Changes in streamflow: recent observations match climate change projections

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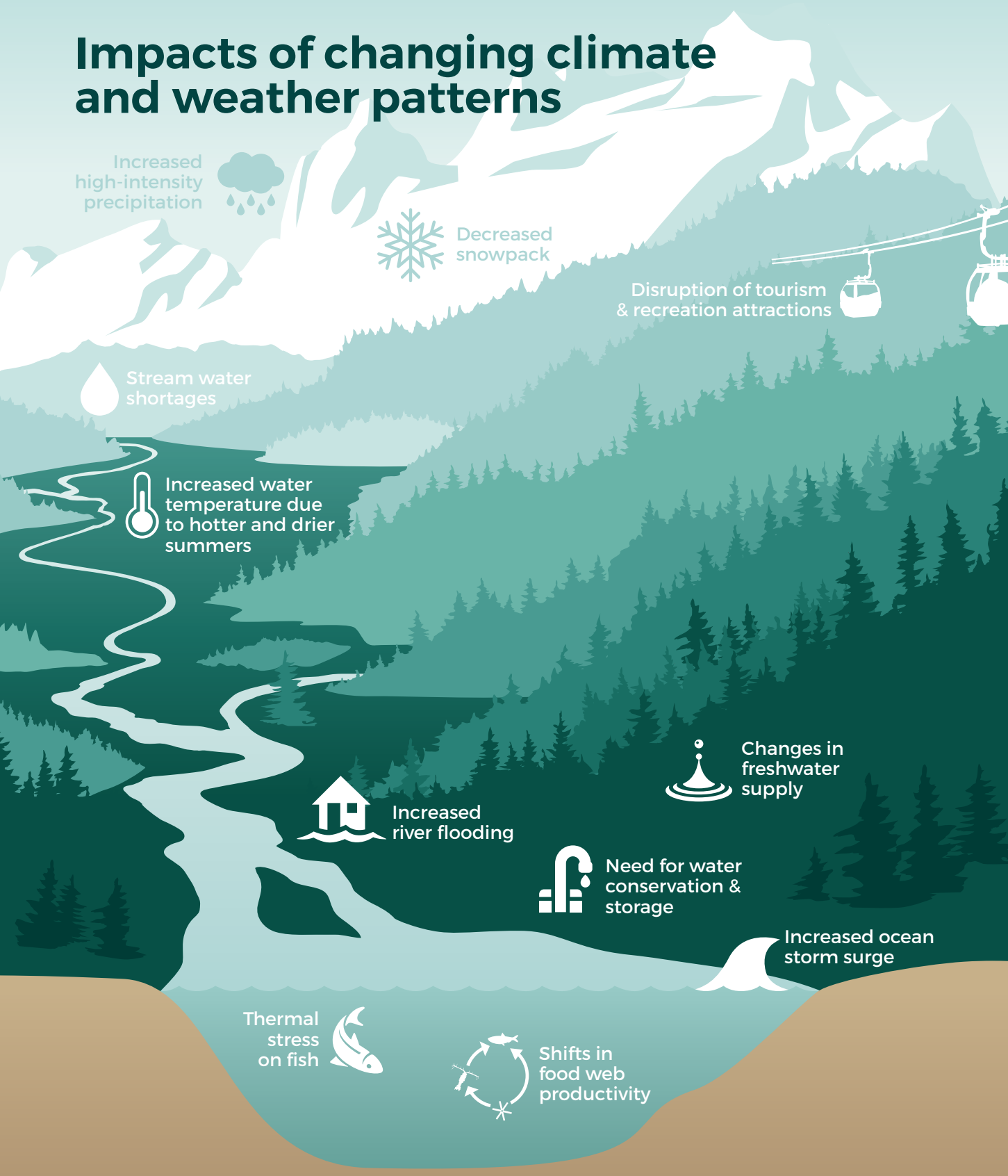
What is happening?

We hear more and more about "extreme" weather events and their impacts in recent years. For example, on Sept. 20 2015, high rainfall and flooding in the Squamish valley washed out sections of the Forest Service Road accessing the Upper Squamish Valley. Squamish Search and Rescue lifted five adults and two children out of the area by helicopter and reported that at least five vehicles were swept into the river on that day.[1] It turns out that new maximum streamflows were observed, for that calendar day and the next, into the Daisy Lake Reservoir on the Cheakamus River north of Squamish. Streamflows on those days were not extreme compared to historical records, but were higher than recorded since 1960 for those calendar dates.

For this article, naturalized daily freshwater flow into the Daisy Lake Reservoir was examined.[2] Compared to long-term averages for 1960 to 2014, daily flows in 2015 showed highest volumes early in the year rather than in the fall, and summer flows that were consistently below average from early June almost to the end of August (Figure 1). New minimums for a few calendar days were recorded in June and July. Data for 2016 is following a similar pattern and this new seasonal pattern matches climate projections for the region.[3]

Impacts of changing climate and weather patterns



Why is it important?

Many species are adapted to the historical patterns of seasonal flow in freshwater streams and creeks. In Howe Sound this would include, among others, salmonid and eulachon species that migrate between the sea and freshwater to spawn and back to mature. Phytoplankton, plant like organisms at the base of marine food webs, blooms in the spring depending on a number of factors including freshwater input and cloudiness of the water, especially at the head of a fjord like Howe Sound. Changes in the timing of a spring phytoplankton bloom due to a different freshwater flow regime could produce a timing mismatch that would impact the growth and survival of zooplankton, and have impacts further up the food web (see Plankton article).

Streamflow is a traditional metric for hydrology; one that is used to describe the hydrologic regime, or seasonal pattern of flow in a stream or river.[4] This pattern is obviously a reflection of the climate and weather patterns, as flow varies with rainfall and snow and glacier melt related to temperature.

Howe Sound sits within the South Coast Region, where trends show climate warming and increased precipitation with large variability in the winter season.[5] Projections for the region include warming in all seasons and modest precipitation changes compared to historical variability. Precipitation is projected to increase in all seasons except summer. These changes are already reflected in the new pattern of flows reported in the Cheakamus watershed.

Potential direct impacts include decreased snowpack, increased high-intensity precipitation, possible water shortages, and increased thermal stress on fish and aquatic habitats (due to hotter and drier summers).[3] In addition, both river flooding and ocean storm surge events may increase in frequency and magnitude and a transition to rainfall-dominant watersheds would create the need for water conservation and storage.[3] Some of the potential indirect impacts of these projected changes include disruption of tourist and recreation attractions with economic consequences, shifts in food web productivity with ecological consequences, and changes in fresh water supply with consequences for wellbeing and governance.

Flooded road in the Squamish valley, September 20, 2015. (Photo: Barb Lang)

Rivers, waterways were the paths of Our Ancestors[6]

Historically, the rivers, lakes and oceans of our territories teemed with salmon, herring and trout, all valuable food sources. These waterways were also the roads and highways of our Ancestors, an efficient way of getting from one Nation to another for trade and social gatherings. Water features large in our oral histories, reflecting the fact that water was, and in many ways still is, the lifeblood of the Squamish Nation.

Photo: Gary Fiegehen

"We would travel by canoe from **Stá7mes** (Stawamus) to the town of Newport (Squamish) to go shopping. My sister Ch'atatult-t (Florence) and I would take the canoe. We would buck the tide but we made it. I was strong for a small woman." – Kwítelut-t Sintl' (Late Elder Lena Jacobs), Squamish Nation

What is the current state?

Streamflow in 2015 and 2016 compared to the historical pattern shows higher than average winter flows, especially late January through late February when we would typically be experiencing snowfall, earlier spring freshet, and lower than average flows in summer from June through August (Figure 1.) These changes are mirrored to some extent across watersheds that impact B.C. coastal waters.[7] 2015 was an extreme climate year according to more than one indicator. Global records set in 2015 include the warmest year, the largest increase in carbon dioxide, the highest sea surface temperatures and heat contained in the upper portion of the ocean (meaning highest sea surface heights), and the lowest sea ice levels.[8]

Historically, the seasonal pattern in the Cheakamus River watershed has included high flows during snow and glacial melt starting in April and peaking in June

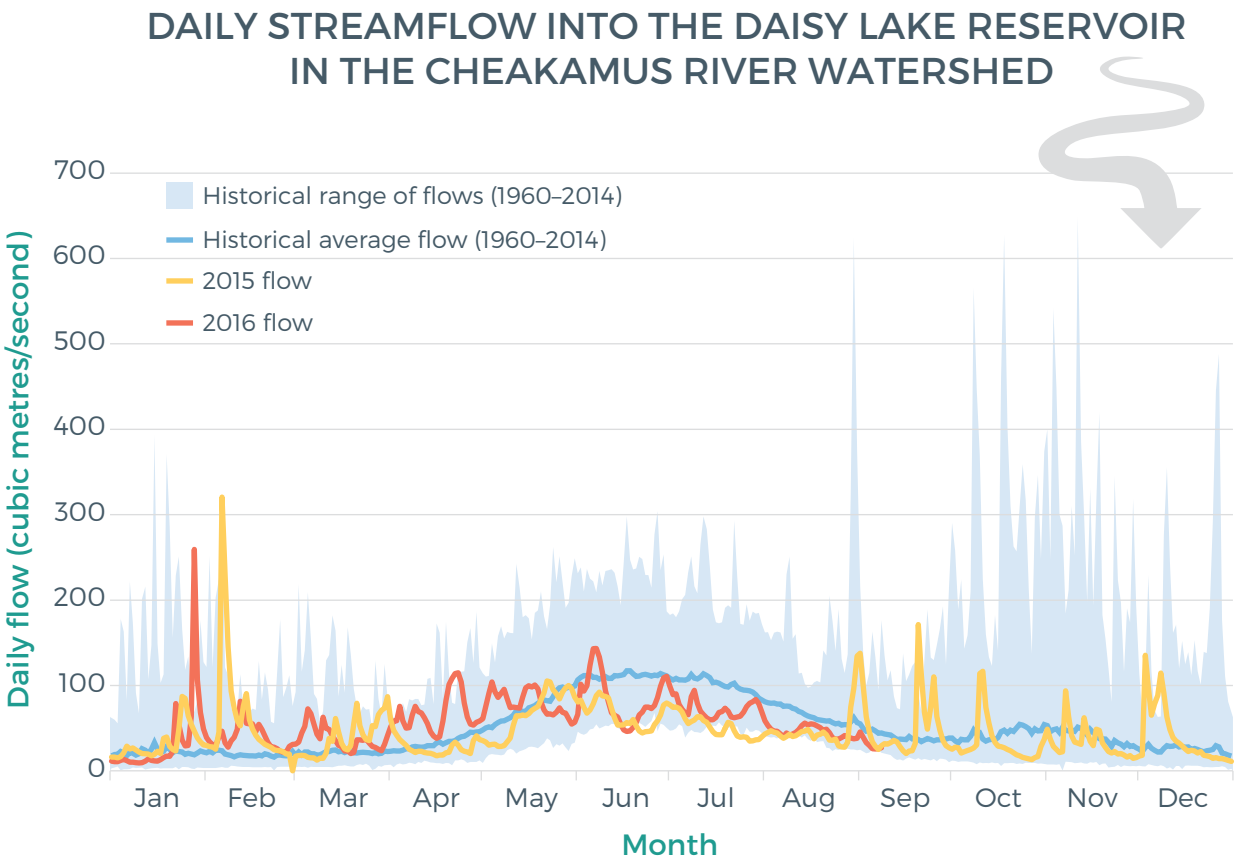


Figure 1. Daily streamflow into the Daisy Lake Reservoir in the Cheakamus River watershed.

or July, and decreasing through late summer and early fall. Flow is highly variable starting in October through December due to significant rainfall events and this is typically where the highest daily flows occur (Figure 1, average, maximum and minimum flows). Lower flows are also typical of the colder winter months, but large variability in the maximums recorded reminds us that winter snowfalls are interspersed with rainfall events.

What is being done?

Monitoring stream flows and noting the changes in seasonal patterns and extremes allows us to prepare for ongoing changes. For example, the District of Squamish is completing an Integrated Flood Hazard Management Plan (see Squamish Flood Planning article) in response to increased risk of flooding due to increased rainfall, sea level rise and risk of storm surge. BC Hydro is monitoring and studying hydrological changes to determine how climate change affects water supply and the seasonal timing of reservoir inflows in order to develop a climate change adaptation strategy.[9]

More broadly, local and regional governments around Howe Sound, individuals, and the Squamish Global Innovation Hub responded to the B.C. Government's Climate Action Leadership Plan, showing that people and governments are engaged. In August 2016, the Province released its Climate Leadership Plan.[10] Locally, Squamish has its own Climate Action Network to bring volunteers together on a number of projects looking at energy, food, and waste.[11]

Photo: Gary Fiegehen

What can you do?

SOME ACTIONS CONTRIBUTED BY CORI

Individual and Organization Actions:

- Record stream levels when enumerating salmon spawning.
- Withdraw, relocate or abandon private assets in high risk areas of flooding.
- Become familiar with the current Integrated Flood Hazard Management Plan. Be aware of flood hazards in your area and be prepared for an emergency at your home and workplace.
- Help prevent climate change by producing fewer greenhouse gasses. Adopt policies and practices within your organization.
- Implement and practice water conservation measures in your home and within your organization.
- Eat sustainable seafood to foster healthy and resilient fish populations.

Government Actions and Policy:

- Continue to closely monitor streamflow data and trends.
- Take action to minimize rainfall related flooding and associated consequences.
- Increase capacity to respond to extreme weather events, including droughts.
- Increase public education on what to do in the event of extreme weather, flooding and drought.
- Develop an education plan for the Integrated Flood Hazard Management Plan to educate locals, especially those in high-risk areas.
- Identify and develop plans for slopes at high risk of landslide.
- Protect the coastline from storm surge and flooding using Green Shores techniques (see Shorelines article).
- Withdraw, relocate or abandon public assets in high risk areas of flooding.
- Incorporate latest climate change hazard assessments into emergency response planning.
- Continue to renew the Integrated Flood Hazard Management Plan every five to 10 years.
- Develop policies for back-up power in all eventualities.
- Increase flood construction levels, add covenants to reduce liability and retrofit existing buildings.
- Identify future no-build zones or use land acquisition or restriction tools such as land trusts.
- Begin planning for opportunistic retreat of key facilities and infrastructure from high flood hazard areas at the end of their service life.
- Work with BC Hydro to ensure sufficient water flow in “managed” rivers supports salmon spawning and migration.

Resources

Pacific Climate Impacts Consortium
pacificclimate.org
The Pacific Climate Impacts Consortium (PCIC) is a regional climate service center at the University of Victoria that provides practical information on the physical impacts of climate variability and change in the Pacific and Yukon Region of Canada.

Climate Central
climatecentral.org
An independent organization (U.S.) of leading scientists and journalists researching and reporting facts about the changing climate and its impact.

City of Vancouver Climate Change Adaptation Strategy
vancouver.ca/files/cov/Vancouver-Climate-Change-Adaptation-Strategy-2012-11-07.pdf

Preparing for Climate Change
wcel.org/sites/default/files/WCEL_climate_change_FINAL.pdf
An implementation guide for local governments in British Columbia.

Footnotes

[1] Endicott, C. and J. Thuncher. 2015. "Campers rescued as Squamish Valley floods" The Squamish Chief, Sept 21, 2016. Accessed Sept 22, 2016. http://www.squamishchief.com/news/local-news/campers-rescued-as-squamish-valley-floods-1.2064282

[2] Record of naturalized inflow to Daisy Lake Reservoir. Sept 2016. Provided to the author by S. Smith, Manager, Hydrology, BC Hydro. Note that data through 2014 have had a quality review and data smoothing technique applied. Data for 2015 and 2016 have had only a cursory quality review. See also BC Hydro. 2005. Cheakamus Project Water Use Plan. Accessed Sept 15, 2016. https://www.bchydro.com/content/dam/hydro/medialib/internet/documents/environment/pdf/environment_cheakamus_wup.pdf

[3] Pacific Climate Impacts Consortium. 2013. Climate Summary for South Coast Region. Accessed Sept 16, 2016. https://www.pacificclimate.org/sites/default/files/publications/Climate_Summary-South_Coast.pdf

[4] Koshida, G., S. Cohen and L. Mortsch. 2015. Climate and water availability indicators in Canada: Challenges and a way forward. Part I – Indicators. Canadian Water Resources Journal / Revue canadienne des resources hydriques. http://dx.doi.org/10.1080/07011784.2015.1006023

[5] Pacific Climate Impacts Consortium. 2013.

[6] Reproduced with permission from "Where Rivers, Mountains and People Meet", Squamish Lílwat Cultural Centre.

[7] Morrison, J., W. Callendar, M.G.G. Foreman, D. Masson, and I. Fine. 2014. A model simulation of future oceanic conditions along the British Columbia continental shelf. Part I: Forcing fields and initial conditions. Atmosphere- Ocean, 52, 1, 1-19, doi:10.1080/07055900.2013.868340.

[8] Thompson, A. 2016. "2015 Set Frenzy of Climate Records." Climate Central, August 2, 2016. Accessed Sept 15, 2016. http://www.climatecentral.org/news/2015-set-frenzy-of-climate-records-20575

[9] Jost, G. and F. Weber. 2013. Potential Impacts of Climate Change on BC Hydro-Managed Water Resources. BC Hydro. Accessed Sept 22, 2016. https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/environmental-reports/potential-impacts-climate-change-on-bchydro-managed-water-resources.pdf

[10] Province of B.C. 2016. Climate Leadership. Accessed Sept 16, 2016. http://climate.gov.bc.ca/

[11] Squamish Climate Action Network. Accessed Sept 16, 2016. http://squamishcan.net/about-us/