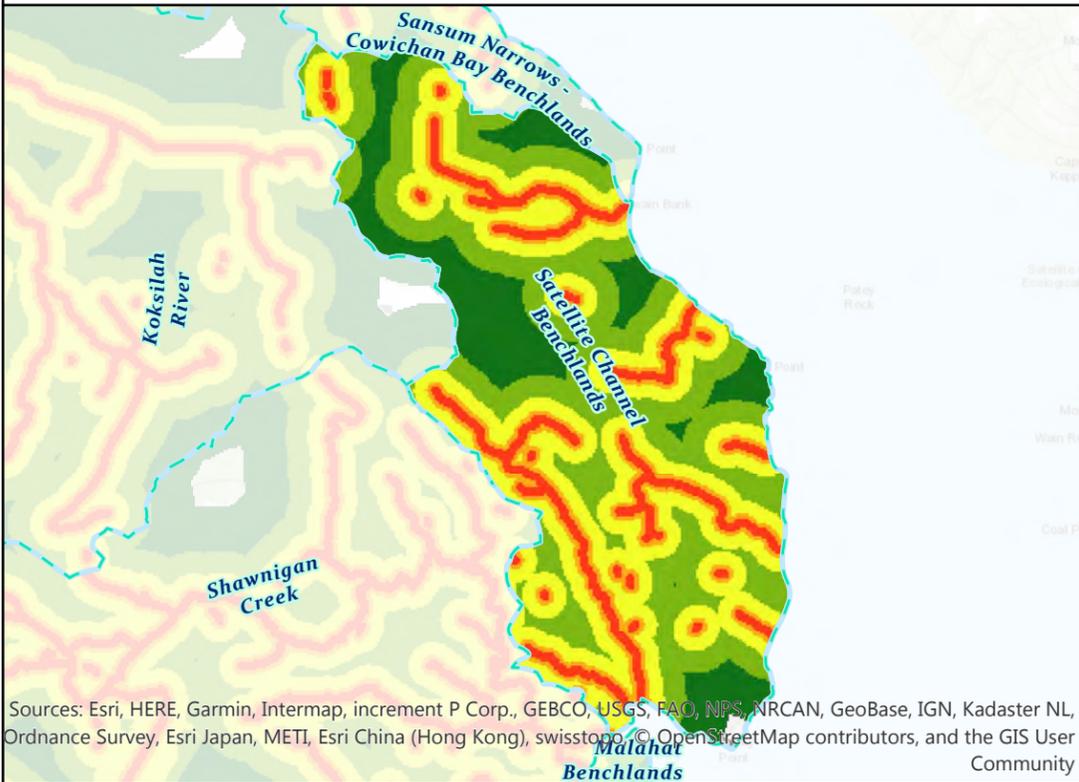
CONSEQUENCE



RISK



HAZARD



**Legend**

WATERSHED BOUNDARIES

**CONSEQUENCES OR HAZARDS**

- ≤ 20
- ≤ 40
- ≤ 60
- ≤ 80
- ≤ 100

**RISK**

- ≤ 1000
- ≤ 2000
- ≤ 4000
- ≤ 7000
- ≤ 10000

**REFERENCES:**

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**NOTES:**

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**REVISIONS:**

0 - CJW - 2018-11-29 - Issued - DK

CLIENT:  
Cowichan Valley Regional District

PROJECT LOCATION:  
Cowichan Valley Regional District  
Satellite Channel Benchlands Watershed

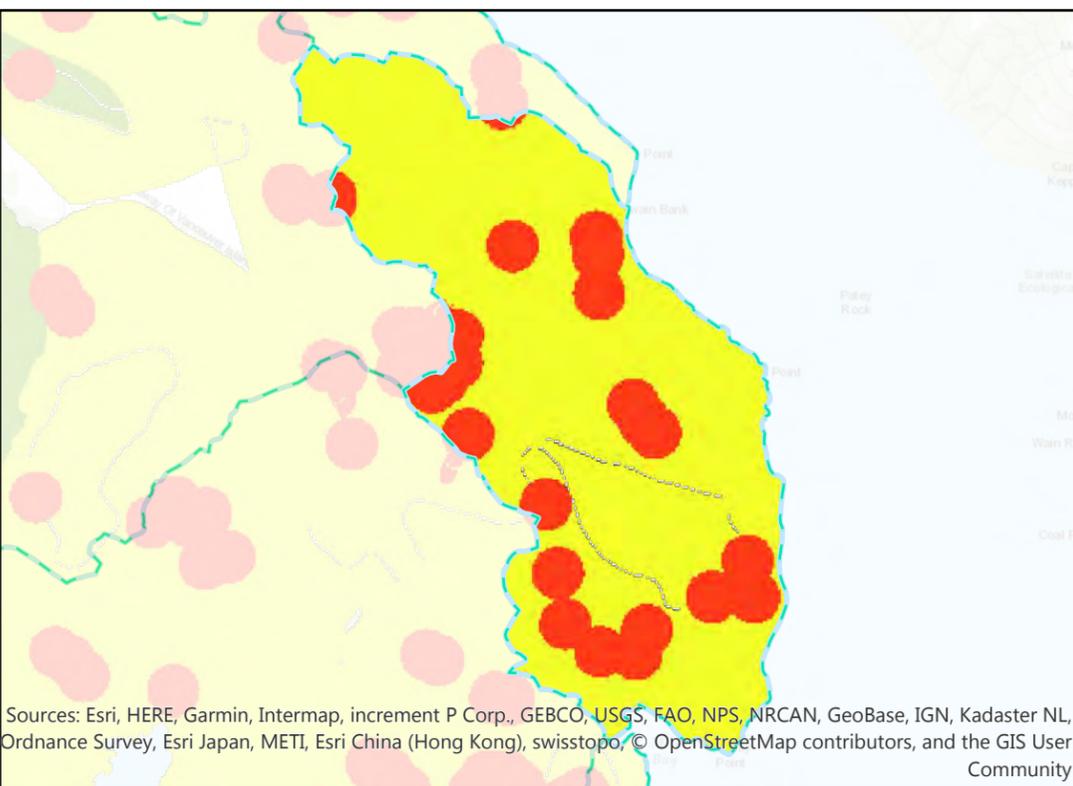


**Flood Risk Assessment - Satellite Channel Benchlands**



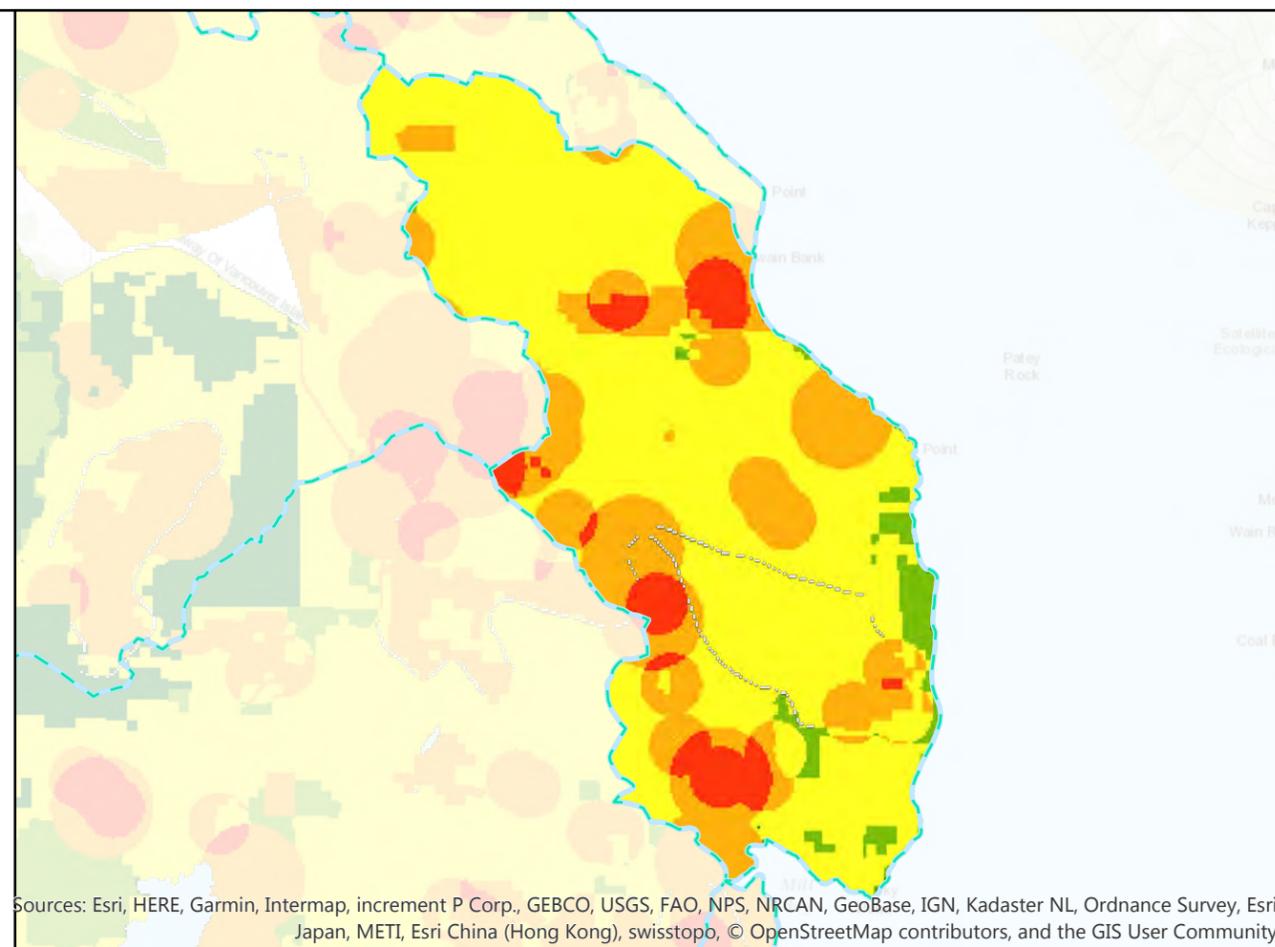
BY: CJW	SCALE CONS: 1:69,708	DATE: 2019/01/08	REF No:	REV: 0
CHKD: DK	Proj Coord Sys: NAD 1983 UTM Zone 10N		651957-102-SATC	

CONSEQUENCE



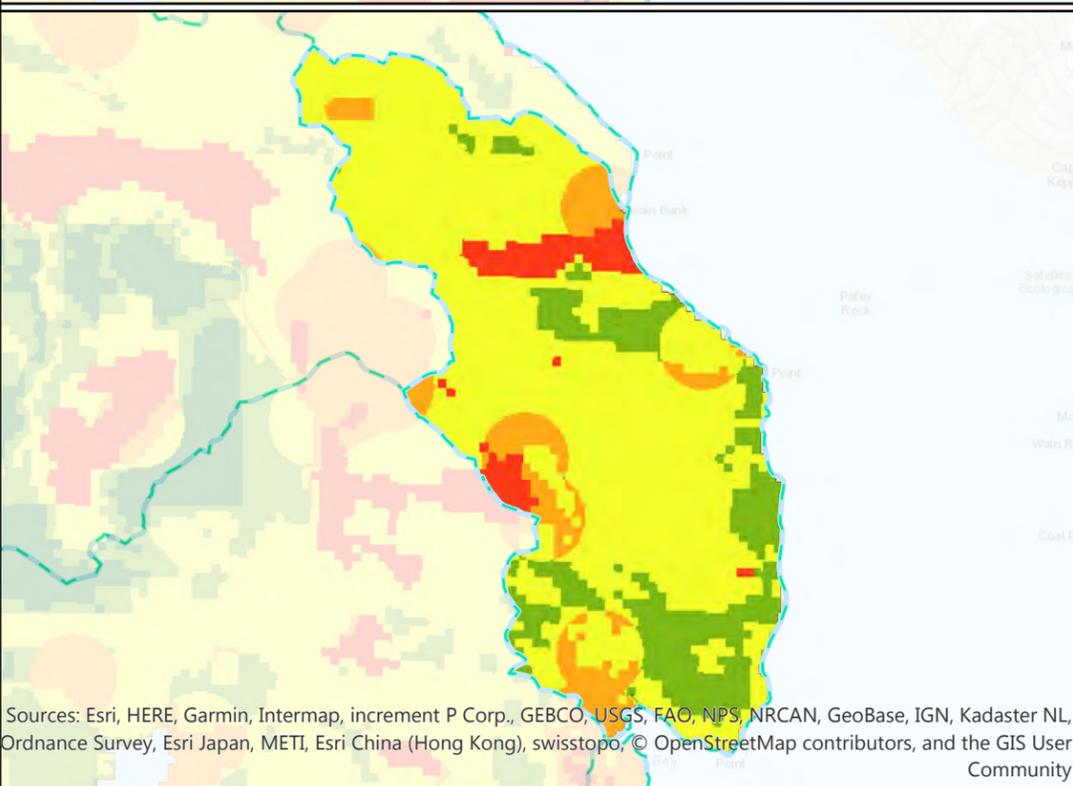
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RISK

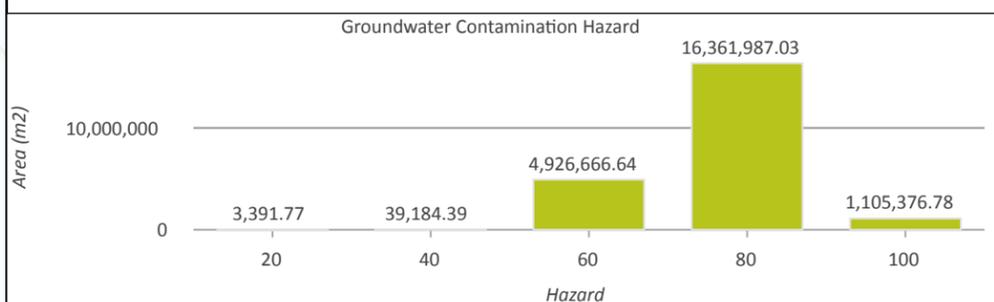
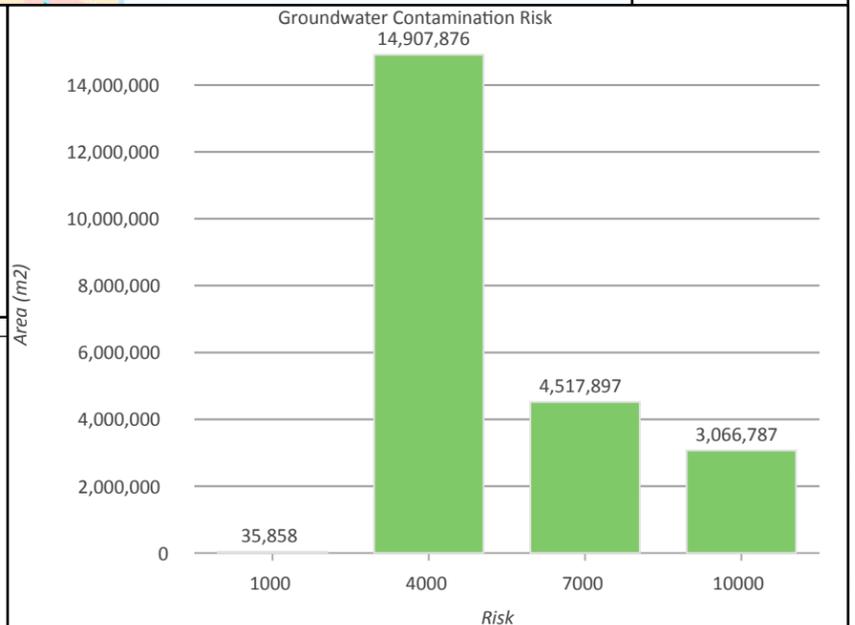
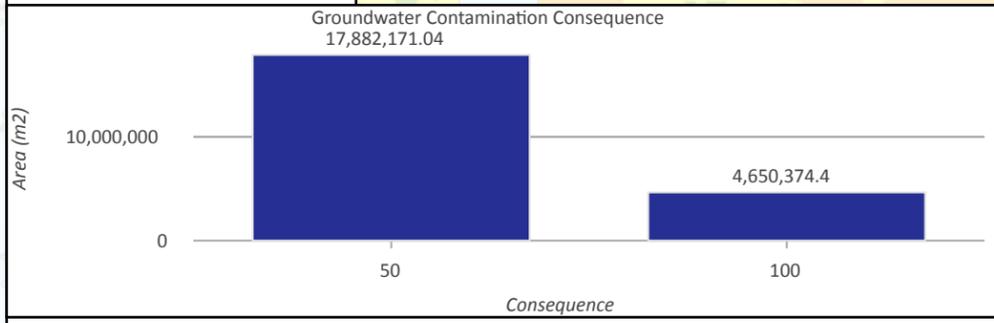


Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

HAZARD



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community



**Legend**

WATERSHED BOUNDARIES

CONSEQUENCES OR HAZARDS	RISK
≤ 20	≤ 1000
≤ 40	≤ 2000
≤ 60	≤ 4000
≤ 80	≤ 7000
≤ 100	≤ 10000

**REFERENCES:**  
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**REVISIONS:**  
0 - CJW - 2018-11-29 - Issued - DK

CLIENT:  
Cowichan Valley Regional District

PROJECT LOCATION:  
Cowichan Valley Regional District  
Satellite Channel Benchlands Watershed

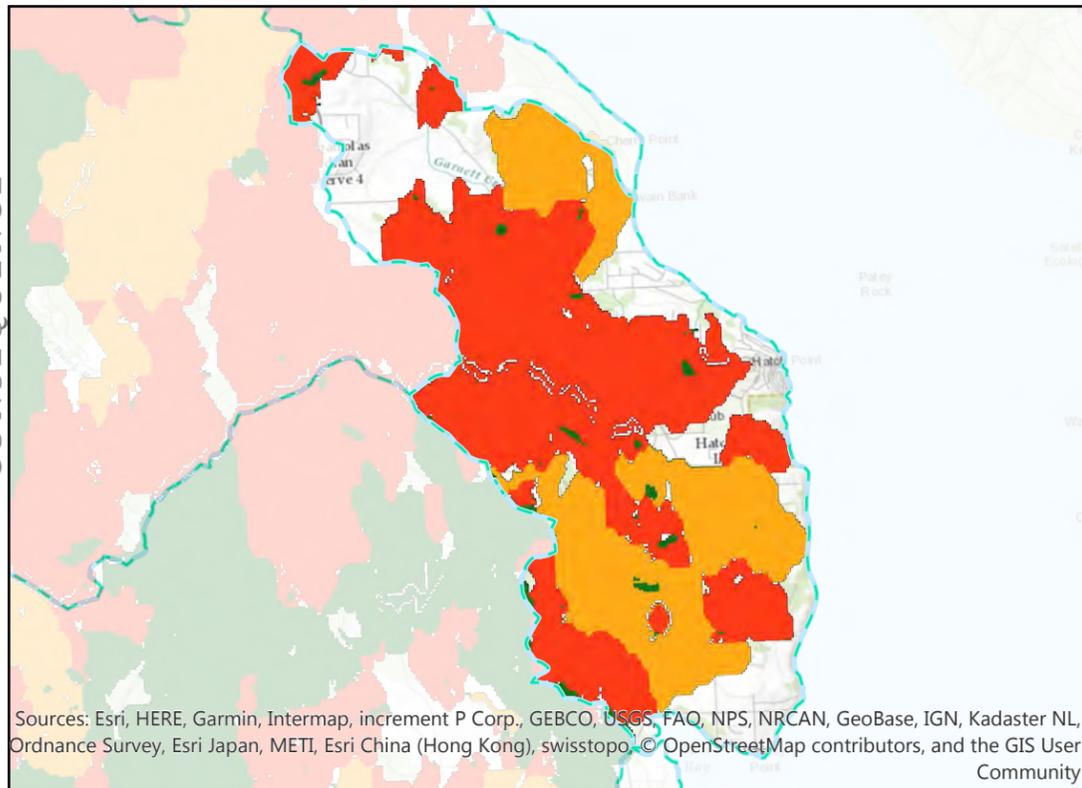


**Groundwater Contamination Risk Assessment - Satellite Channel**

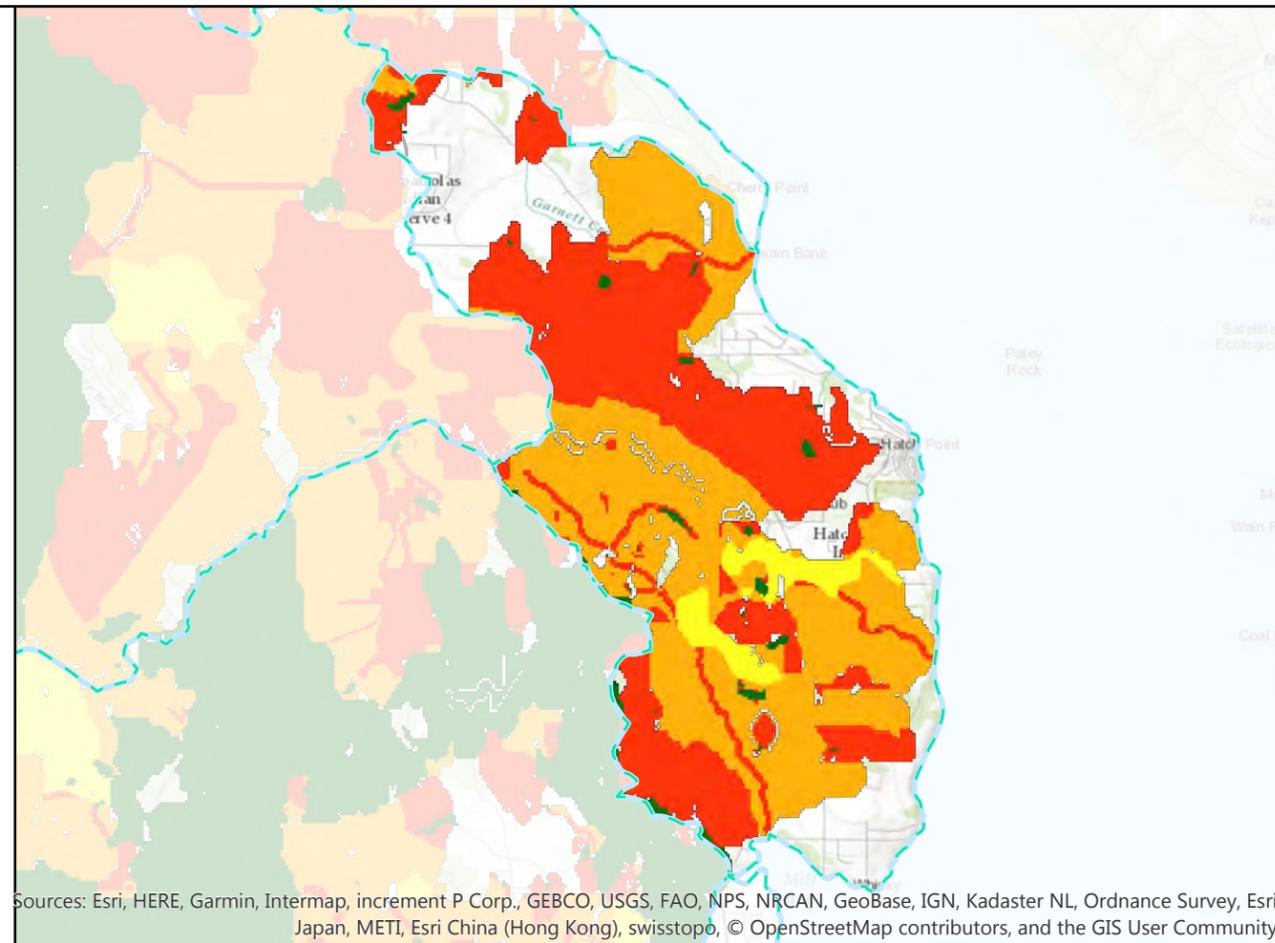


BY: CJW	SCALE CONS: 1:69,708	DATE: 2019/01/08	REF No:	REV: 0
CHKD: DK	Proj Coord Sys: NAD 1983 UTM Zone 10N		651957-103-SATC	

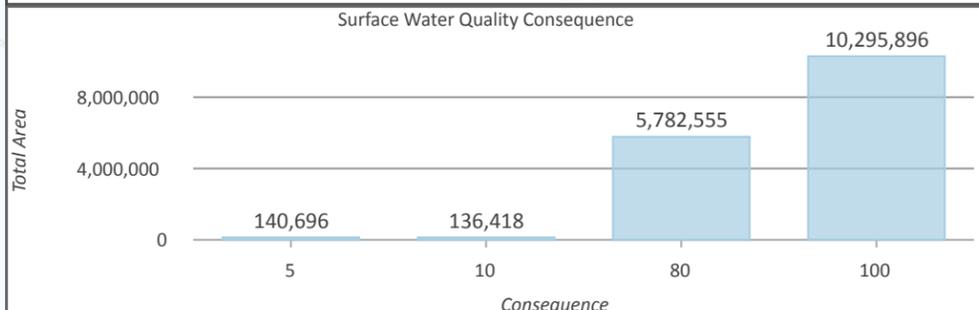
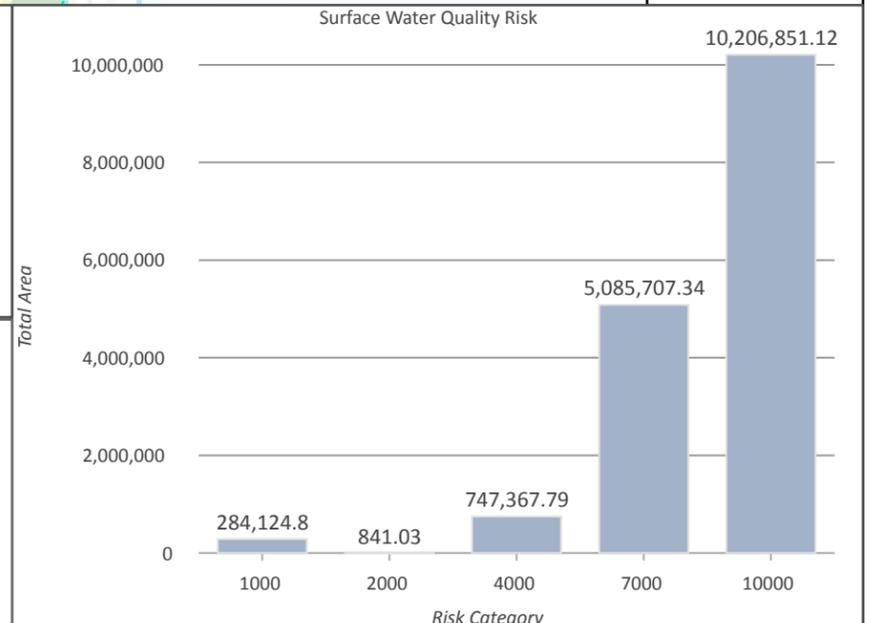
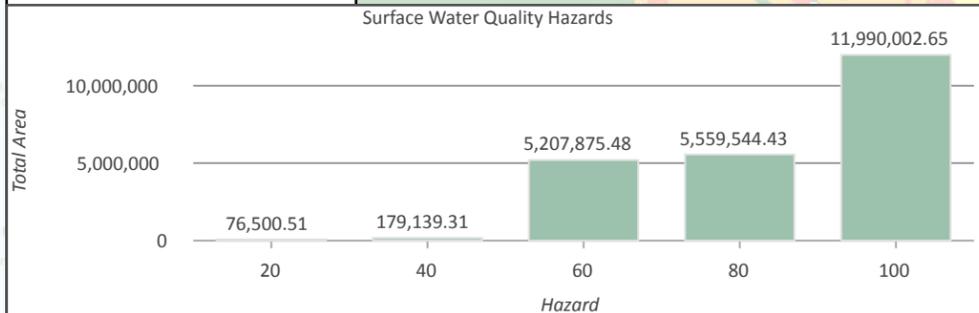
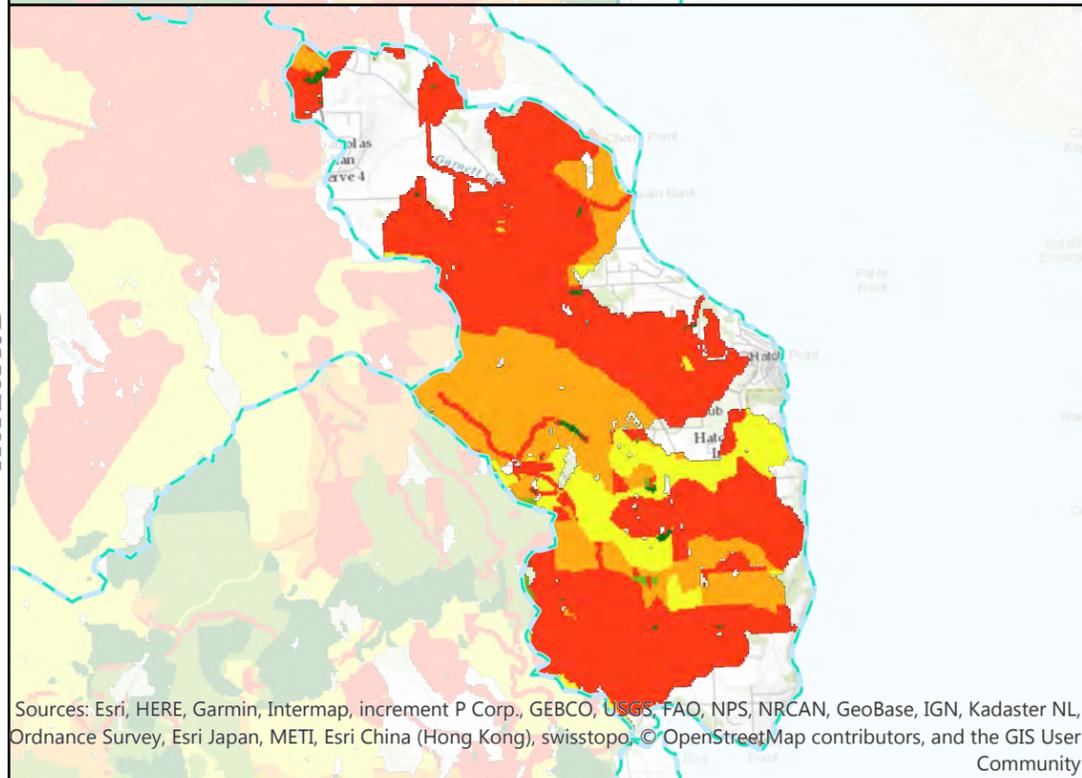
CONSEQUENCE



RISK



HAZARD



Legend

CONSEQUENCES OR HAZARDS		RISK	
	≤ 20		≤ 1000
	≤ 40		≤ 2000
	≤ 60		≤ 4000
	≤ 80		≤ 7000
	≤ 100		≤ 10000

**REFERENCES:**  
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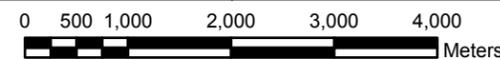
**REVISIONS:**  
 0 - CJW - 2018-11-29 - Issued - DK

CLIENT:  
 Cowichan Valley Regional District

PROJECT LOCATION:  
 Cowichan Valley Regional District Satellite Channel Benchlands Watershed

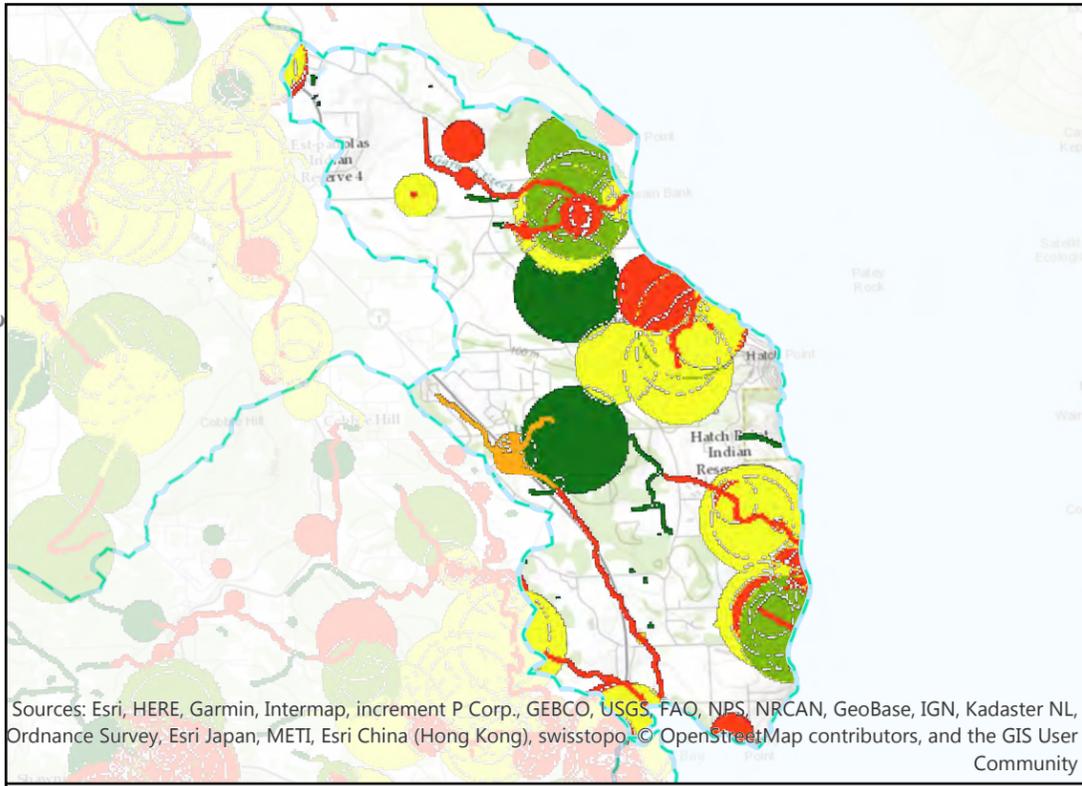


Surface Water Quality Risk Assessment - Satellite Channel

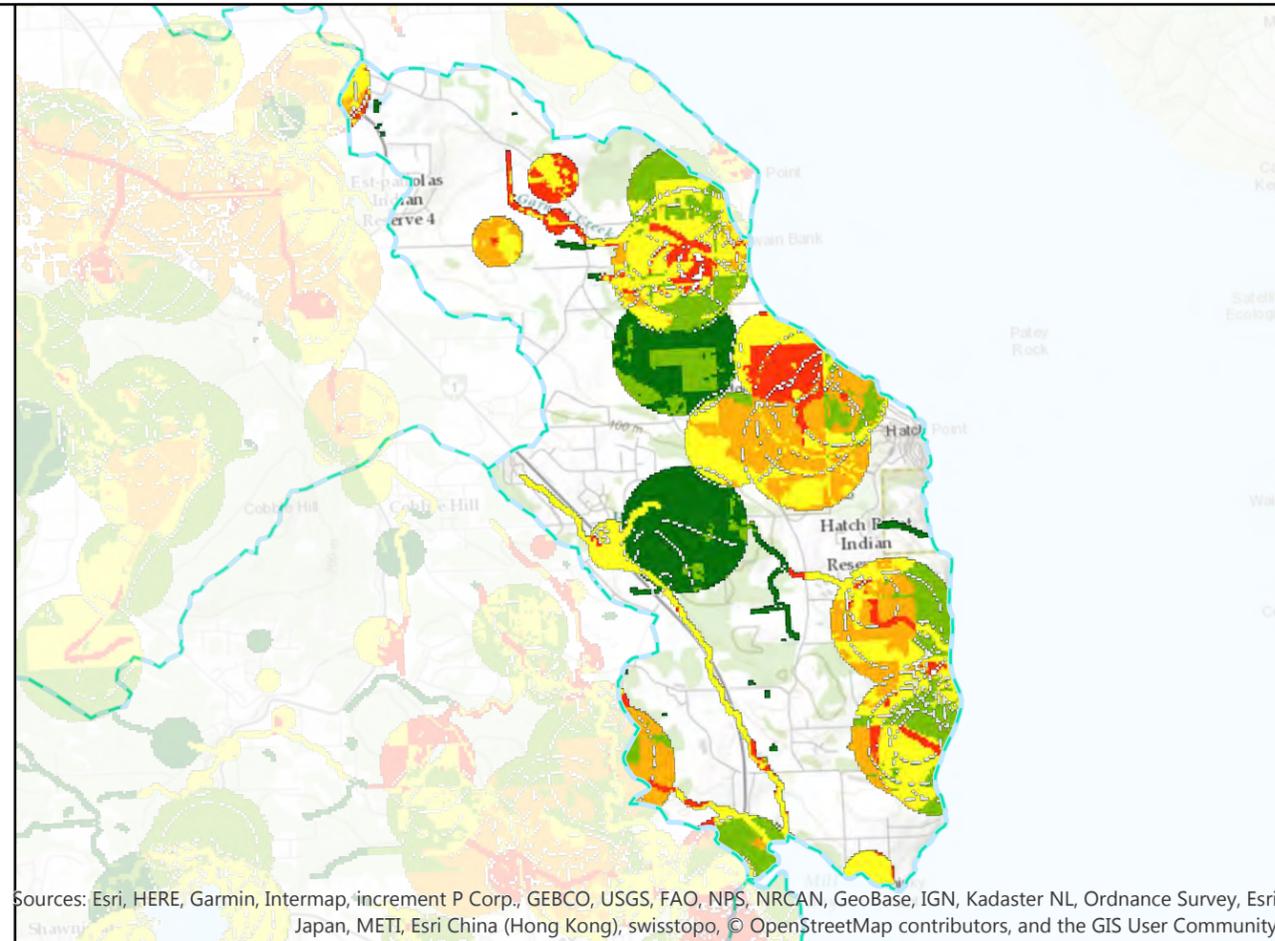


BY:	SCALE: 1:69,824	DATE: 2019/01/08	REF No:	REV: 0
CHKD:	Proj Coord Sys: PCS Albers		651957-104-SATC	

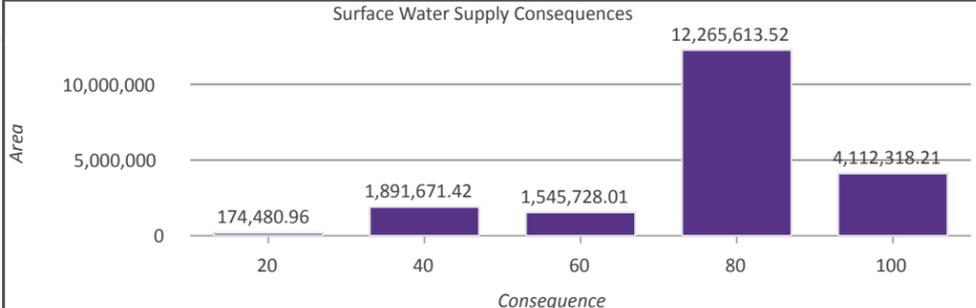
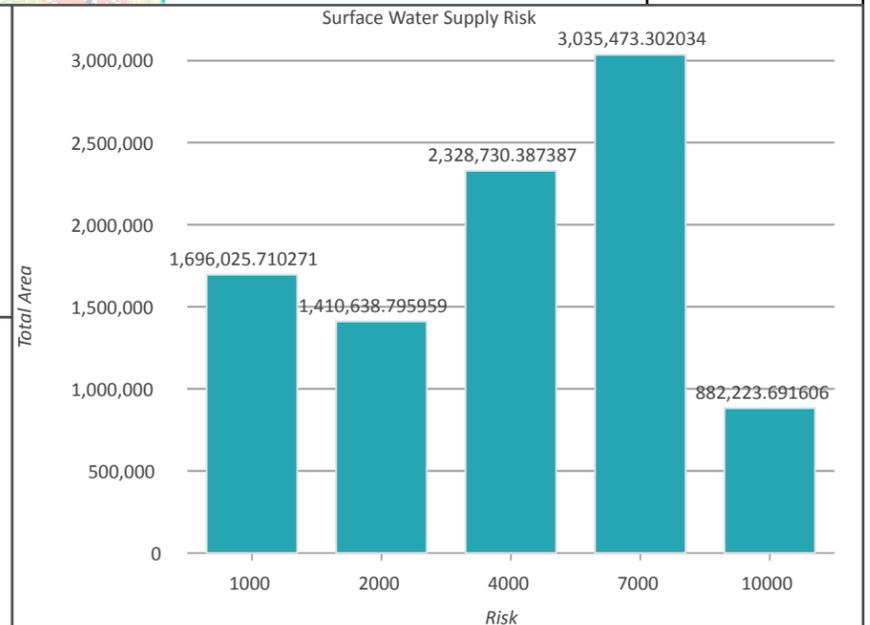
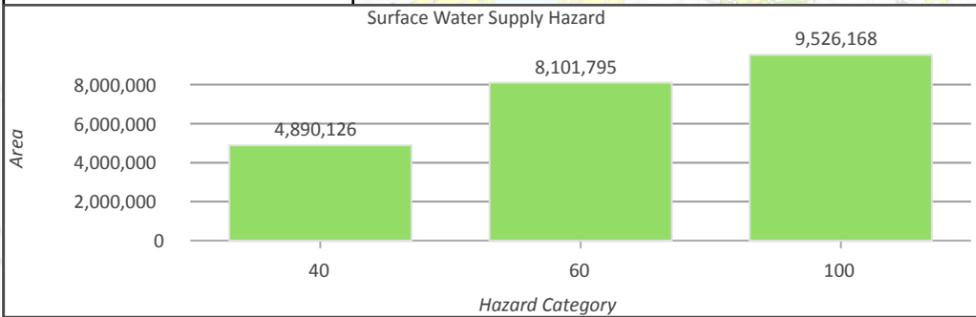
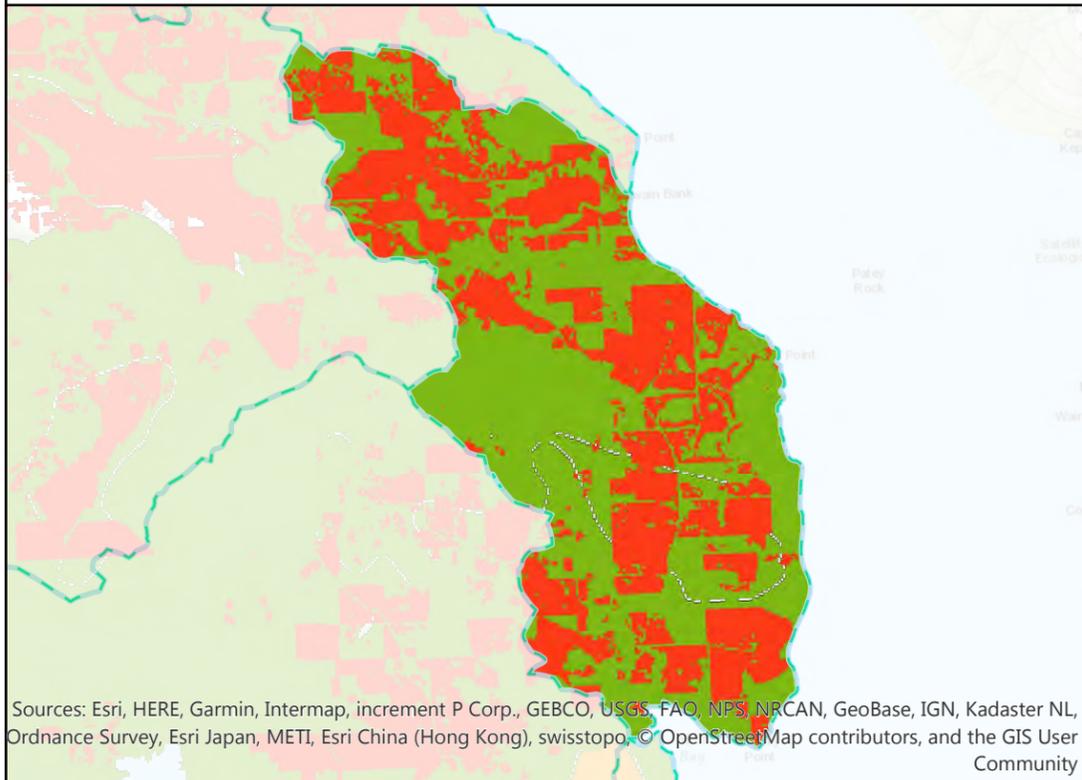
CONSEQUENCE



RISK



HAZARD



**Legend**

WATERSHED BOUNDARIES

CONSEQUENCES OR HAZARDS	RISK
≤ 20	≤ 1000
≤ 40	≤ 2000
≤ 60	≤ 4000
≤ 80	≤ 7000
≤ 100	≤ 10000

**REFERENCES:**  
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**REVISIONS:**  
 0 - CJW - 2018-11-29 - Issued - DK

CLIENT:  
 Cowichan Valley Regional District

PROJECT LOCATION:  
 Cowichan Valley Regional District Satellite Channel Benchlands Watershed

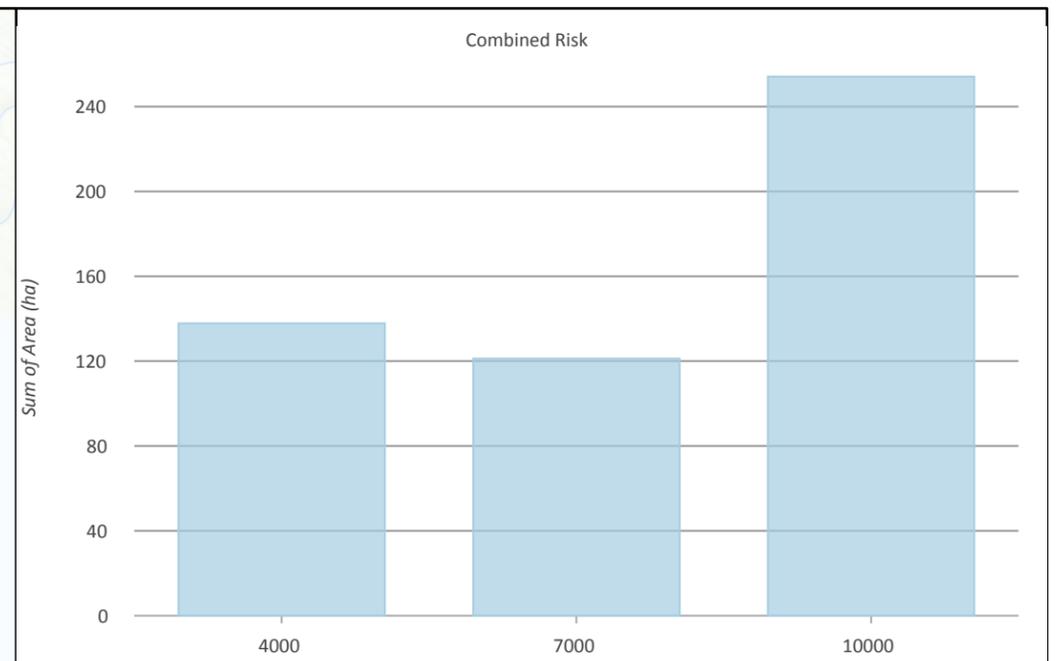
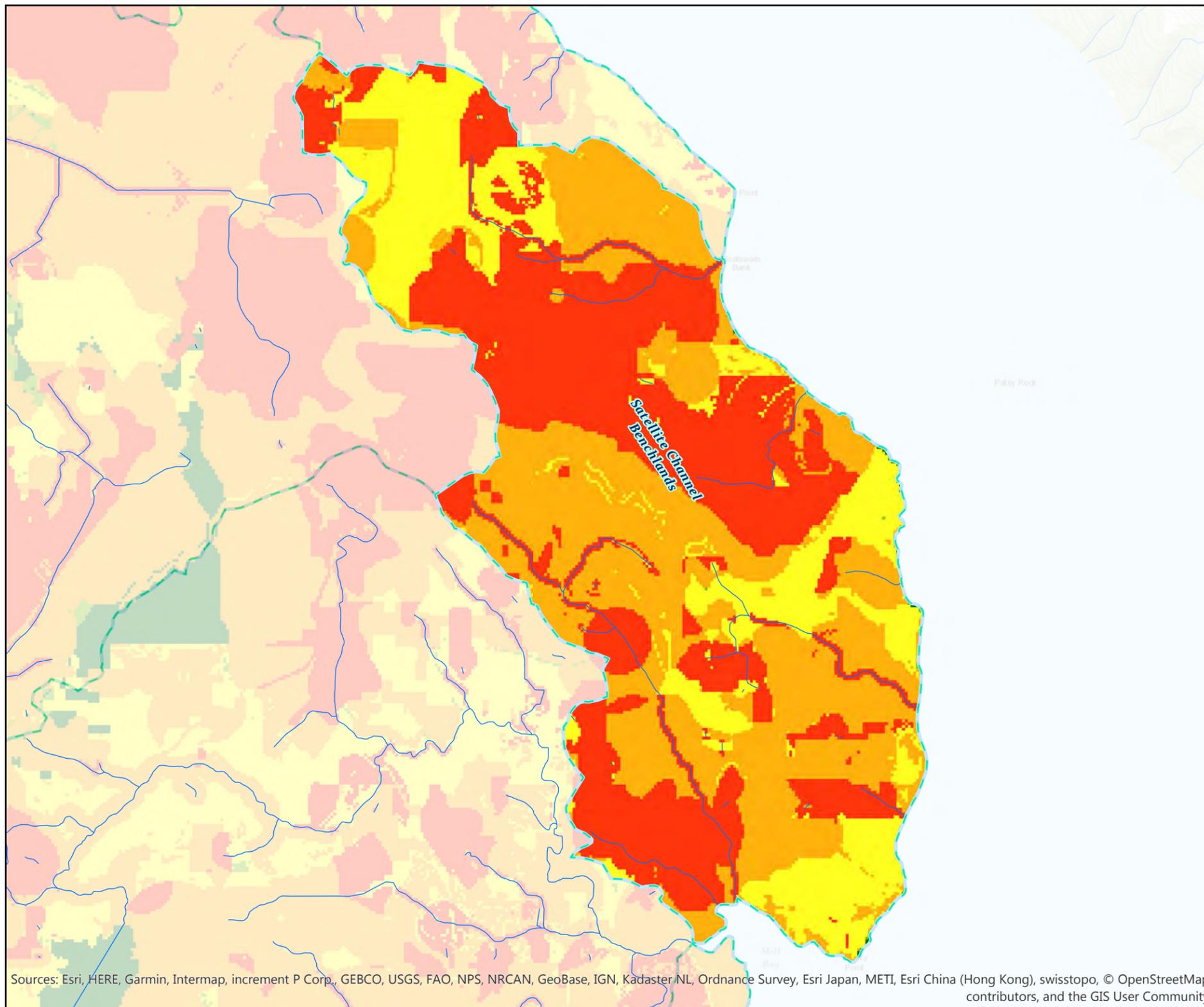


**Surface Water Supply Risk Assessment - Satellite Channel**



BY:	SCALE: 1:68,008	DATE: 2019/01/08	REF No:	REV: 0
CHKD:	Proj Coord Sys: PCS Albers		651957-105-SATC	

MXD Path: D:\Local\Projects\651957\_CVRD\GIS\CVRD\Presentation\CVRD\Presentation.aprx



NAME	Risk	POP <sub>2021</sub>	POP <sub>2026</sub>	POP <sub>2031</sub>	POP <sub>2036</sub>
SHAWNIGAN CREEK	10047	10760	11613	12598	
BUSH CREEK	0	0	0	0	
KOKSILAH RIVER	5463	5851	6315	6850	
HOLLAND CREEK	1302	1368	1446	1537	
BONSALL CREEK	934	974	1019	1073	
CHEMAINUS RIVER	1490	1461	1439	1421	
COWICHAN RIVER	36368	37905	39683	41766	
YELLOW POINT BENCHLANDS	2239	2352	2487	2643	
LADYSMITH - SALT AIR BENCHLANDS	8410	8834	9342	9929	
STOCKING CREEK	1531	1608	1701	1807	
CHEMAINUS BENCHLANDS	3663	3818	3997	4207	
SATELLITE CHANNEL BENCHLANDS	4390	4701	5074	5504	
SANSUM NARROWS - COWICHAN BAY BENCHLANDS	4941	5150	5391	5674	
MALAHAT BENCHLANDS	2829	3030	3271	3548	

NAME	POP <sub>2001</sub>	POP <sub>2006</sub>	POP <sub>2011</sub>	POP <sub>2016</sub>
SHAWNIGAN CREEK	6348	8439	8925	9484
BUSH CREEK	0			
KOKSILAH RIVER	4555	4808	4954	5157
HOLLAND CREEK	1611	1114	1169	1245
BONSALL CREEK	672	830	815	890
CHEMAINUS RIVER	1423	1395	1497	1514
COWICHAN RIVER	29779	32673	34075	34647
YELLOW POINT BENCHLANDS	1167	1958	2021	2141
LADYSMITH - SALT AIR BENCHLANDS	5275	7488	7541	8042
STOCKING CREEK	1332	1003	1354	1464
CHEMAINUS BENCHLANDS	3177	3129	3085	3490
SATELLITE CHANNEL BENCHLANDS	5425	3902	3989	4144
SANSUM NARROWS - COWICHAN BAY BENCHLANDS	5993	4221	4500	4707
MALAHAT BENCHLANDS	1673	2472	2548	2671

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

**Legend**

WATERSHED BOUNDARIES

**RISK**

- ≤ 1000
- ≤ 2000
- ≤ 4000
- ≤ 7000
- ≤ 10000

**REFERENCES:**

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**REVISIONS:**

0 - CJW - 2018-11-30 - Issued - DK

CLIENT:  
Cowichan Valley Regional District

PROJECT LOCATION:  
Cowichan Valley Regional District  
Satellite Channel Benchlands Watershed

**Combined Risk Assessment - Satellite Channel Benchlands**

BY: CJW    SCALE CONS: 1:41,000    DATE: 2019/01/08    REF No:    REV: 0

CHKD: DK    Proj Coord Sys: NAD 1983 UTM Zone 10N    **651957-106-SATC**

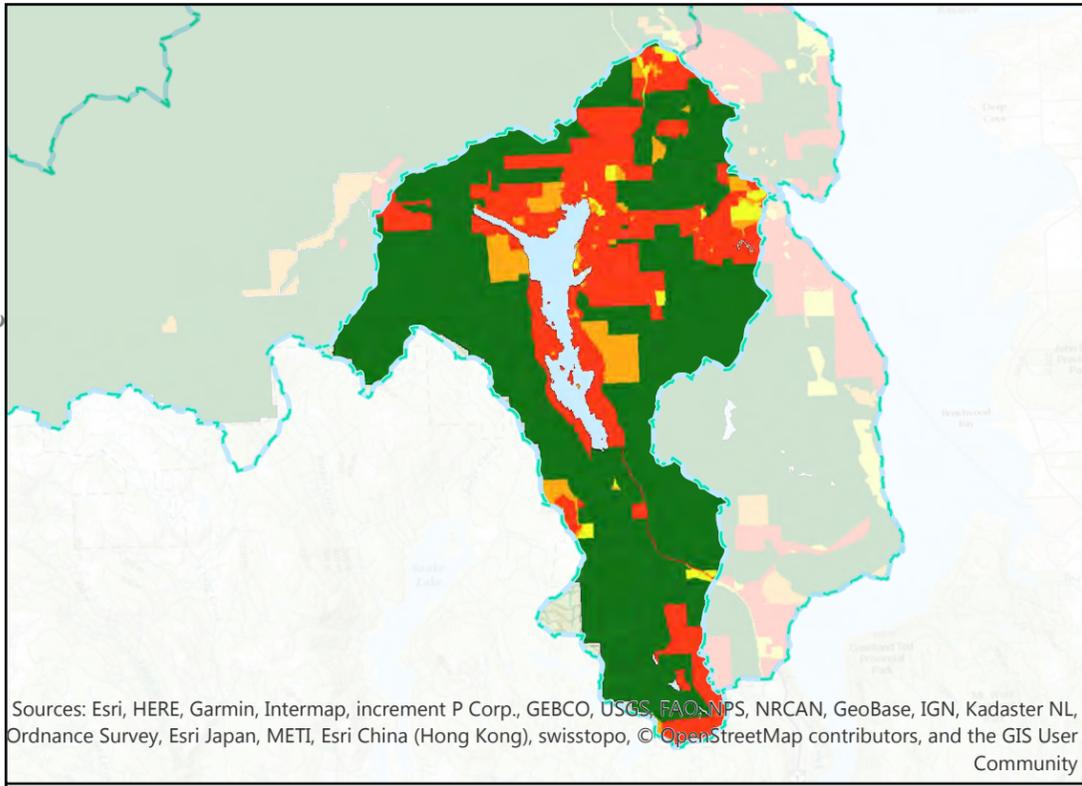
MXD Path: D:\Local\Projects\651957\_CVRD\GIS\CVRD\Presentation\CVRD\Presentation.aprx

<b>12. Shawnigan Creek</b>	
<b>Topic</b>	<b>Discussion</b>
Slope Failure	<p>Hazard was determined qualitatively at a high level to describe areas based on the degree to which they may be prone to landslides and other mass movements using terrain characteristics. Hazard classifications were generated to show relative comparisons between terrain units within the CVRD watershed study area. Risk ratings derived from this analysis are relative, and should be used to guide prioritization of further detailed studies.</p> <p>Hazard is greatest along the steeper slopes east of Shawnigan Lake (Old Baldy Mountain) and portions of the southern end of the watershed where logging activities have occurred along relatively steep slopes. Consequence is greatest at populated areas surrounding Lake Shawnigan, Cobble Hill, and Mill Bay, and at the mine situated northwest of the Malahat Benchlands. Risk is greatest at the mine and along the slope immediately to the south, as well as the areas of Cliffside and around the southern portion of Shawnigan Lake that are adjacent to relatively steep slopes.</p>
Flooding	<p>Some floodplain mapping has been completed around Shawnigan Lake with some potential flood risk around Shawnigan Lake. Additionally there is considered to be some potential for flooding in the areas of the various rivers and streams, however this is likely over-stated within the hazard analysis provided. Additional modelling and flood analysis is recommended since most of the populated areas are either in close proximity to Shawnigan Lake or the streams and rivers. This should incorporate information such as that contained in the 2002 Shawnigan Lake Water Supply report, and a flood frequency analysis. Here, consequence and risk are therefore considered higher near the streams and rivers and along Shawnigan Lake in the northern half of the watershed where the vast majority of the population resides. Projected population increases in the watershed are expected to enhance consequence and risk. Also, likelihood may be enhanced with increased population depending on the nature of development and stormwater runoff.</p>
Groundwater Contamination	<p>Likelihood of groundwater contamination varies greatly throughout the watershed and is expected to increase in populated areas that continue to expand their population. The DRASTIC vulnerability value and the presence of contaminated sites are the main drivers in this watershed. Consequence is maximized in the vicinity of a municipal water supply wells. Risk is greatest in populated areas such as Cobble Hill, Mill Bay, and specific residential neighbourhoods situated at or near Shawnigan Lake.</p>
Surface Water Quality	<p>Hazard is greatest in developed areas surrounding Shawnigan Lake and Cobble Hill and along streams that outlet Shawnigan Lake where there is low or no forest cover. These areas occupy a relatively large cumulative area of the watershed. Consequence is greatest at low order streams around Cobble Hill and Mill Bay, although the extents of higher consequence are small relative to the size of the watershed. Risk is greatest along specific low order streams in the Cobble Hill area and occupy a small proportion of the watershed's area. Projected population increases in the watershed will add more high risk areas where permeable surfaces are replaced with impermeable surfaces and where forest cover is reduced.</p>
Surface Water Supply	<p>Hazard is greatest in small isolated zones surrounding Shawnigan Lake and to the south of Cobble Hill. Consequence is considered very low for the majority of the watershed and is greatest south of Cobble Hill. Risk is greatest within small zones to the south of Cobble Hill and within Mill Bay, occupying a very small proportion of the watershed's area. Projected population increase for the watershed is expected to add pressures on groundwater sources that may increase the level of hazard and risk.</p>

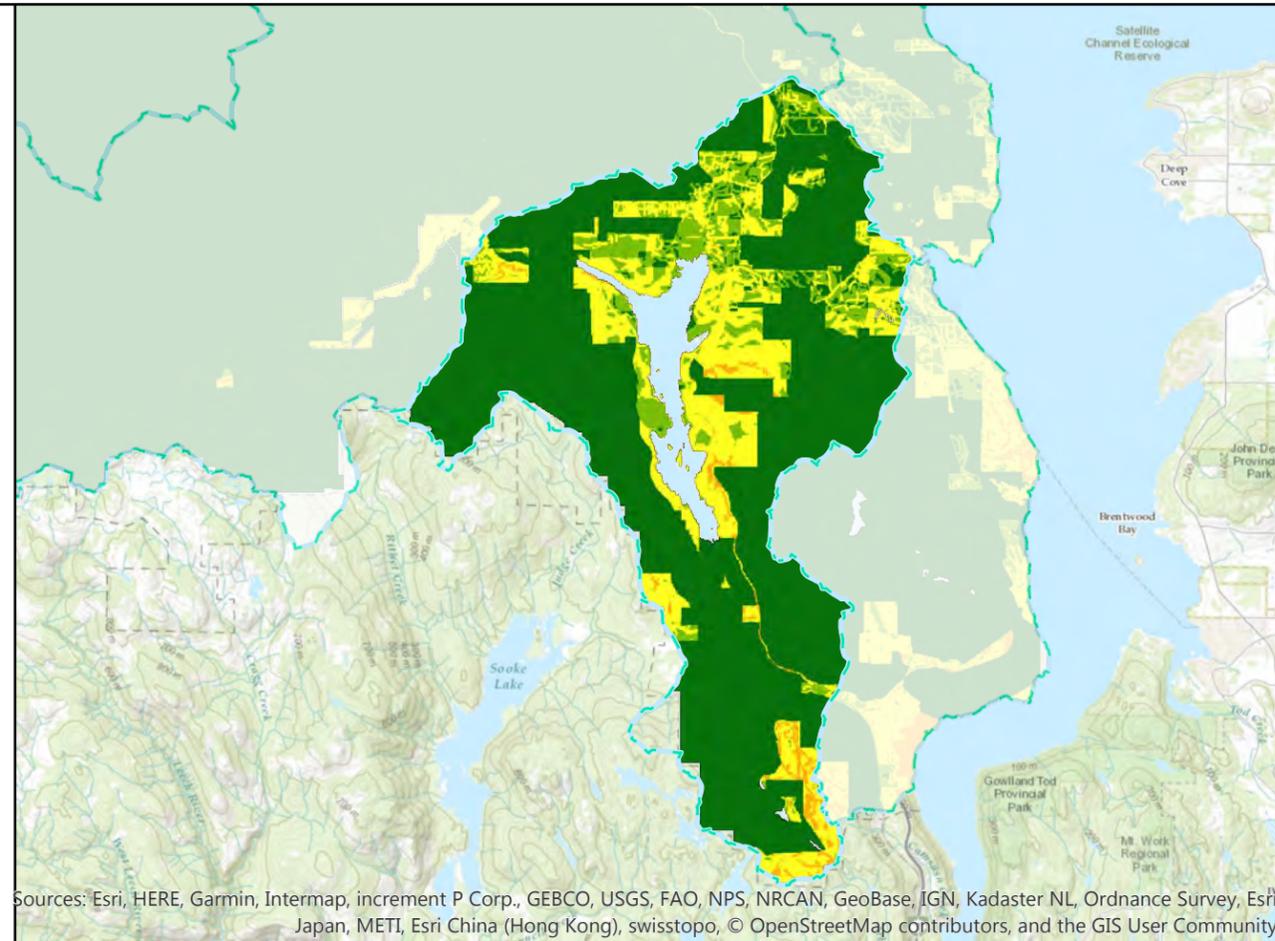
## 12. Shawnigan Creek

General Data Notes and Multivariate Risk	Risk is higher in the populated northeast part of the watershed, with contributions from Surface Water Supply / Stream Health, Groundwater Contamination, and, to a lesser degree, Flooding and Slope Failure. Shawnigan Creek is part of the southern region defined in the LAM population study, and is expected to grow by approximately 33% in the next twenty years. Additional refinement of consequences and risk is recommended to better understand how to plan for this growth.
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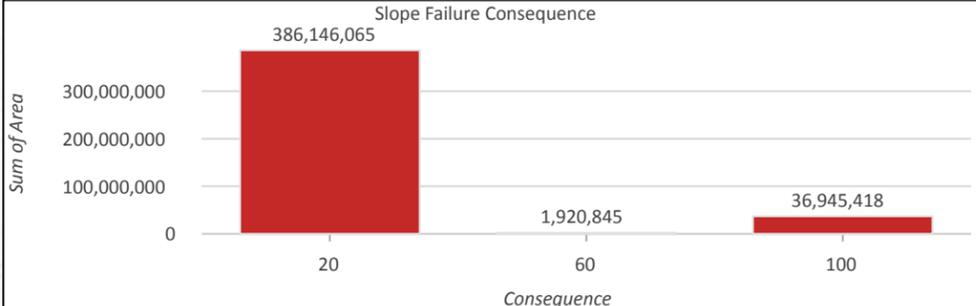
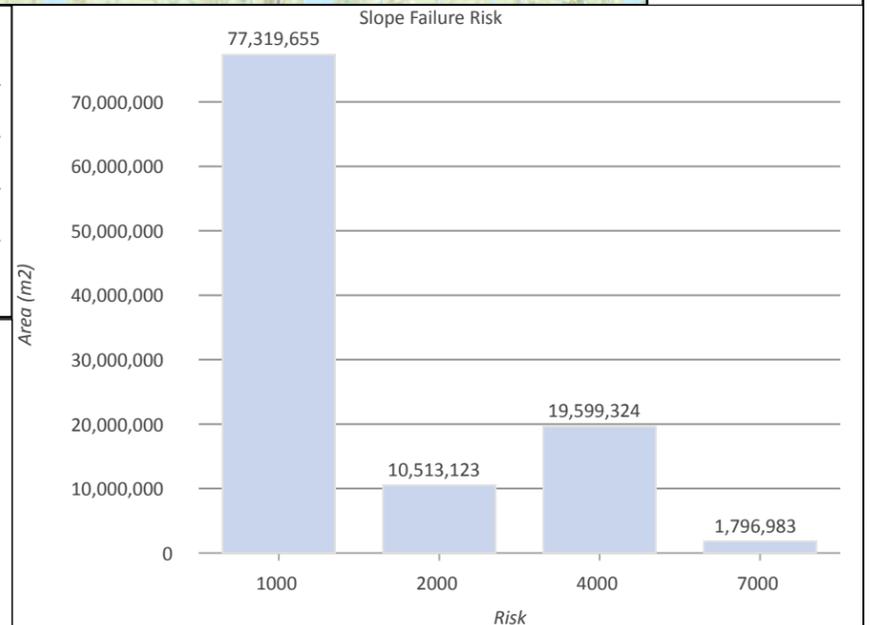
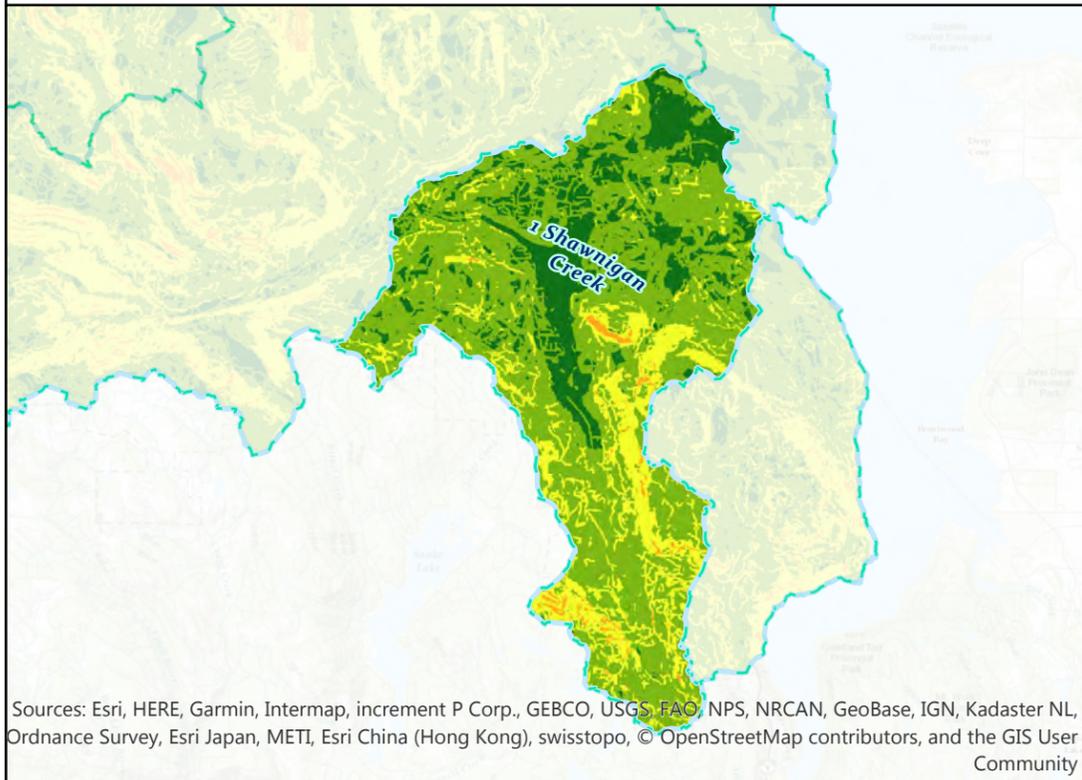
CONSEQUENCE



RISK



HAZARD



**Legend**

WATERSHED BOUNDARIES

**CONSEQUENCES OR HAZARDS**

- ≤ 20
- ≤ 40
- ≤ 60
- ≤ 80
- ≤ 100

**RISK**

- ≤ 1000
- ≤ 2000
- ≤ 4000
- ≤ 7000
- ≤ 10000

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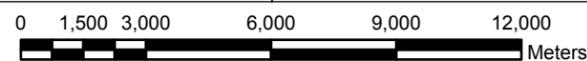
CLIENT:  
Cowichan Valley Regional District

PROJECT LOCATION:  
Cowichan Valley Regional District  
Shawnigan Creek Watershed

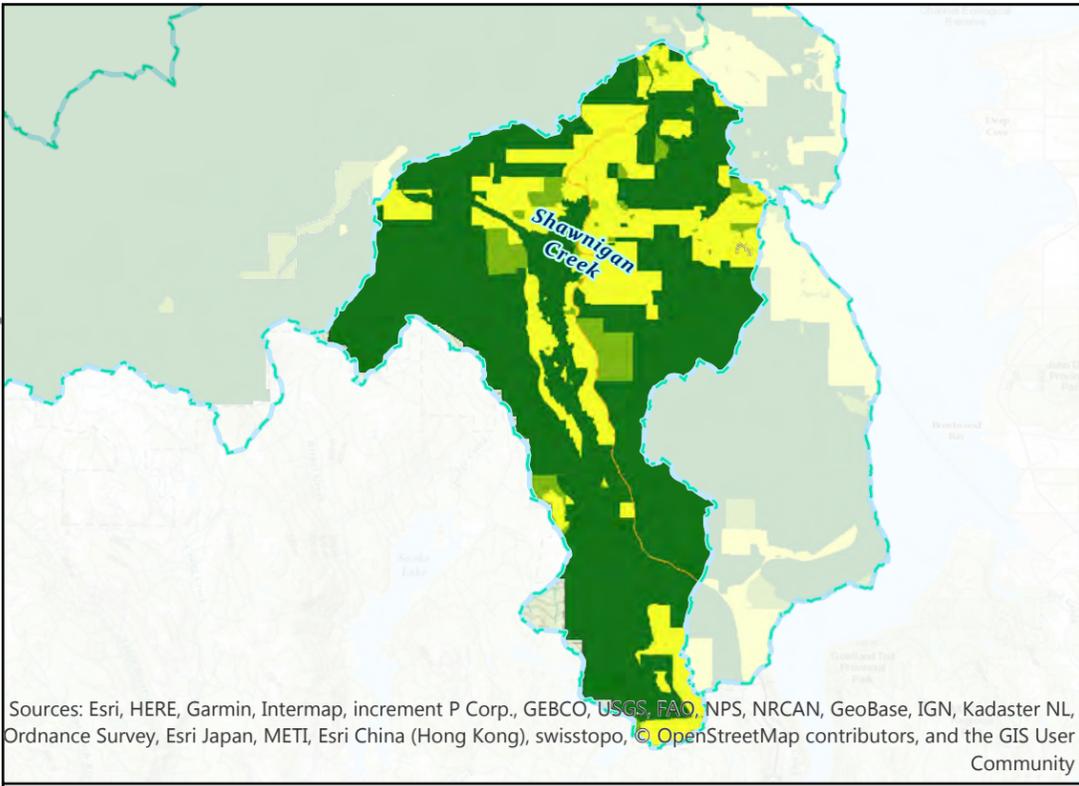


**Slope Failure Risk Assessment - Shawnigan Creek**

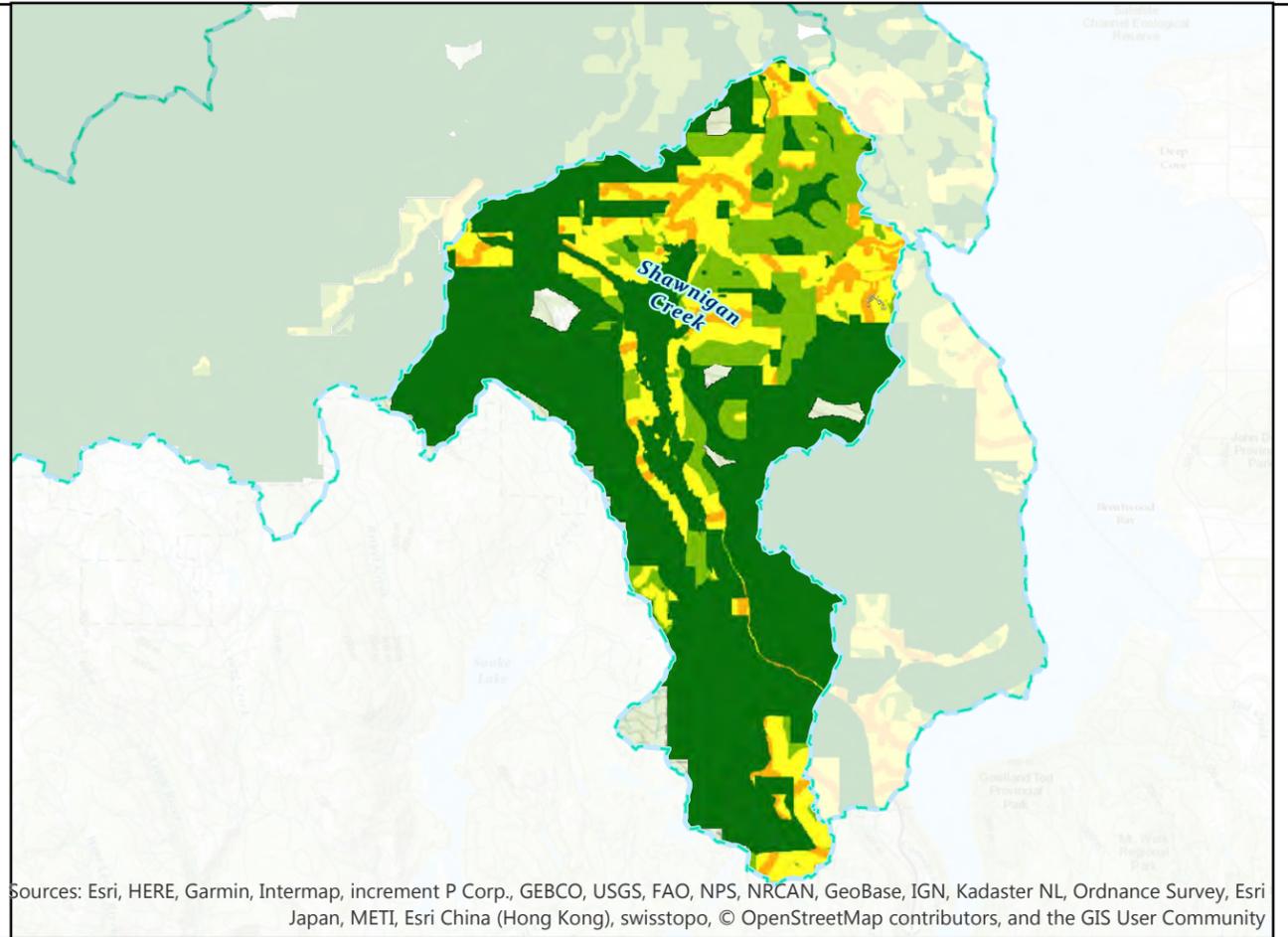
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CHKD: DK	Proj Coord Sys: PCS Albers	651957-101-SHAWN		



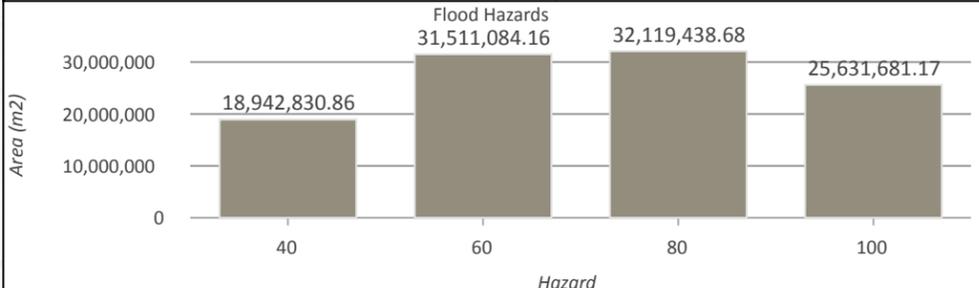
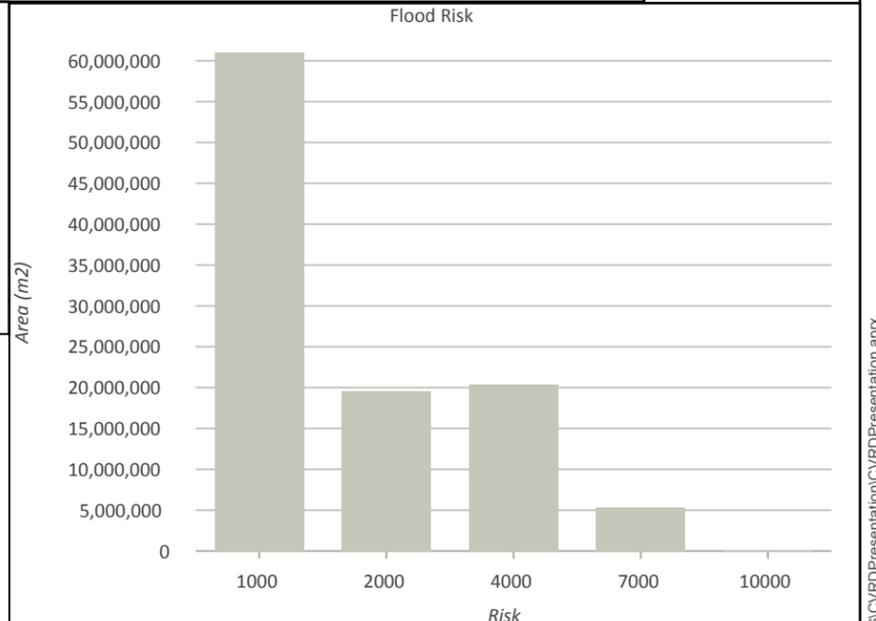
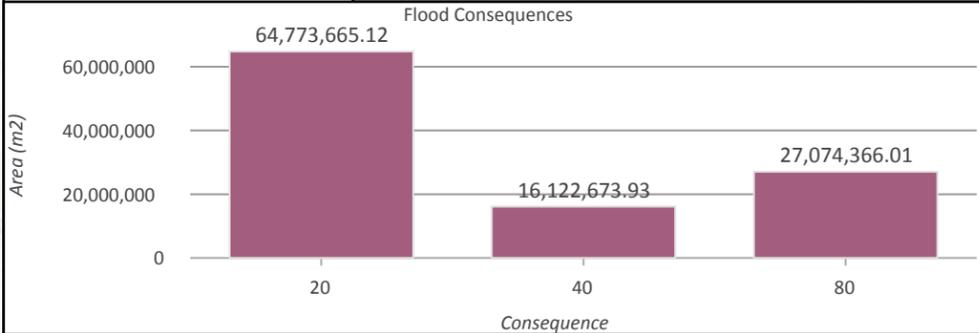
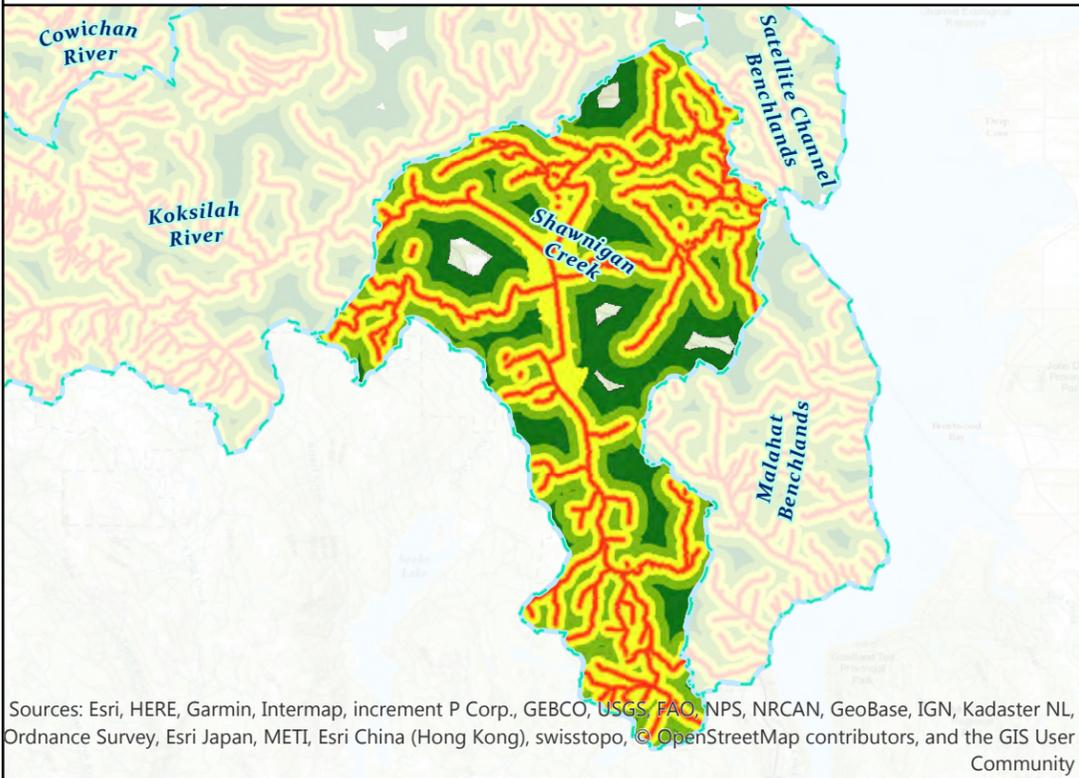
CONSEQUENCE



RISK



HAZARD



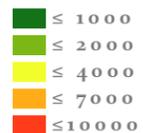
**Legend**

WATERSHED BOUNDARIES

**CONSEQUENCES OR HAZARDS**



**RISK**



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0 - CJW - 2018-11-29 - Issued - DK

CLIENT:  
Cowichan Valley Regional District

PROJECT LOCATION:  
Cowichan Valley Regional District  
Shawnigan Creek Watershed

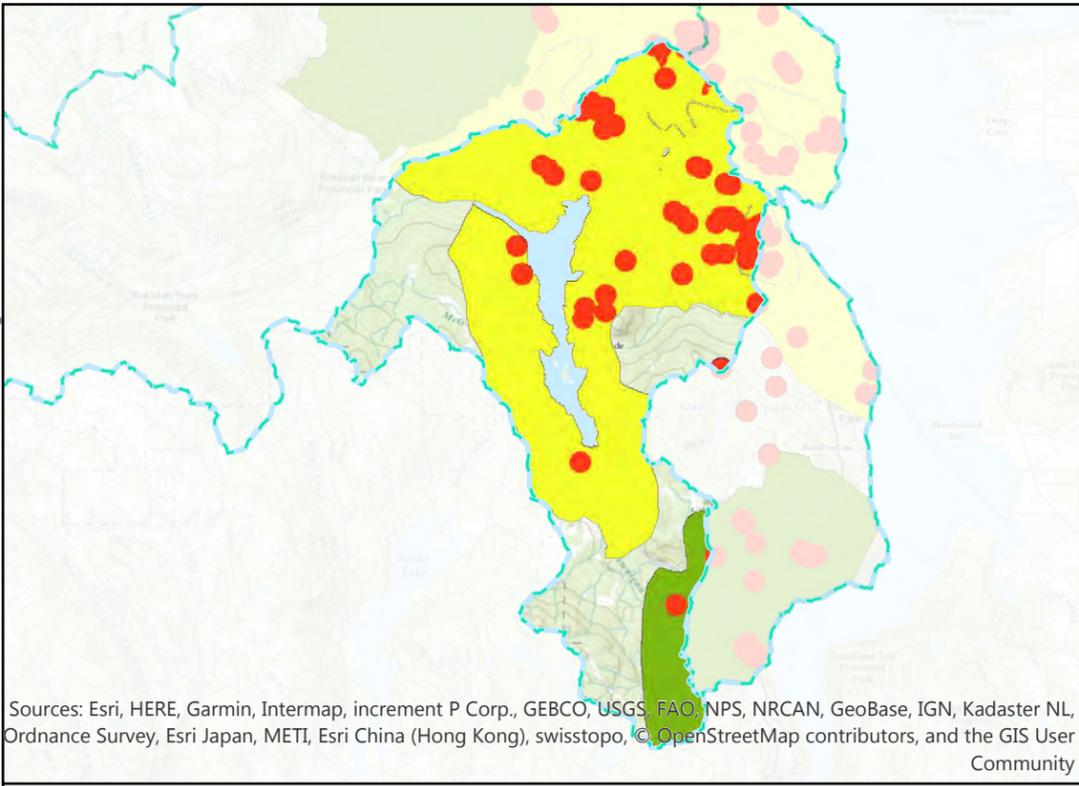


**Flood Risk Assessment - Shawnigan Creek**

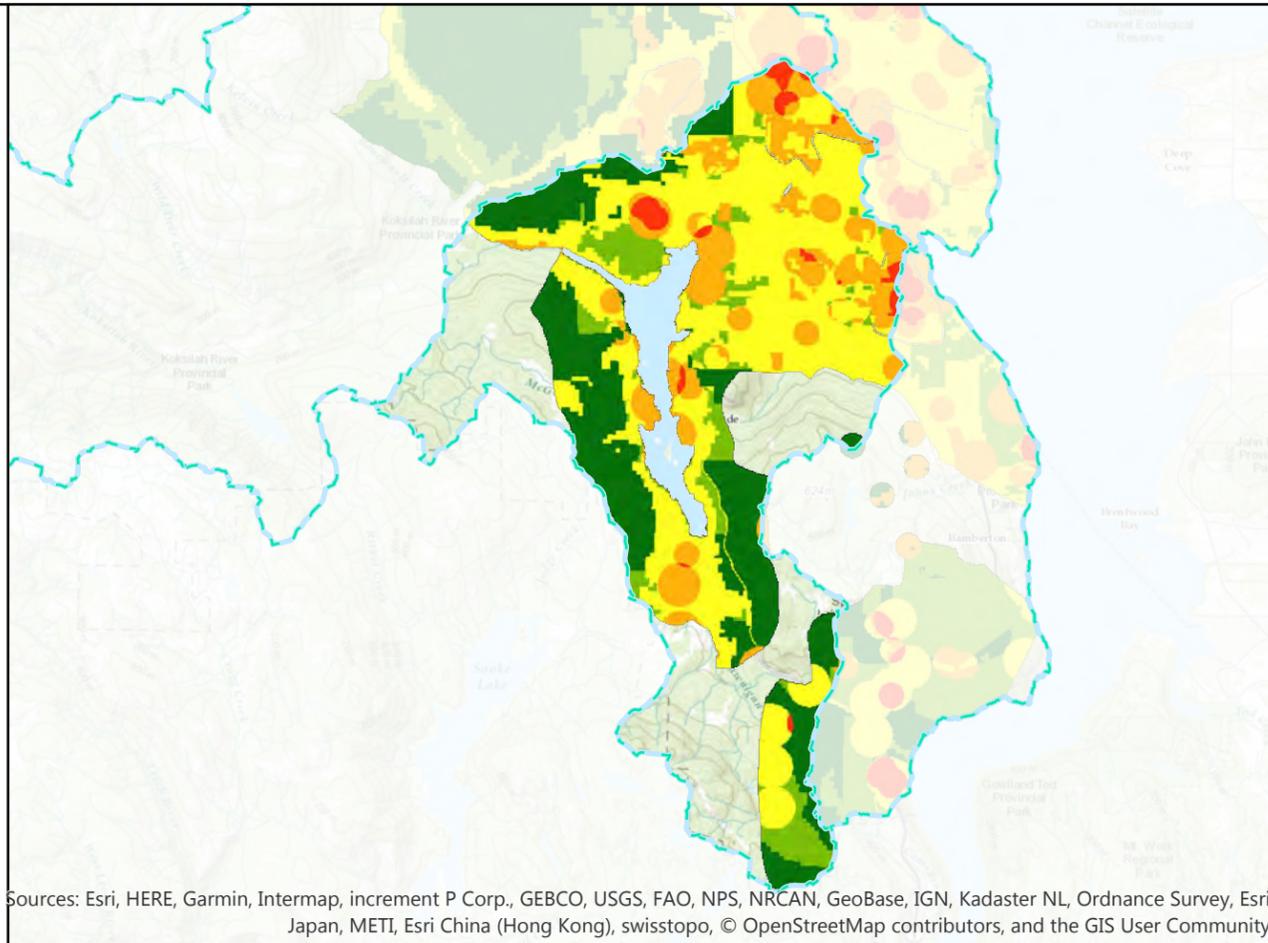


BY: CJW	SCALE CONS: 1:167,469	DATE: 2019/01/08	REF No:	REV: 0
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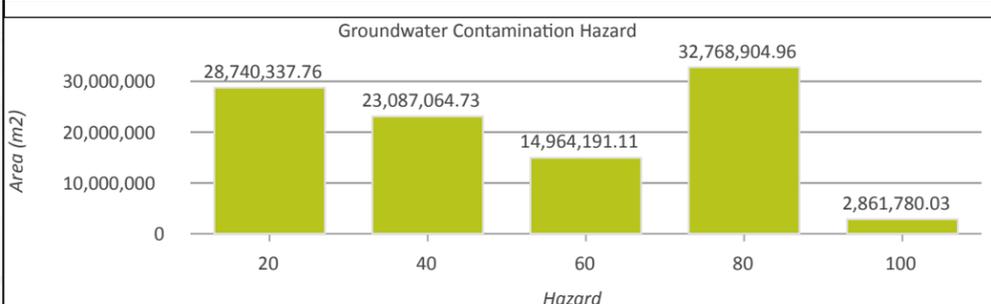
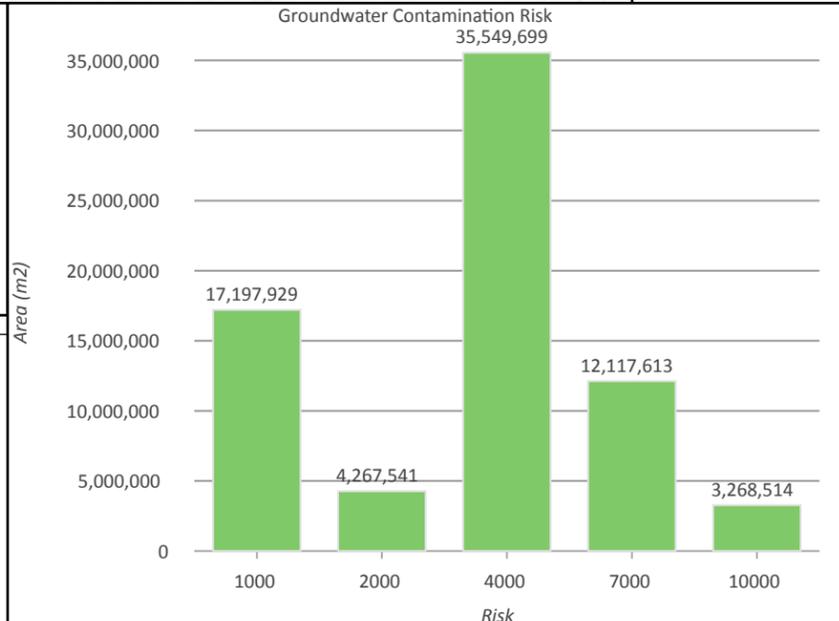
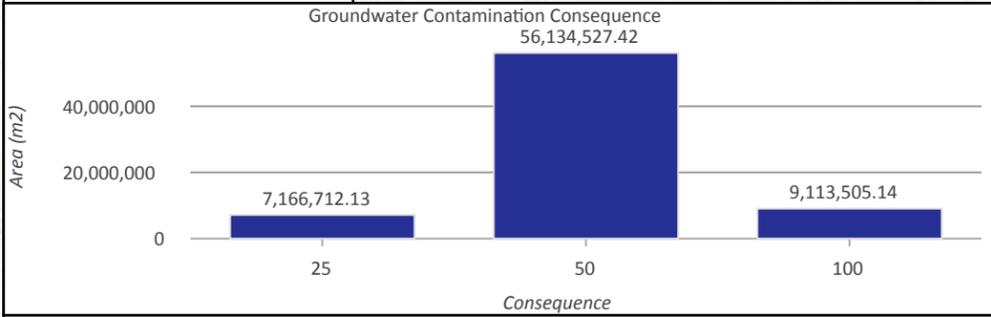
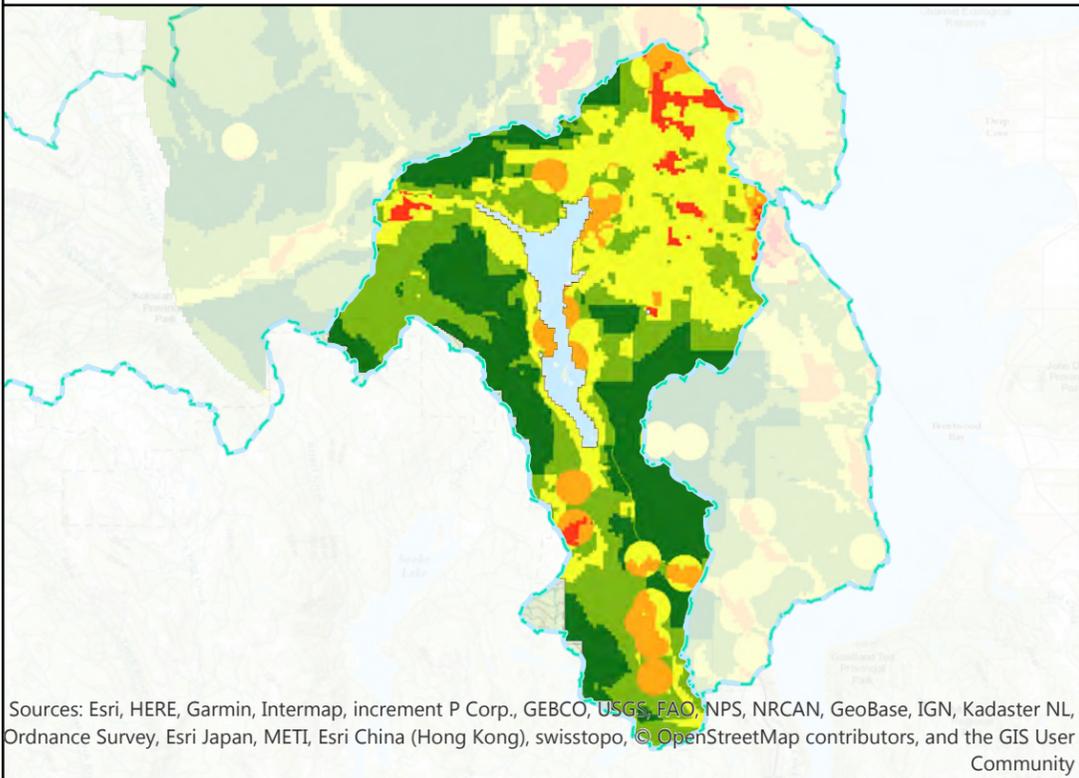
CONSEQUENCE



RISK



HAZARD



**Legend**

WATERSHED BOUNDARIES

**CONSEQUENCES OR HAZARDS**



**RISK**



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**NOTES:**

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2. Numerical scale reflects full-size print. Print scaling will distort this scale, however scale bar will remain accurate.  
3. Intended for illustration purposes, accuracy has not been verified for construction or navigation purposes.

**REVISIONS:**

0 - CJW - 2018-11-29 - Issued - DK

CLIENT:  
Cowichan Valley Regional District

PROJECT LOCATION:  
Cowichan Valley Regional District  
Shawnigan Creek Watershed



**Groundwater Contamination Risk Assessment - Shawnigan Creek**



BY: CJW

SCALE CONS: 1:167,469

DATE: 2019/01/08

REF No:

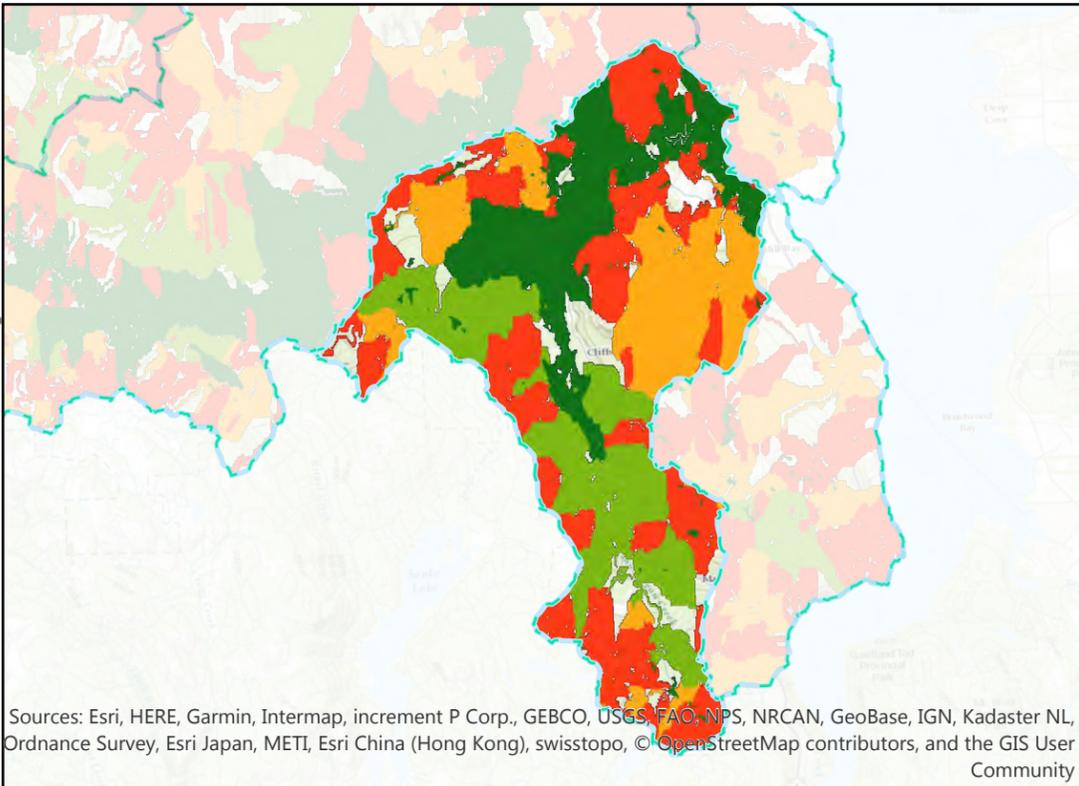
REV: 0

CHKD: DK

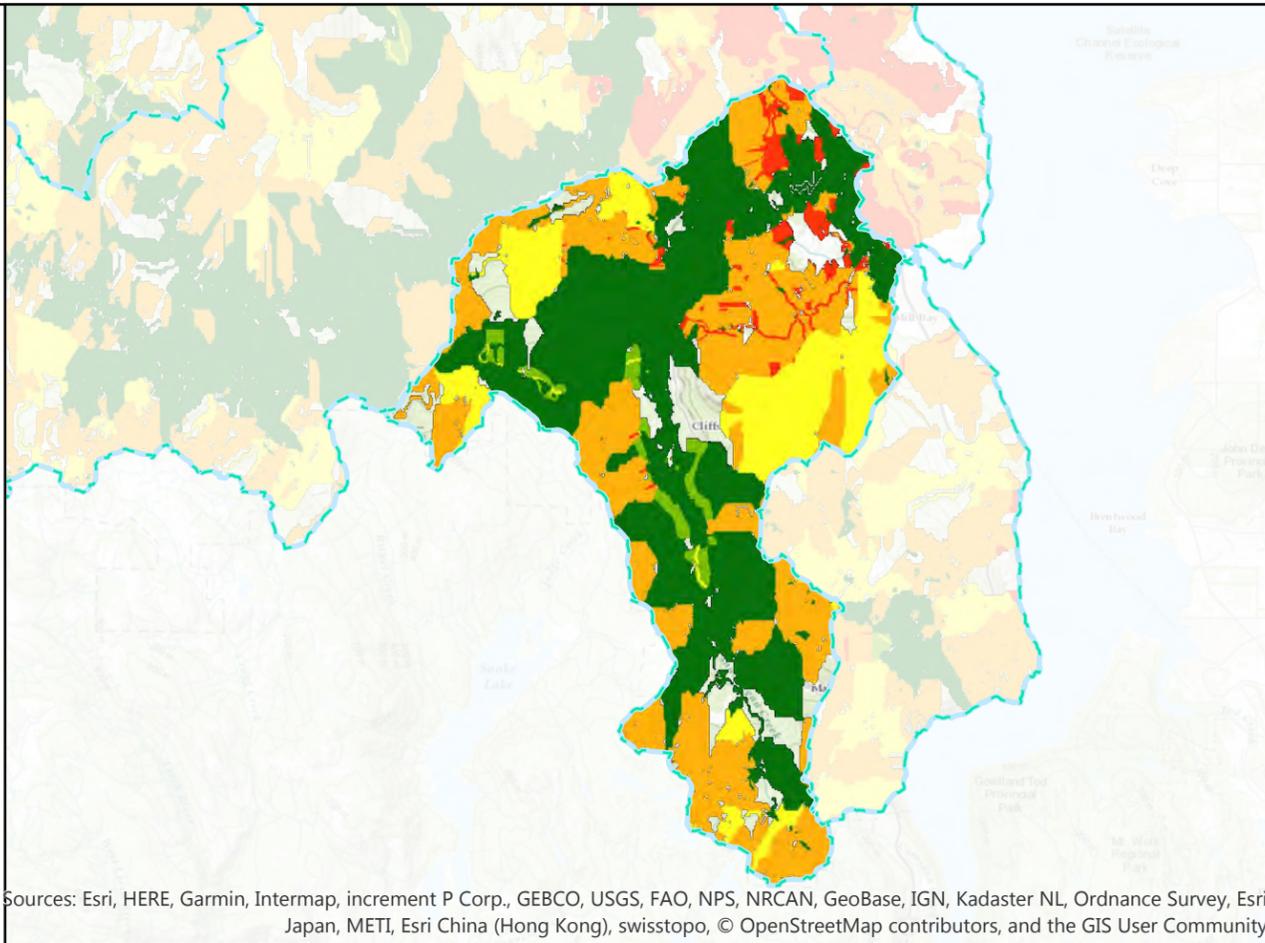
Proj Coord Sys: NAD 1983 UTM Zone 10N

**651957-103-SHAWN**

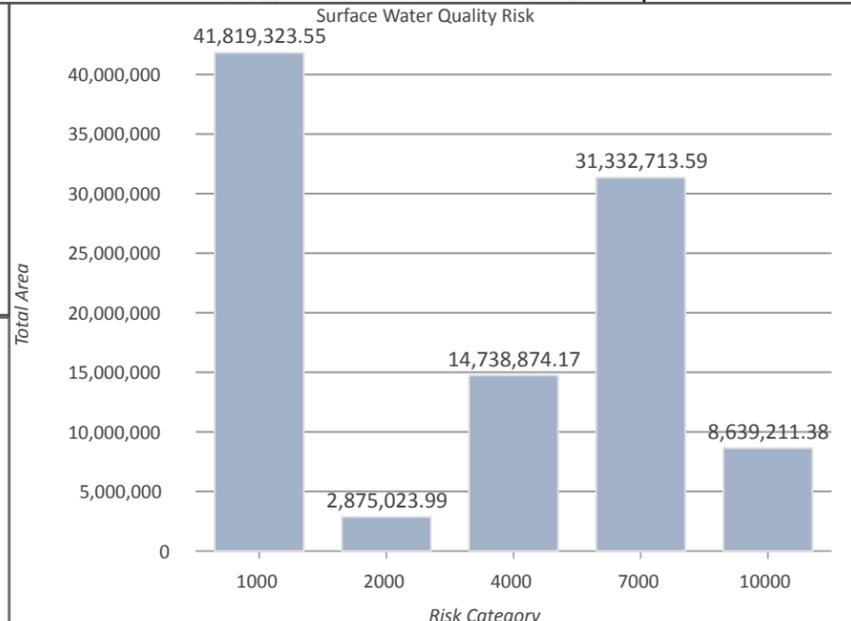
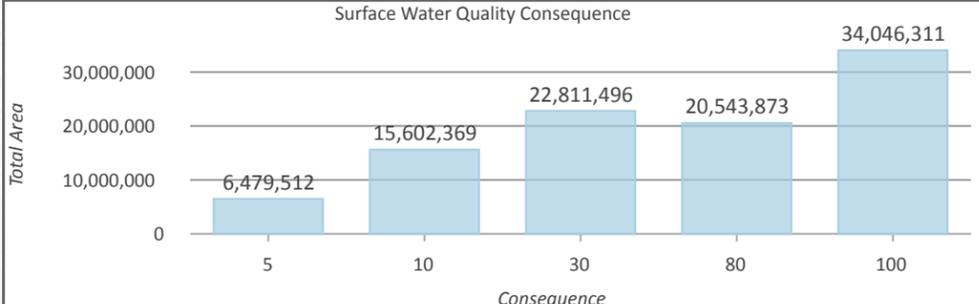
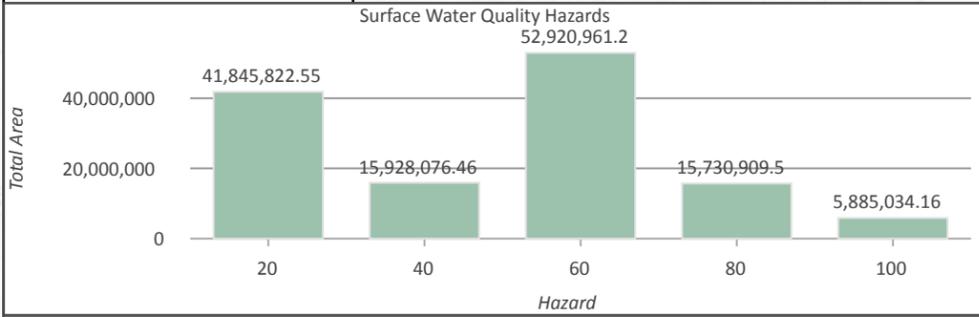
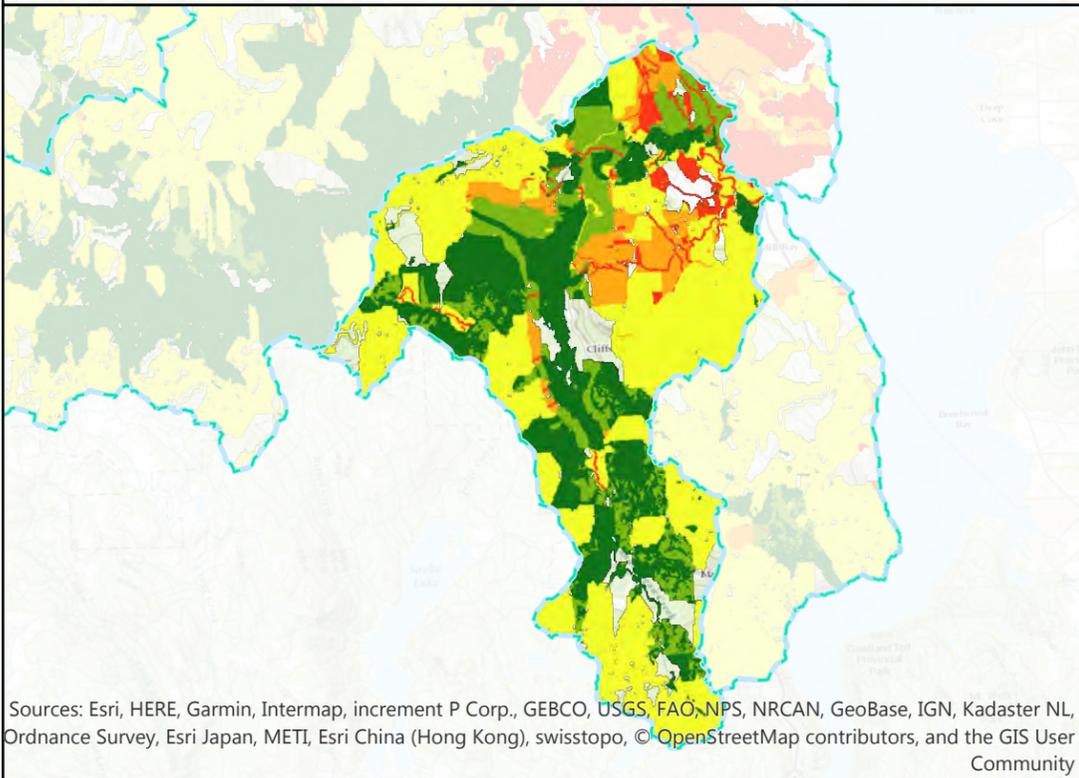
CONSEQUENCE



RISK



HAZARD



**Legend**

WATERSHED BOUNDARIES

**CONSEQUENCES OR HAZARDS**

- ≤ 20
- ≤ 40
- ≤ 60
- ≤ 80
- ≤ 100

**RISK**

- ≤ 1000
- ≤ 2000
- ≤ 4000
- ≤ 7000
- ≤ 10000

**REFERENCES:**

1. Risk data compiled from various data sources provided by the Cowichan Valley Regional District. Presentation of data is intended to provide a general guidance on potential issues, rather than a definitive study.

**NOTES:**

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**REVISIONS:**

0 - CJW - 2018-11-29 - Issued - DK

CLIENT:  
Cowichan Valley Regional District

PROJECT LOCATION:  
Cowichan Valley Regional District  
Shawnigan Creek Watershed



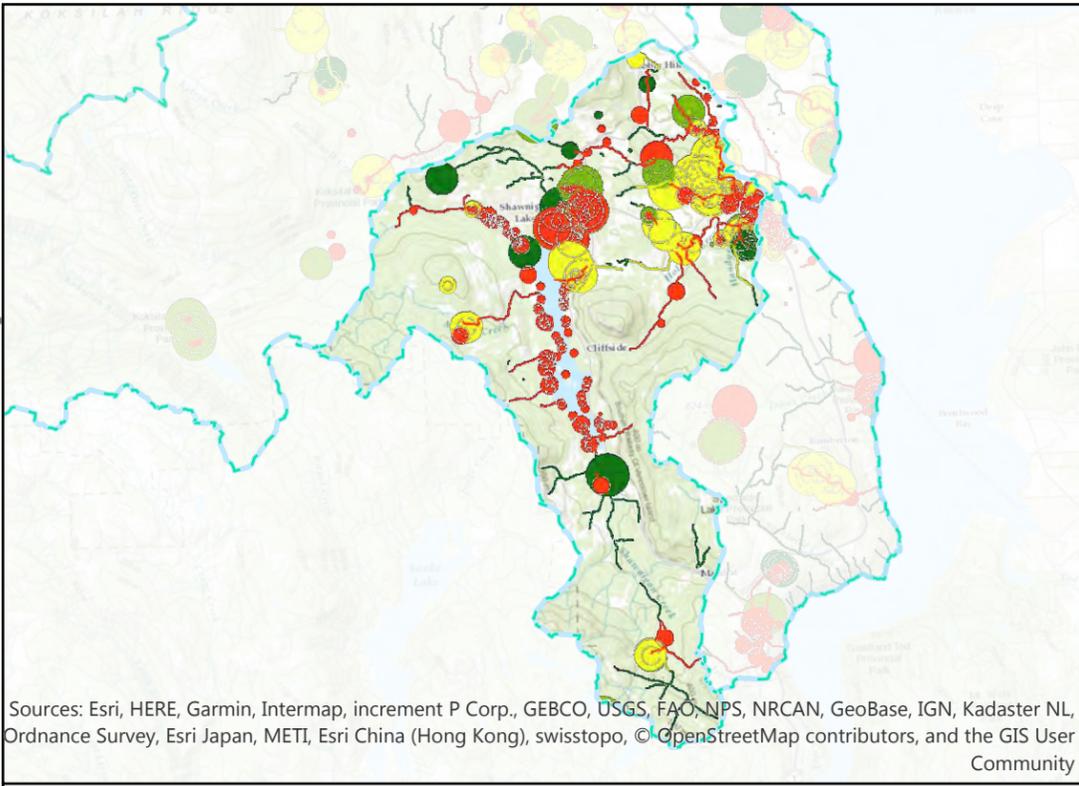
**Surface Water Quality Risk Assessment - Shawnigan Creek**



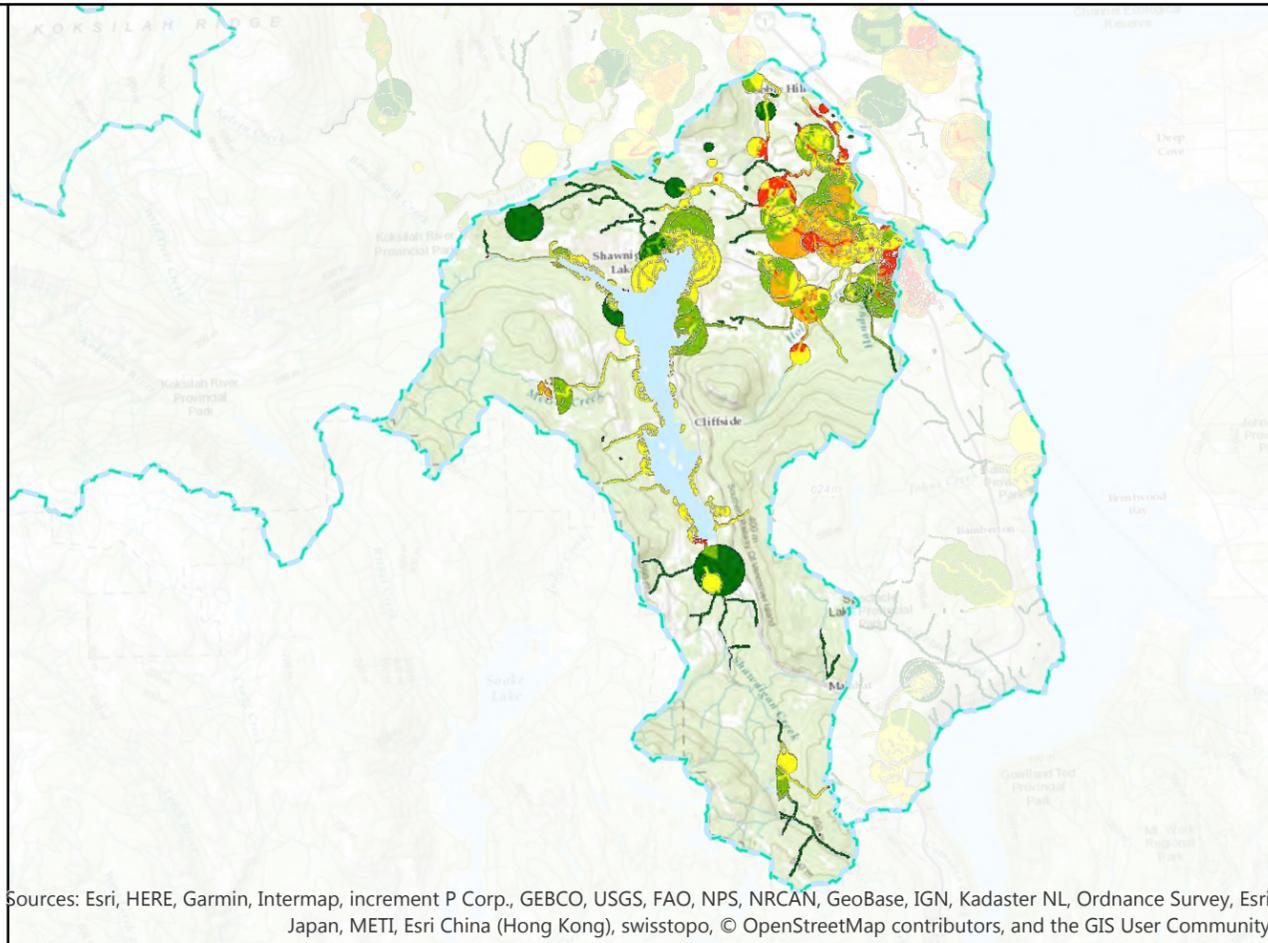
BY:	SCALE: 1:172,352	DATE: 2019/01/08	REF No:	REV: 0
CHKD:	Proj Coord Sys: PCS Albers		651957-104-SHAWN	

MXD Path: D:\Local\Projects\651957\_CVDR\GIS\CVRD\Presentation\CVRD\Presentation.aprx

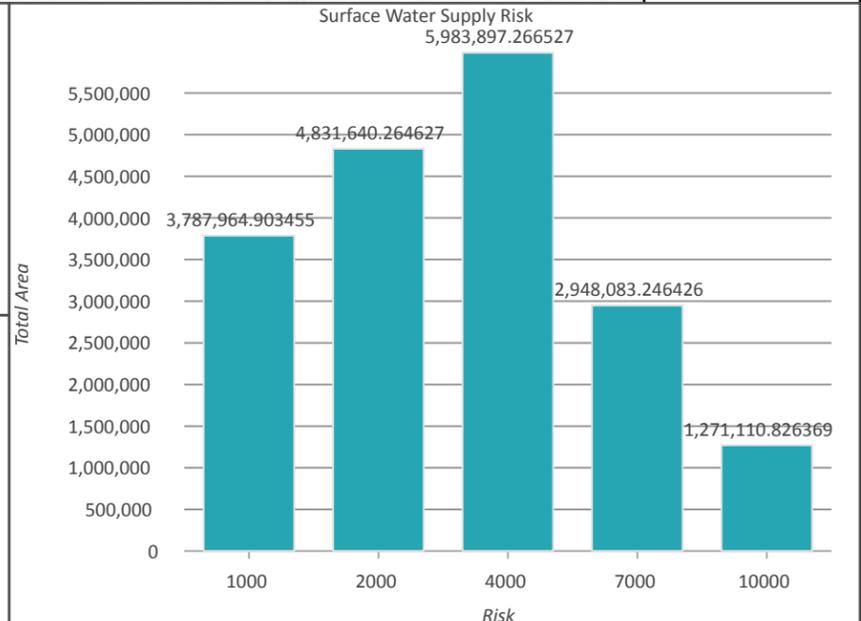
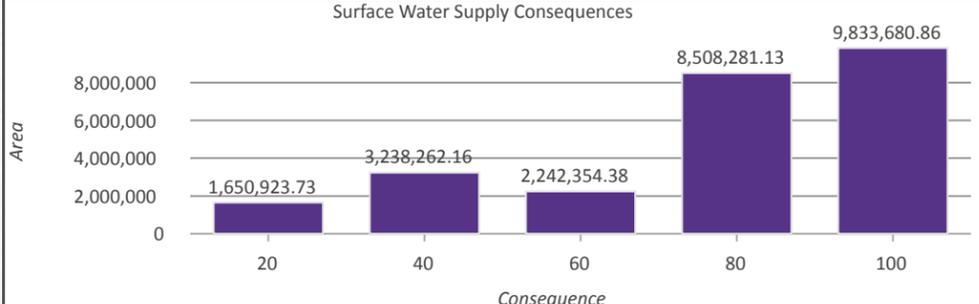
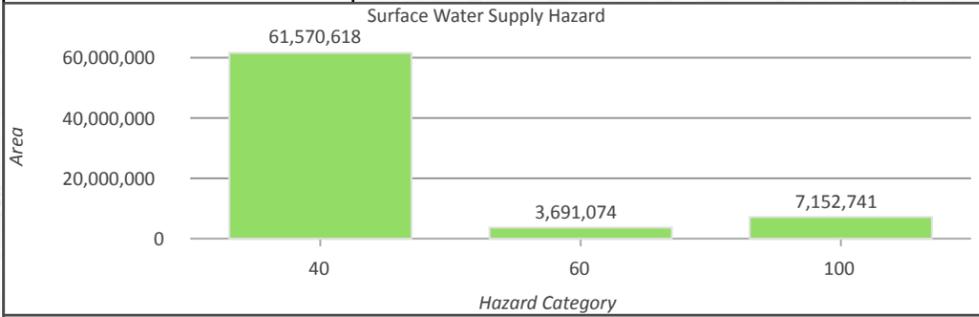
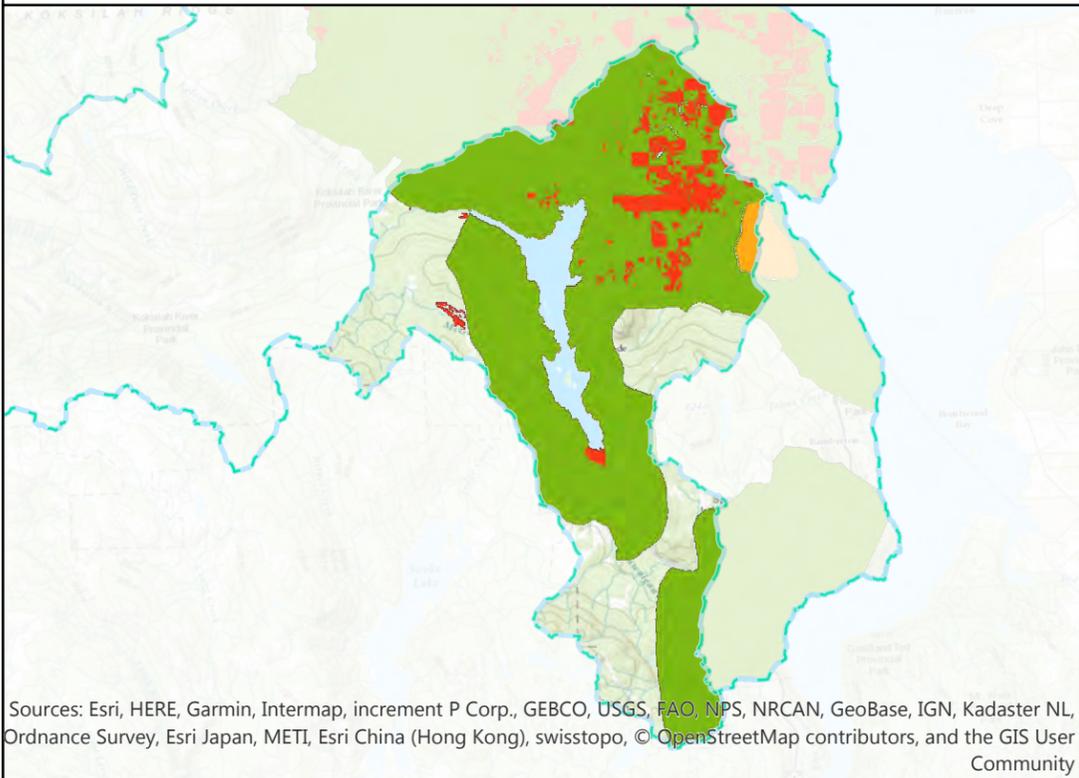
CONSEQUENCE



RISK



HAZARD



**Legend**

WATERSHED BOUNDARIES

CONSEQUENCES OR HAZARDS	RISK
≤ 20	≤ 1000
≤ 40	≤ 2000
≤ 60	≤ 4000
≤ 80	≤ 7000
≤ 100	≤ 10000

**REFERENCES:**  
1. Risk data compiled from various data sources provided by the Cowichan Valley Regional District. Presentation of data is intended to provide a general guidance on potential issues, rather than a definitive study.

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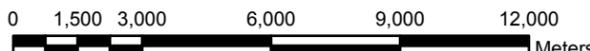
**REVISIONS:**  
0 - CJW - 2018-11-29 - Issued - DK

CLIENT:  
Cowichan Valley Regional District

PROJECT LOCATION:  
Cowichan Valley Regional District Shawnigan Creek Watershed

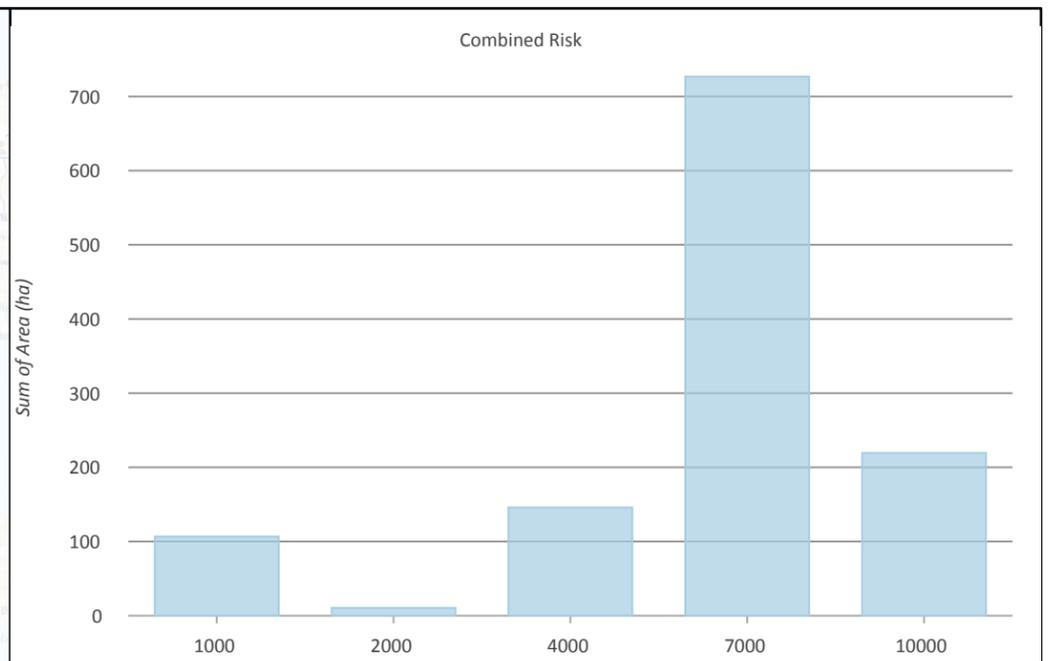
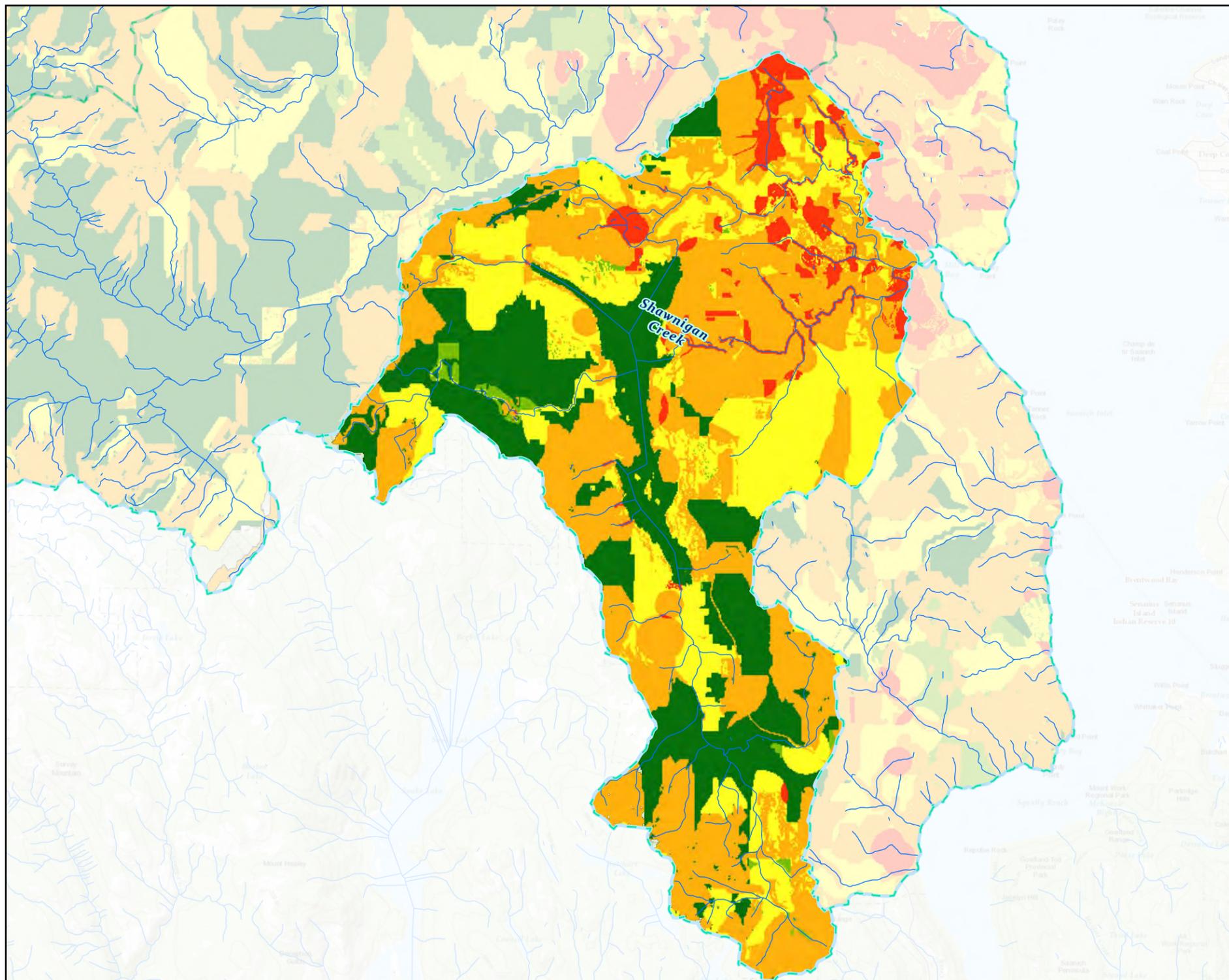


**Surface Water Supply Risk Assessment - Shawnigan Creek**



BY:	SCALE: 1:167,469	DATE: 2019/01/08	REF No:	REV: 0
CHKD:	Proj Coord Sys: PCS Albers		651957-105-SHAWN	

MXD Path: D:\Local\Projects\651957\_CVDR\GIS\CVRD\Presentation\CVRD\Presentation.aprx



NAME	Risk	POP <sub>2021</sub>	POP <sub>2026</sub>	POP <sub>2031</sub>	POP <sub>2036</sub>
SHAWNIGAN CREEK		10047	10760	11613	12598
BUSH CREEK		0	0	0	0
KOKSILAH RIVER		5463	5851	6315	6850
HOLLAND CREEK		1302	1368	1446	1537
BONSALL CREEK		934	974	1019	1073
CHEMAINUS RIVER		1490	1461	1439	1421
COWICHAN RIVER		36368	37905	39683	41766
YELLOW POINT BENCHLANDS		2239	2352	2487	2643
LADYSMITH - SALT AIR BENCHLANDS		8410	8834	9342	9929
STOCKING CREEK		1531	1608	1701	1807
CHEMAINUS BENCHLANDS		3663	3818	3997	4207
SATELLITE CHANNEL BENCHLANDS		4390	4701	5074	5504
SANSUM NARROWS - COWICHAN BAY BENCHLANDS		4941	5150	5391	5674
MALAHAT BENCHLANDS		2829	3030	3271	3548

NAME	POP <sub>2001</sub>	POP <sub>2006</sub>	POP <sub>2011</sub>	POP <sub>2016</sub>
SHAWNIGAN CREEK	6348	8439	8925	9484
BUSH CREEK	0			
KOKSILAH RIVER	4555	4808	4954	5157
HOLLAND CREEK	1611	1114	1169	1245
BONSALL CREEK	672	830	815	890
CHEMAINUS RIVER	1423	1395	1497	1514
COWICHAN RIVER	29779	32673	34075	34647
YELLOW POINT BENCHLANDS	1167	1958	2021	2141
LADYSMITH - SALT AIR BENCHLANDS	5275	7488	7541	8042
STOCKING CREEK	1332	1003	1354	1464
CHEMAINUS BENCHLANDS	3177	3129	3085	3490
SATELLITE CHANNEL BENCHLANDS	5425	3902	3989	4144
SANSUM NARROWS - COWICHAN BAY BENCHLANDS	5993	4221	4500	4707
MALAHAT BENCHLANDS	1673	2472	2548	2671

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

**Legend**

WATERSHED BOUNDARIES

**RISK**

- ≤ 1000
- ≤ 2000
- ≤ 4000
- ≤ 7000
- ≤ 10000

**REFERENCES:**

- Risk data compiled from various data sources provided by the Cowichan Valley Regional District. Presentation of data is intended to provide a general guidance on potential issues, rather than a definitive study.

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**REVISIONS:**

0 - CJW - 2018-11-30 - Issued - DK

CLIENT:  
Cowichan Valley Regional District

PROJECT LOCATION:  
Cowichan Valley Regional District  
Shawnigan Creek Watershed

**Combined Risk Assessment - Shawnigan Creek**

BY: CJW    SCALE CONS: 1:98,000    DATE: 2019/01/08    REF No:    REV: 0

CHKD: DK    Proj Coord Sys: NAD 1983 UTM Zone 10N    **651957-106-SHAWN**