Corporation of the City of
NEW WESTMINSTER

Attachment # 1

Snow Survey & Water Supply Bulletin

– April 1st, 2023

Snow Survey and Water Supply Bulletin – April 1st, 2023

The April 1st snow survey is now complete. Data from 124 manual snow courses and 96 automated snow weather stations around the province (collected by the Ministry of Environment and Climate Change Strategy's Snow Survey Program, BC Hydro and partners), and climate data from Environment and Climate Change Canada (ECCC) and the provincial Climate Related Monitoring Program have been used to form the basis of the following report.

Executive Summary

- March was cool and dry throughout B.C.
- The provincial snow pack decreased to slightly below normal for April 1st with the average of all snow sites across B.C. measuring 88% of normal (March 1st: 94%).
- The Fraser River at Hope snow index is normal at 100%.
- Above normal snow indicates a higher risk for snowmelt related spring flooding for the Upper Fraser West, Chilcotin, Okanagan, Lower Thompson and Boundary basins.
- Basins with normal to slightly below normal snow are still at risk for spring flooding if adverse weather occurs.
- La Niña conditions existed during the fall and winter 2022-23. Typically, La Niña years can lead to increased late season snowfalls and delayed onset of snowmelt.
- By April 1st, nearly 95% of the seasonal snow pack has accumulated, on average.

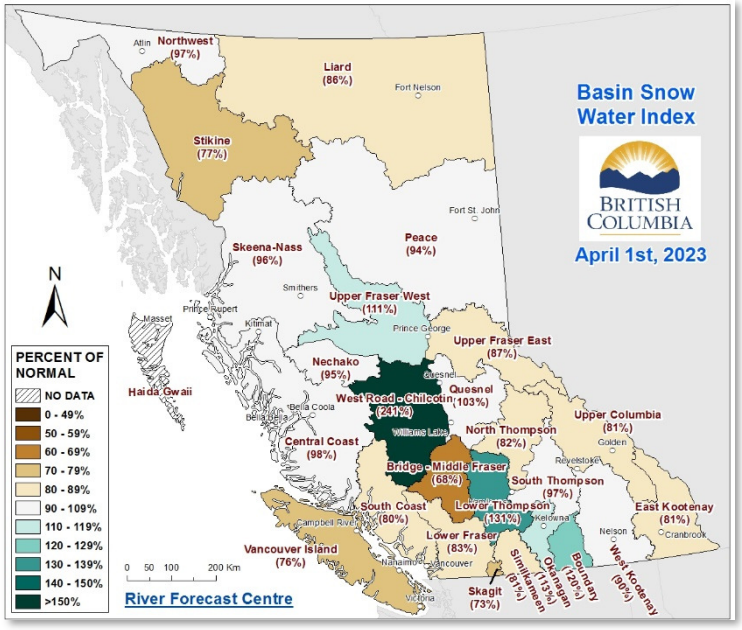

Figure 1. April 1st, 2023 Basin Snow Water Index Map of British Columbia. Larger version available in full report.

Table 1. April 1st 2023 Snow Basin Indices in B.C.

Basin	% of Normal	Basin	% of Normal	Basin	% of Normal
Upper Fraser West	111	North Thompson	82	South Coast	80
Upper Fraser East	87	South Thompson	97	Vancouver Island	76
Nechako	95	Fraser River	87	Central Coast	98
Middle Fraser	89	Upper Columbia	81	Skagit	73
Lower Thompson*	131	West Kootenay	90	Peace	94
Bridge*	68	East Kootenay	81	Skeena-Nass	96
Chilcotin*	241	Boundary	120	Liard	86
Quesnel*	103	Okanagan	113	Stikine	77
Lower Fraser	83	Similkameen	81	Northwest	97
		Nicola	109	Fraser R @ Hope	100
British Columbia 88% of Normal					

* Sub-basin of Middle Fraser

Next scheduled snow bulletin release: May 9th, 2023

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Weather

Temperatures in March were below normal across British Columbia ranging from -0.2 ºC to -3.8ºC for the month. The coldest relative anomalies occurred in northern and interior regions, like Fort St John, Prince George, Quesnel and Williams Lake.

March was very dry throughout B.C. Only a few climate stations in coastal locations measured above 50% of normal precipitation for the month. Several stations ranked among the five lowest March precipitation totals in recorded history. These include Abbotsford, Penticton, Vernon, Quesnel, Kamloops, Prince Rupert, Terrace and Dease Lake. Penticton recorded the second lowest total (1.8 mm) since 1908.

Temperatures have been seasonal to below seasonal through the first ten days of April. Several storms have impacted the province this month, so far. A weak atmospheric river impacted the South Coast and Vancouver Island on April 9th. Another moderate to heavy precipitation event occurred in the South Interior on April 10th. Both these events resulted in High Streamflow Advisories.

Snowpack

Snow Basin Indices (SBI) for April 1st, 2023 range from a low of 73% of normal in the Skagit to a high of 120% in the Boundary (Table 1, 2 and Figure 1, 5, 6). Sub-basins within the Middle Fraser ranged even more widely, with the Bridge region measuring 68% of normal and the Chilcotin at 241%. The provincial snow pack is slightly below normal for April 1st, with the average of all snow measurements across B.C. at 88%, decreasing from 94% of normal on March 1st due to dry conditions during the month.

In general, most regions in the province are slightly below normal (80-100% of normal) for April 1st. Above normal snow pack was measured in the following basins in the Interior, the Upper Fraser West (111%), Okanagan (113%), Boundary (120%), and sub-basins of the Middle Fraser – Quesnel (103%), Chilcotin (241%) and Lower Thompson (131%). Areas with below normal snow pack (<80% of normal) include the Stikine (77%), Vancouver Island (76%), Skagit (73%) and the Bridge sub-basin of the Middle Fraser (68%).

The average of all snow measurements for the entire Fraser River basin (e.g., upstream of the Lower Mainland and inclusive of Upper Fraser West, Upper Fraser East, Nechako, Middle Fraser, Lower Fraser, North Thompson and South Thompson) is 87%, decreasing from 94% on March 1st.

The River Forecast Centre calculates an additional Snow Basin Index for the Fraser River at Hope based on each basin's contribution to the total annual flow of the river. For example, the Upper Fraser East contributes approximately 30% of the total flow for the Fraser River at Hope, the North Thompson about 16%, the South Thompson

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about 11% and the Quesnel approximately 9%. The Fraser River at Hope Snow Basin Index is 100% of normal for April 1st. It ranks as the 28th highest in the past 54 years.

Most regions decreased in snow pack relative to normal compared to March 1st due to drier than normal conditions. Some lower elevation regions measured increases compared to March 1st primarily due to delayed snowmelt from cooler weather. These include the Chilcotin (+102 percentage points) and Skagit (+14).

Last year, the average of all snow stations in British Columbia for April 1st, 2022 was 99% of normal (Table 3). Most snow basins are lower this year compared to last year. Notable exceptions include the Upper Fraser West (+18 percentage points compared to 2022), Lower Thompson (+48), Chilcotin (+169), Boundary (+33), Okanagan (+39), and Nicola (+40).

Please review the full summary data tables and SBI bar charts at the end of this report for further interpretation.

Table 2 – B.C. Snow Basin Indices – April 1, 2023 compared to March 1, 2023

Basin	April 1st % of Normal (Mar 1 value)	Percentage Point Change Mar 1 to Apr 1	Basin	April 1st % of Normal (Mar 1 value)	Percentage Point Change Mar 1 to Apr 1
Fraser River Region			**Columbia Region**		
Upper Fraser East	87 (96)	↓ -9	Upper Columbia	81 (85)	↓ -4
Upper Fraser West	111 (124)	↓ -13	West Kootenay	90 (90)	0
Nechako	95 (99)	↓ -4	East Kootenay	81 (89)	↓ -8
Middle Fraser	89 (94)	↓ -5	Boundary	120 (123)	↓ -3
Lower Thompson*	131 (130)	↑ +1	Okanagan	113 (124)	↓ -11
Bridge*	68 (74)	↓ -6	Similkameen	81 (82)	↓ -1
Chilcotin*	241 (139)	↑ +102	**Northern Region**		
Quesnel*	103 (111)	↓ -8	Peace	94 (102)	↓ -8
Lower Fraser	83 (85)	↓ -2	Skeena-Nass	96 (103)	↓ -7
North Thompson	82 (91)	↓ -9	Liard	86 (103)	↓ -17
South Thompson	97 (105)	↓ -8	Stikine	77 (84)	↓ -7
Coastal Region			Northwest	97 (90)	↑ +7
South Coast	80 (92)	↓ -12	**Additional**		
Vancouver Island	76 (77)	↓ -1	Fraser River	87 (94)	↓ -7
Central Coast	98 (105)	↓ -7	Fraser R at Hope	100 (101)	↓ -1
Skagit	73 (59)	↑ +14	Nicola**	109 (123)	↓ -14
British Columbia 88 (94) ↓ -6					

* Sub-region of the Middle Fraser

** Sub-basin of Lower Thompson – includes representative stations within Okanagan

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Table 3 – B.C. Snow Basin Indices – April 1, 2023 compared to April 1, 2022

Basin	April 1st % of Normal (2022 value)	Percentage Point Change 2022 to '23	Basin	April 1st % of Normal (2022 value)	Percentage Point Change 2022 to '23
Fraser River Region			**Columbia Region**		
Upper Fraser East	87 (117)	↓ -30	Upper Columbia	81 (115)	↓ -34
Upper Fraser West	111 (95)	↑ +18	West Kootenay	90 (101)	↓ -11
Nechako	95 (88)	↑ +7	East Kootenay	81 (101)	↓ -20
Middle Fraser	89 (103)	↓ -14	Boundary	120 (87)	↑ +33
Lower Thompson*	131 (83)	↑ +48	Okanagan	113 (74)	↑ +39
Bridge*	68 (96)	↓ -28	Similkameen	81 (94)	↓ -13
Chilcotin*	241 (72)	↑ +169	**Northern Region**		
Quesnel*	103 (116)	↓ -13	Peace	94 (94)	0
Lower Fraser	83 (91)	↓ -8	Skeena-Nass	96 (99)	↓ -3
North Thompson	82 (119)	↓ -37	Liard	86 (112)	↓ -26
South Thompson	97 (101)	↓ -4	Stikine	77 (105)	↓ -28
Coastal Region			Northwest	97 (134)	↓ -37
South Coast	80 (95)	↓ -15	**Additional**		
Vancouver Island	76 (74)	↑ +2	Fraser River	87 (102)	↓ -15
Central Coast	98 (93)	↑ +5	Fraser R at Hope	100 (108)	↓ -8
Skagit	73 (90)	↓ -17	Nicola**	109 (69)	↑ +40
British Columbia 88 (99) ↓ -11					

* Sub-region of the Middle Fraser

** Sub-basin of Lower Thompson – includes representative stations within Okanagan

One manual snow course measured an all-time record high snow pack for April 1st:

- 1C33A Granite Mountain: 292 mm snow water equivalent (SWE; 149% of normal) – 17 years of record (Quesnel – Middle Fraser)

Percentiles express variability within datasets and are a particularly important metric for assessing conditions in regions for which percent of normal can be extremely high or low, ranking a snow water equivalent (SWE) value amongst all historical values for a given location. The basins with the highest average percentile are Middle Fraser sub-basins: Chilcotin (84th percentile) & Lower Thompson (80th); the region with the lowest is Bridge, also a Middle Fraser sub-basin (11th). A box plot displaying the percentile variance ordered from highest to lowest median, including sub-basins, is provided below in Figure 2.

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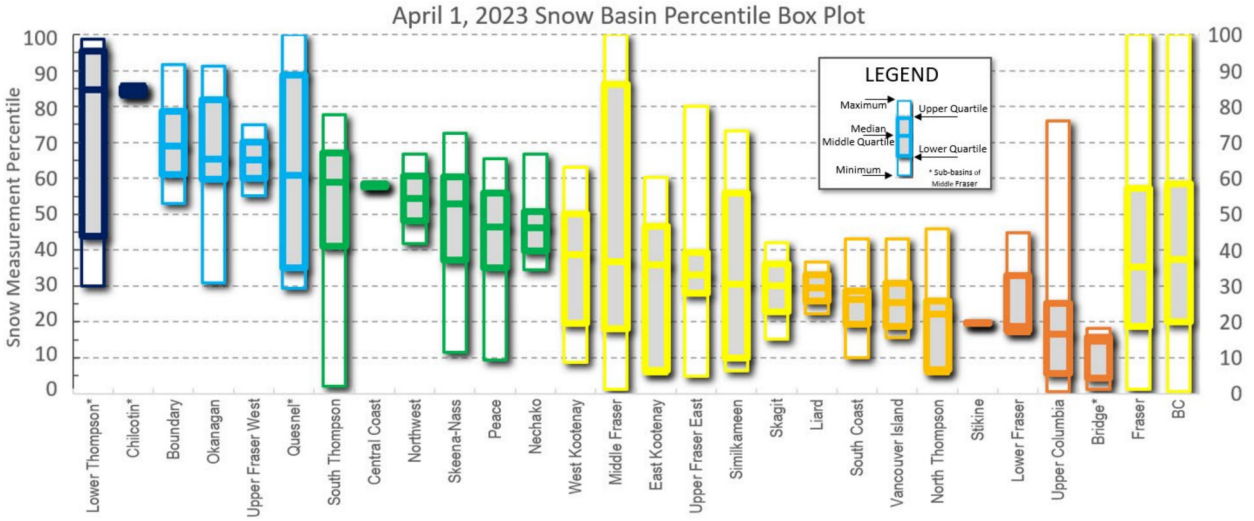
Figure 2. Snow Basin Percentile Box Plot – April 1st, 2023



The B.C. automated snow weather stations (ASWS) provide real-time SWE and snow depth data, usually recorded at a one-hour interval and summarized at a daily timestep for analysis. Figure 3 shows the percentage of snow stations that fall within a given percentile class over time. Percentile classes are defined as: well above normal (80th to 100th percentile), above normal (60th to 80th), normal (40th to 60th), below normal (20th to 40th), and well below normal (0 to 20th).

After a relatively dry January, storms in February drove a substantial shift to normal or above normal conditions for many stations. The more recent return to drier conditions is evident in the mid-March uptick in percent of stations in below normal and well below normal classes. For comparison, Figure 4 displays the changes in percentile classes at ASWS last year (2021-22).

Figure 3. Snow Water Equivalent Percentiles at Automated Snow Weather Stations (2022-2023)

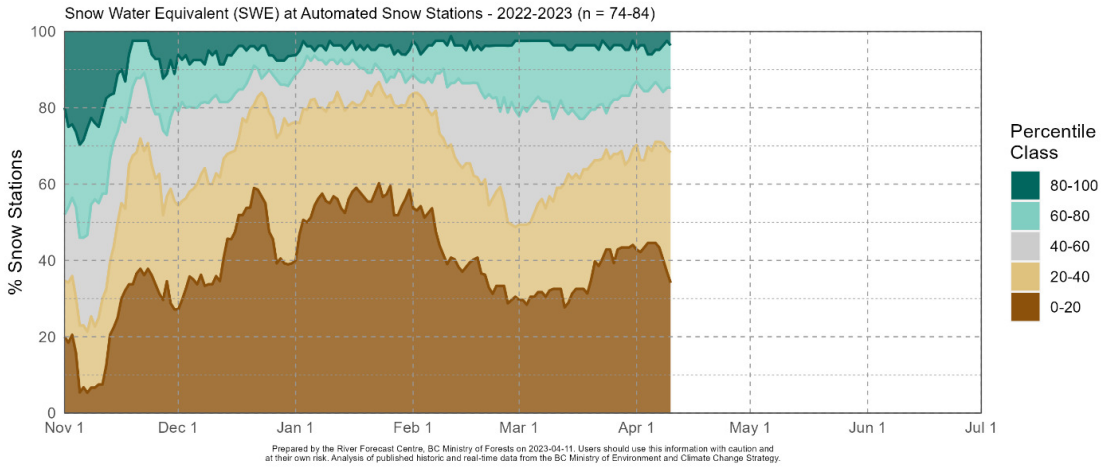


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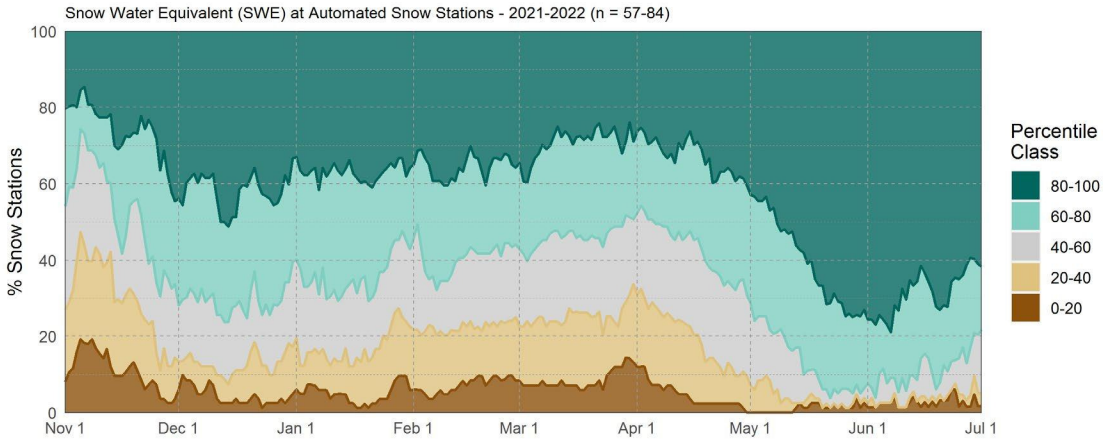
Figure 4. Snow Water Equivalent Percentiles at Automated Snow Weather Stations (2021-2022)



Seasonal Volume Forecasts

The seasonal volume runoff forecasts for April 1st are mostly near normal to slightly below normal (80-100% of normal). This includes forecasts for the Upper Fraser, Quesnel River, Thompson Basin, Bulkley, Skeena, Okanagan Lake, Kalamalka-Wood Lake, and Cowichan Lake. Below normal flow is predicted for the Similkameen River (~70%). The Nicola River and Nicola Lake forecasts range from slightly below normal to above normal (89-139% of normal). See the table further below in the report.

In 2021, updated inflow models were developed for Nicola Lake, Nicola River, Okanagan Lake and Kalamalka-Wood Lake. The new models incorporate ten additional years of data, including several years in the 2010s with extremely high or low runoff, as well as several other substantial refinements (see February 1st 2021 Snow Bulletin for additional details). In the past two seasons, both the original and updated models were run concurrently to examine the effects of the updates.

Outlook

The Climate Prediction Center (CPC) shows that La Niña conditions have ended and El Niño-Southern Oscillation (ENSO) neutral conditions are expected to continue through the spring and early summer 2023. La Niña conditions were present during the fall and winter 2022-23. La Niña occurs when oceanic temperature anomalies along the equatorial Pacific Ocean region are below normal for an extended period. Historically, La Niña conditions create cooler temperatures for British Columbia and wetter weather in the South Coast and Vancouver Island during the winter and spring months.

In the past, winter La Niña conditions in B.C. have often generated above normal snow pack for April 1st, particularly for the South

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Coast and Southern Interior. La Niña conditions can lead to late-season snow accumulation and delayed snowmelt, which increases the risk for freshet flooding (e.g., spring of 2022).

Seasonal weather forecasts from late-March by ECCC indicate a greater likelihood of above normal temperatures for northwestern sections of B.C. from April through June and below normal temperatures for some areas in the South Interior. There is a higher probability of above normal precipitation in the northeastern regions of the province.

Spring Flood Risk (Freshet)

Flooding is a provincial risk every spring due to a combination of snowmelt and/or rainfall (also known as freshet). Rivers are at risk for flooding even if the snow pack is below normal. The weather conditions during spring play a critical role in the rate at which the snow melts. For example, a gradual warming under dry conditions is ideal to lessen the flood risk. A lengthy cold period with high amounts of precipitation followed by a sudden extreme heat wave could lead to catastrophic conditions, especially if additional rain follows. Spring weather is impossible to predict with accuracy in advance.

Communities and residents vulnerable to flooding should prepare accordingly. Information for Get Prepared for Floods is available from the Ministry of Emergency Management and Climate Readiness.

Typically, regions with above normal snow pack have a higher risk for flooding. As of April 1st, 2023, these areas include Upper Fraser West (111% of normal snow pack), Lower Thompson (131%), Chilcotin (241%), Boundary (120%), and Okanagan (113%). There are pockets in the Quesnel and South Thompson where snow stations measured above normal.

Regions with near normal or slightly below normal snow pack measurements for April 1st can still be susceptible to spring flooding based on weather conditions over the next three months.

November 2021 Atmospheric River Floods

The unprecedented and catastrophic flooding that occurred in November 2021 has made many rivers more vulnerable to flooding during freshet. Due to the significant erosion and possible changes in river channel morphology that occurred within many areas (including but not limited to the Coldwater River, Nicola River and tributaries, Tulameen River, Coquihalla River and lower Fraser River), rivers may be at increased vulnerability to high flows at lower levels than previous freshet seasons. The freshet season differentiates from the fall flooding season as flows tend be sustained for longer periods of time during snowmelt compared to shorter duration rainfall events. Currently, the Nicola River has

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a higher risk as it measures above normal snow pack for April 1st.

Extreme Weather Events

In general, flooding usually occurs due to extreme weather. In 2021, there were two extreme weather events that resulted in catastrophe: the heat dome in late-June and atmospheric rivers in November. Alpine temperatures during the heat dome reached up to 38°C and triggered extraordinary snow melt rates (80-100 mm SWE / day) at high elevation ASWS with snow remaining. If such an extreme heat event occurred earlier in the freshet season when there is more snow to melt (May or early-June), it could lead to significant flooding at a provincial scale.

Atmospheric rivers tend to affect the province primarily between September and January. However, strong storms can occur as early as August for the North Coast and extend into the February and March for the South Coast. It is less likely that these events will occur from April to June, but not impossible.

Although not as extreme as the previous examples, the most likely cause for major flooding would be a period of persistent cool temperatures and wet weather into the late spring, followed by a sudden heat wave of at least five or more days. There is evidence that floods in 1948 and 1894 on the Fraser River were caused by this scenario. Based on active manual snow surveys that were sampled in 1948, the snow conditions for April 1st, 1948 were average, showing the importance of spring weather to flooding. An additional high-risk scenario is a widespread heavy rainfall event that coincides with high flows from snowmelt.

Wrap-around low pressure, or cold low, systems pose as another risk of primarily rain-driven flooding. The risk of these events occurring increases in June and typically extends into July. These systems can deliver extreme rainfall which wraps around the province and typically leads to upslope precipitation enhancement to eastern slope mountainous regions. These can be augmented or enhanced by snowmelt and high antecedent streamflow conditions. Flood events from this phenomenon have occurred in the Peace Region in 2012 and 2016, Fernie (and Calgary/Alberta) in 2013, and in the Chilcotin in 2019.

Gaps in Snow Monitoring

Regions in the province that lack physical snow monitoring (manual or automated) include:

- Cache Creek and Bonaparte River. The Caverhill Lake New (1C42) manual snow survey was conducted for April 1st and was measured at 130% of normal (96th percentile). Unfortunately, the nearby Deadman River (1C32) sustained extensive damage from wildfire and will no longer be measured. A replacement automated snow weather station was built at Deadman River (1C32P) last spring. The April 1st measurement at the snow pillow was 253 mm. The previous all time high SWE value for the Deadman River manual snow site was 196 mm over a 38-year period.

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- The Nazko and West Road River region no longer has snow monitoring. This region experienced intense flooding in 2018 and sustained high flows in 2020.
- The Chilako River (just north of the West Road River).
- Salmon River near Prince George.
- Salmon River near Salmon Arm.

These regions typically are the first rivers in the season to experience significant increases in flow from snowmelt due to their lower elevation.

Remote sensing is used to support areal-based assessment of snow coverage in these regions; however, it is difficult to accurately determine seasonal flood risks in these areas due to lack of on-the-ground measurements.

La Niña Conditions

Although sea surface temperature patterns have transitioned from La Nina to ENSO-neutral, effects of the winter La Nina conditions can persist into spring. Areas in the South Interior (including the Okanagan, Boundary and Kootenay) can still receive additional precipitation in April and early May which could increase SBI for May 1st.

Typically, freshet (snowmelt) flood risk is limited on Vancouver Island and the South Coast as precipitation from Atmospheric Rivers in the fall and winter period overshadows the effect of snowmelt during spring.

Summary

By early April, approximately 95% of the seasonal provincial snow pack typically accumulates. Snow pack throughout B.C. ranges from 68 to 241% of normal. The average for all snow measurements across the province for April 1st is 88% of normal, decreasing from 94% on March 1st. The Fraser River at Hope is 100% of normal. Several regions in the Interior are above normal and indicate a higher risk for snowmelt related flooding during the spring months (freshet).

The combination of slightly below normal April 1st snow pack and La Niña conditions over the winter potentially leading to cooler March and April temperatures means there is a slightly elevated risk for freshet-related flooding.

Snow pack is only one factor related to freshet flood risk. Weather conditions from April through June determine the timing, magnitude, and rate of snow melt; heavy rainfall events can exacerbate the situation. Flooding is possible in years with normal or even below normal snow pack. Conversely, high snow pack does not necessarily lead to flooding in the absence of significant contributing weather during the snow melt season.

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The River Forecast Centre continues to monitor snow pack conditions and will provide an updated seasonal flood risk forecast in the May 1st, 2023 bulletin scheduled for release on May 9th.

River Forecast Centre
April 12, 2023

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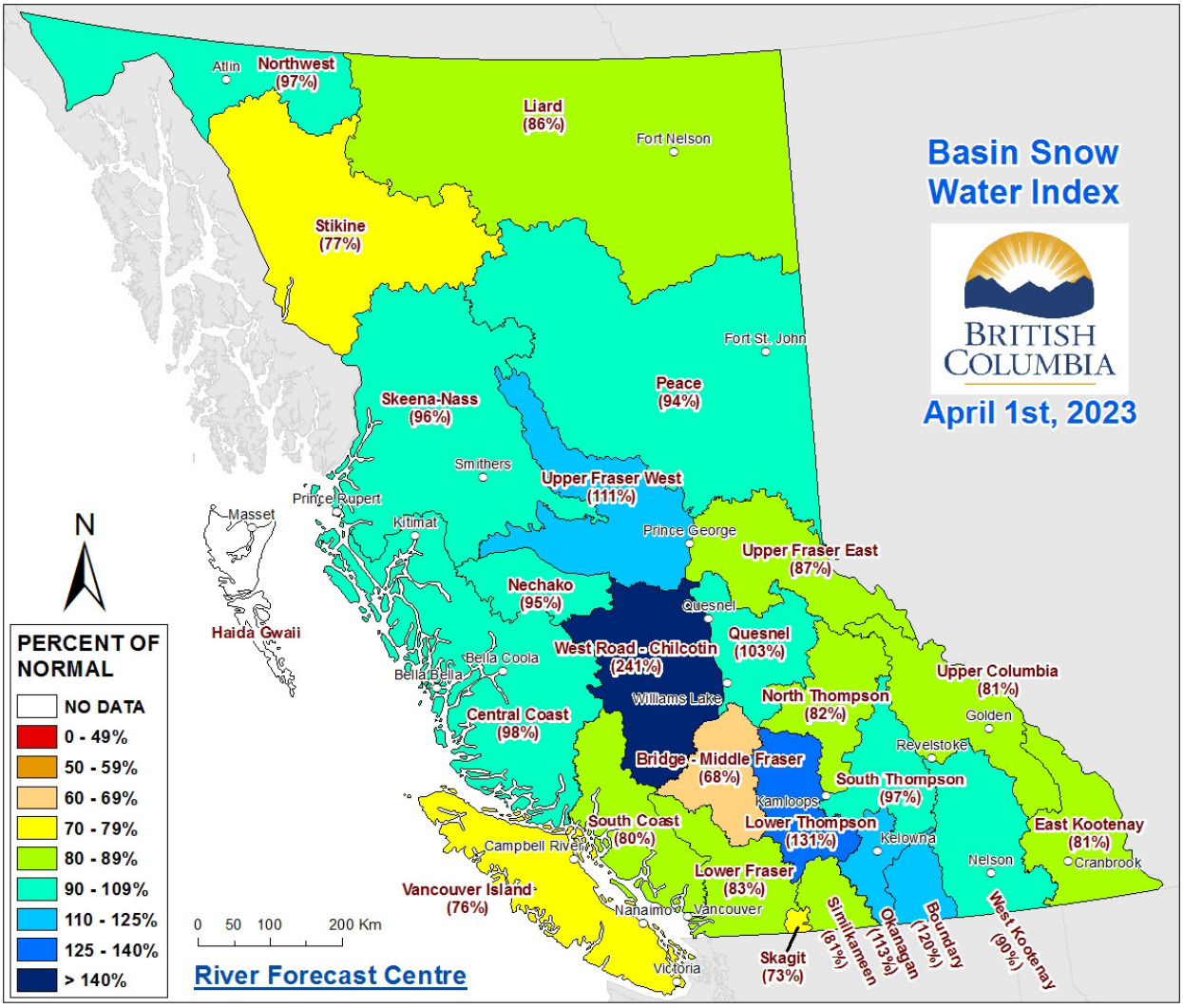
Figure 5: Basin Snow Water Index – April 1st, 2023



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