Cover Sheet

Skagit Basin Supply and Demand Synthesis

Compiled Feedback

July 6, 2021

1. WSAS Review
2. Ecology Staff
3. Larry Wasserman
4. Joel Massmann (Keta Waters) via Larry Wasserman 1
5. Joel Massmann (Keta Waters) via Larry Wasserman 2
6. Thomas Mortimer (Skagit PUD)
7. Skagit County Drainage and Irrigation Districts Consortium

WASHINGTON STATE
Academy of Sciences
Science in the Service of Washington State

Independent Peer Review of the Skagit Basin Water Supply and Demand Analysis

Prepared for the Washington State Joint Legislative Task Force on Water Supply

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WSAS Committee on the Skagit Water Supply:
Michael Goodchild, *chair*, University of California, Santa Barbara (emeritus)
Rebecca Flitcroft, U.S. Forest Service
Eric Grossman, U.S. Geological Survey
Se-Yeun Lee, Seattle University
Mark Wigmosta, Pacific Northwest National Laboratory

WSAS Staff:
Donna Gerardi Riordan, Executive Director
Yasmeen Hussain, Program Officer
Devon Emily Thorsell, Program Operations Manager

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Washington State Academy of Sciences
901 5th Avenue, Suite 2900
Seattle, WA 98164
wsas.programs@washacad.org
www.washacad.org
206.219.2401

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INTERPRETATION OF CHARGE

The Washington State Joint Legislative Task Force on Water Supply requested that the Washington State Academy of Sciences (WSAS) conduct an independent peer review of the Skagit Basin Water Supply and Demand Analysis led by the State of Washington Water Research Center[1]. The Supply and Demand Analysis is a synthesis of existing scientific and technical knowledge of the Skagit hydrologic system to inform understanding of water supply and demand in the Skagit Basin and identify current gaps in knowledge to support effective water management in a changing environment. The analysis is presented as an interactive ESRI Story Map product.

WSAS convened a committee of disciplinary experts (referred to in this document as "the committee") with the charge to conduct an independent peer review. The committee performed its review in April and May 2021. Committee members are listed in the front matter and their full bios are in the Appendix.

The committee considered the following questions in their review of the Supply and Demand Analysis:

- Did the product provide a holistic view of water resource availability and use in the Skagit basin?
- In your view, is the synthesis of current data and science on current and projected future water supply and demand in the Skagit Basin (WRIA 3 and 4) complete and accurate? Is the content clear? Are there data or sources missing?
- Are there caveats or clarifications needed about the presented information?
- Is information about data gaps reflective of your understanding? Based on your knowledge of research on other watersheds, are there other knowledge gaps that additional research could fill in the near and long term?
- To what extent is the study replicable (could others repeat the study and reach the same conclusions; and is there sufficient detail in the report to support replication by others?)
- How effective is the Story Map format for communicating the content?

The purpose of the committee's review is to provide input to the Supply and Demand Analysis team to strengthen the scientific and technical aspects of the analysis.

[1] The Supply and Demand Analysis is led by the State of Washington Water Research Center with a team that includes the Climate Impacts Group, University of Washington, HDR Engineering, and NOAA Northwest Fisheries Science Center.

KEY RECOMMENDATIONS

- Provide more detail in the maps (such as labeling landmarks, municipalities, basins, streams, etc.) and in the text (plot titles, etc.) to help the reader orient their understanding of the water supply and demand data to well-known landmarks and also help the reader understand which basins are being referenced in the map.
- Define terms, both for the understanding of non-technical audiences and to clarify meaning and methods for technical audiences.
- Use units consistently to allow comparisons, and check that the correct units have been presented.
- Check for consistency in the data presented between different tabs and sections, and for correct water balance (equivalence of water inflows and outflows) throughout.
- Use the same figure legends for different figures that present the same type of data, to help the user understand where data is comparable.
- Clearly show whether the presented streamflow is regulated or unregulated.
- Correct the description of Surface Water Figure 1.
- Check potential errors in the Concrete to Marblemount data presented in Surface Water Map 2 and Surface Water Map 4.
- Present information about dam operations and glaciers in the Climate Change and Surface Flow section.
- Correct the depiction of the life history of fishes in Fish Habitat Figure 1.
- Incorporate more recent information in the Flow & Fish Habitat Section.

OVERALL COMMENTS

The Skagit Basin Water Supply and Demand story map is comprehensive and has considered several dimensions of water supply and demand. The list of key points provided at the beginning of each tab were very helpful for understanding the results of the analysis, as were the 'knowledge gaps' featured in detail in each tab and in an overall list at the end of the product.

Audience – Definitions, Complexity

It seems that the report team was presented with a challenge to create a product that would be useful for a broad range of audiences, from scientists to policymakers. On one side of this challenge, it is important to provide definitions of terms that non-technical users may not be familiar with. Since the user may skip around the Story Map, it is more challenging to understand how and where basic definitions should be provided. One way to address this would be to have a glossary of terms or single set of definitions and provide links to that list.

On the other side, it is also important not to oversimplify the truly complex issues discussed in the Story Map. The product would be well served by having the nuances of the presented data introduced earlier in the Story Map.

Use of Story Map Format

Compared to the traditional report format, the Story Map allowed for greater use of graphics and encouraged the reader to interact with the report to explore parts in greater depth. The interface was relatively intuitive and usable on different types of devices. The Story Map was particularly powerful when it took advantage of opportunities to link the reader to the underlying data (such as a table, Excel workbook, etc.). Providing underlying data and model information would also help to make the Analysis more replicable.

On the other hand, the Story Map was challenging to follow. A reader may find it difficult to see how the parts of the report fit together, and the format encourages repetition. A traditional PDF report would be easier to print and extract sections. In addition, the format of a PDF requires the report to be very selective about which material to present. In comparison, the Story Map contains a multitude of maps and strategies for presenting data, which can be very informative for an interested reader, but can create confusing redundancy and poses a challenge to identify key information. The nonlinear structure of the Story Map also is difficult from a reviewer's perspective, as there are no page or line numbers with which to identify the location of a comment or suggestion.

These issues could be addressed by several potential mechanisms. These could include providing an outline of all subheadings and figures in the Story Map, removing redundant or extraneous information, or providing a PDF report that summarizes the results. Displaying an outline of each tab with hyperlinks or tabs to subsections of each main tab would be helpful for navigation and orientation within the Analysis. In addition, an index of key terms would be helpful for readers who may be searching for particular phrases.

Map Design and Consistency

The committee recommends that the base maps more clearly show their location in the Skagit basin. Details such as municipalities, streams, and so on would help the reader orient their understanding of the water supply and demand data to well-known landmarks. This change would also help the reader understand what basins are being referenced in the map.

Many of the maps (including SW 1, 3, 4) present layers as choropleth maps. The choropleth maps obscure the base map, as the only way to see the base map is to turn off the colored layer. It would be more useful if symbols or charts could show the same information, or if the layers were made more

transparent. The committee also notes that the maps refresh when the user navigates away; scrolling up or down to compare another figure or review the text causes the user to lose their place in the map.

The Story Map contains multiple maps and strategies for presenting data, but the committee noticed that there was not always consistency between different maps, plots, and texts representing the same information but seemingly arriving at different results. In addition, the Story Map would benefit from more guidance for how to use each map and find different layers.

TAB: BIG PICTURE (BP)

Story Map outline components (such as headings, map/figure numbers, etc.) are shown in **bold**, and WSAS committee comments are presented in unbolded text.

- **Geography (BP Map 1)**
    - The committee recommends adding mainstem river labels on the map and include layers that show the Mt. Vernon gage, the location of hydroelectric facilities, and the boundaries of municipal areas. This change would provide context to the other content in the Big Picture (BP) section.
    - It would be helpful to define "acre-feet" in the text.
- **Rights, uses, and sources**
    - **Diversion rights by sector and source (BP Figure 1)**
        - The committee recommends providing a note in the figure itself to explain that band thickness correlates with volume, and to note that "Muni inchoate" are rights held for future use.
        - While the text explains that consumptive use is missing from the diagram, information on consumptive use would be very helpful to include if possible.
    - **Rights and rules relating to stream flow**
        - As the Skagit Instream Flow Rule is shown in BP Figure 2 and discussed in the text in this section, it would be helpful to provide additional information in the text to explain phrases such as "water users junior to the IFR," which is currently not explained until a later section.
- **Water over time and space**
    - **Seasonal surface flows (BP Figure 2)**
        - It is important to explicitly call out in the italicized text at the top of the figure description whether the plot shows regulated or simply natural flow. It is not clear which one is used.
            - The statement "stream flows in the figure to the right reflect water storage and releases by major dams in the basin. Future changes in flows with climate change assume no change in flow regulation by the dams" suggests that both historical and future streamflows presented are regulated flows.

        - The legend of “observed historical and simulated future flows” doesn’t provide the information of whether the flows are regulated or natural. The reader may assume that historical flow is regulated flow because it is labeled “observed” and that future flow is natural because it is labeled “simulated” and all simulations in Surface Water tap are naturalized flows. If this is true, it is not appropriate to compare regulated historical flow with naturalized future flows.
    - It is important to define what years are covered in the “historical” time period; does this simply mean any year before 2020, or is a specific date range covered? Recent years’ warm winters have led to higher winter flows and lower spring/summer flows, which would affect the historical hydrograph if included in the plot.
    - The committee recommends changing the time axis to water year (Oct-Sept) rather than calendar year, to demonstrate how precipitation during October-March affects streamflow in April-September, and to make this plot more comparable to other hydrographs in Surface Water. As many non-technical readers may not be familiar with water years, defining this term and time period would need to accompany the suggested change.
    - The committee recommends defining in the text what is meant by the 5^{th} and 95^{th} percentile flows.
    - It would be helpful if the user could pick a flow (e.g., the median) and overlay the historical and future flows.
    - The phrase “less snow pack due to higher temperature” could be changed to “less snow pack due to warmer winter temperature” to convey that winter temperature (not temperature overall) is the key.
- **Seasonal water withdrawals (BP Figure 3)**
    - The committee suggests plotting Skagit Median Flow in acre-feet/month to allow direct comparison with the water withdrawals on the same plot. There may be a scale problem getting them both on the same plot, but the plot could allow the user to switch between linear and log scale.
    - The committee recommends showing dashes on the figure legend for Municipal 2040 and Inchoate, so that a reader could rely less on the text description.
    - In the text, the line “For example, the sum of current municipal, domestic, agricultural irrigation, and other uses is about 22,000 acre-feet/year” should note this example is for July and is per month, not per year.
- **Water across the basin (BP Map 2)**
    - It would be helpful to make the basin labels, which provide important context, more visible and easier to read.
    - The committee recommends that the map provide guidance and hints to the user on how to toggle the map layers to view precipitation versus snow water equivalent. It would also be helpful for the map to strategically point out where the ‘darker purple’ areas referenced in the text are located.

        - The committee recommends providing a more detailed explanation of why the spatial distribution of water in the basin is important.
    - **Diversion rights across the basin (BP Map 3)**
        - The committee recommends referring specifically to BP Figure 1, rather than referring generically to a Sankey diagram, as not all Story Map visitors will know what that means.
- **Scarcity, Insecurity, & Opportunity**
    - **Seasonal Scarcity: Late summer is where it's at (BP Figure 4)**
        - It seems that the units for withdrawals should be acre-feet/month, rather than per year.
        - The committee suggests plotting Skagit Median Flow in acre-feet/month to allow direct comparison with water withdraws and allowing the user to switch between linear and log scale.
        - The committee recommends that the study define "water scarcity" up front, as it is currently not clear that the presented data shows water scarcity. Potentially, this definition would include environmental flow and the instream flow rule. The text argues that water scarcity occurs in the summer months, and August shows the largest difference between future withdrawals and flow. Future flow volume is roughly 20 times that of future withdrawals in August, when both are expressed in acre-feet per month. This result is not very convincing in supporting the claim of water scarcity.
            - The following statement in the Flow Regulation tab appears to demonstrate that the phrase 'water scarcity' should be better defined to reflect the components being considered: "95% of the variation in annual flow can be explained by low water supply. Factors related to surface water removals (natural and anthropogenic) explain no more than 5% of annual variation in flow, and most of this variation is likely the consequence of changes in hydropower operations to stabilize flows at Mt. Vernon."
- **Bibliography**
    - Several key references, which were cited in the individual tabs, are lacking in the Big Picture bibliography.

TAB: SURFACE WATER (SW)

- **Highlights**
    - The sum of sub-basin contribution as listed is 101%, likely due to rounding. It would be ideal to represent the total as 100%.
- **Overview**
    - The committee recommends clarifying that the summary of observed streamflow from USGS gages is based on regulated flow but that the current condition that is used as a basis

of future change calculation is based on unregulated flow. Otherwise, the text may provide the misleading view that the current condition is also based on USGS's observed (regulated) streamflow.

- The last sentence of this section should read "… due to a shift from snow to rain with increasing temperatures," not from rain to snow as is currently written.

- **Surface Flows**
  - **Sub-basin contributions to streamflow at Mt. Vernon (SW Map 1)**
    - It would be helpful to define/explain the use of "water year" early in the Story Map, as some site visitors may not be familiar with water years. It is appropriate that water year is used in this and other plots in the Surface Water tab.
    - It would be helpful to have more information about how the percentages of flow contributed by subbasins was calculated. The text refers to USGS gages, but there is no reference document cited or other description of how this was calculated.
    - The committee recommends that the interactive map include the percent contributed by subbasins in the winter season, in addition to the summer contribution that is currently shown. The text states that "lower elevation basins contribute relatively more water in winter," indicating that a map showing this information will tell a different story than the current map.
  - **Monthly Variation in Surface Water at Mt. Vernon (SW Figure 1)**
    - This plot's 50th-percentile (median) line shows a double winter peak in November and January. However, the accompanying text describes a "second peak in November," which appears to refer to the 80th-percentile line, and there is mismatch with the analysis as the second-largest peak occurs in January. There are a few potential corrections for this discrepancy: (1) change the text to refer to the 50th-percentile line, as is usual for hydrographs, (2) double-check the data analysis that resulted in a double peak in November/January, or (3) if the first two are not being done, clarify in the text that the 80th-percentile line is being described.
    - The title of figure should include the phrase "regulated streamflow." As both regulated and unregulated streamflow are used in this section, the reader will be helped by more specific information.
    - The figure caption lists water volume as acre-feet (AF), while map legend shows volume as 1000 ac-ft (KAF).
    - The figure caption describes water volume only, but the figure also includes streamflow. The caption needs to include both water volume and streamflow with proper units.
    - The committee recommends defining "AFY" (in the text) when it is first used.
    - The text describes summer as July to September, but typically analyses define summer as the months of June through August.
  - **Surface Water: Sub-basins of the Skagit Watershed (SW Map 2)**
    - The committee appreciates the hydrographs of sub-basins provided in this map, and the notes on regulation and withdrawals are very helpful.

        - This map would be improved by showing coverage area, as the pink tags don't provide enough information about what area the plot covers. Even if the user is very familiar with the area, it's sometimes unclear what coverage area is being described. For example, it is not clear whether the hydrograph of Concrete to Marblemount includes the water from the Sauk River. Based on the water volumes, it seems like the water from the Sauk River is included but considering the stated intent of this map, the expectation is that the plot doesn't include the water from the Sauk River. Another example is the plot of "Sauk River". Based on the stated intent of this map, the expectation is that this hydrograph doesn't cover the Sauk River above Whitechuck, but the plot title "Sauk River" gives the impression that it covers the entire Sauk River.
        - The committee recommends checking the water balance information for the sub-basins for accuracy. For example, the hydrograph of Concrete to Marblemount shows water volumes that suggest that the water from the Sauk River is included, though the map's stated intent would suggest that's not the case.
        - The committee recommends using the same figure legends for the hydrographs as was used in SW Figure 1, as SW Figure 1 shows the water volume for the entire Skagit River and these show water volume for each sub-basin. This would help the reader understand that the figures show the same types of data.
        - The hydrographs would make more sense if they were ordered upstream to downstream, instead of the current downstream-to-upstream order.
- **Climate Change & Surface Flow (SW Map 3)**
    - The committee recommends that this map show where current glaciers are located and present changes in the contribution of glacier melt to summer low flows. The analysis presented in the Climate Change and Surface Flow section uses DHSVM that has a glacier module, but no information is presented about glaciers.
    - The committee recommends including dam operations in the projection of future streamflow in the Skagit River, as the Skagit River has five dams that affect the timing and magnitude of streamflow. If inclusion of simulated dam operations is outside the scope of this analysis, the potential impacts of dam operations on summer low flows could be discussed (see for example Lee et al 2016) and the gap could be mentioned in the Knowledge Gaps section.
    - The committee recommends describing what is meant by "downscaled" and why it is needed (GCM grid resolution, DHSVM grid resolution, etc.) and similarly describing the term "bias-corrected" and why it is needed.

- **Changes in summer streamflow (SW Map 4)**
  - The committee recommends checking that there is not an error in the model that produced the Skagit River Concrete to Marblemount data. This region *(circled in red in the map screenshot to the right*) appears to produce more summer flows than the Sauk River. If this area represents Illabot Creek, it would be surprising to have this level of summer flow given the smaller watershed and smaller glaciers than the Sauk River. USGS data would be able to confirm whether the area circled in red in the embedded screenshot has historically produced more summer streamflow than the Sauk River.

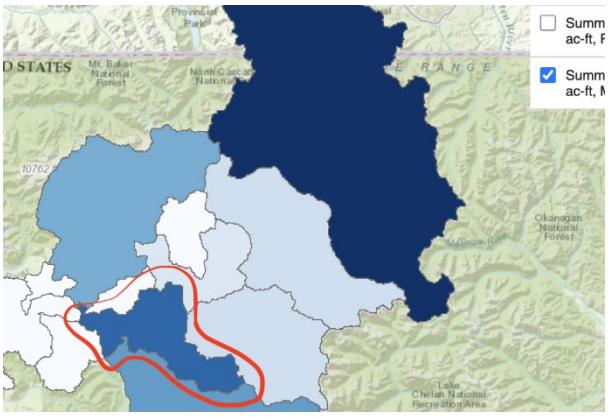

Figure 1. The region outlined in red appears to produce more summer flows than the Sauk River.

  - The committee suggests including only the issue of less summer rain (not higher temperature) as the main reason of the decrease in summer streamflow in the lower Skagit, which is a rain-dominant sub-basin. It is unlikely that higher temperature would significantly affect the decrease in summer streamflow in this rain-dominant watershed, especially in the 2050s (see Fig 3b in Lee et al 2020[2]).
  - The committee recommends several changes to the map. It would be helpful to include the names of key places in the Skagit that will help the reader orient to the areas being described. As the described change in summer flow appear to include glacier melt, it would be helpful for the map to show the current locations of glaciers. It would also be helpful to have the subbasin values display on the map when a map layer is selected (rather than having to select each subbasin), to give the reader a sense of the spatial variation. Finally, a layer that shows future minus historic values would be a good addition to this map.
- **Climate Change: Skagit River at Mt. Vernon (SW Figure 2)**
  - The text on winter flow change would be more accurate to cite Lee et al. (2016) than Hamman et al (2016). Hamman et al (2016) did not include unregulated flow, and its reported changes in regulated stream flows were cited from Lee et al. (2016). Lee et al. (2016) included both unregulated and regulated streamflow under climate change.

[2] Lee, S. Y., Fullerton, A. H., Sun, N., & Torgersen, C. E. (2020). Projecting spatiotemporally explicit effects of climate change on stream temperature: A model comparison and implications for coldwater fishes. Journal of Hydrology, 588, 125066.

- As climate change will influence the use of regulated flows, the potential changes to regulated flows should be included in the analysis, discussed, or at least included as a knowledge gap.
- The committee recommends clarifying whether the historical and future time periods use water years (water year 1981-2010, as in Oct 1980 to Sept 2010, and 2021-2050), or calendar years (as in Jan 1980-Dec 2010). The expectation is that it is water years, given that the hydrographs in this section are presented in water years. It would also be helpful to define what water year means when it is first used in the text and in the figure.

- **Lower Skagit Basin (SW Map 5)**
  - The committee recommends that this map distinctly show the coverage area for each plot. For example, it is not clear whether the plot for Nookachamps Creek includes the flow from East Fork Nookachamps. If the East Fork Nookachamps is not included, it would be clearer to show this in the map and clarify in the name (e.g., "Nookachamps Creek except East Fork Nookachamps")
  - The committee recommends simplifying this set of plots by reducing the number of subbasins shown and simplifying the plots themselves. The plots and key take-away for each of these rain-dominant sub-basins are unsurprisingly pretty similar to each other. If there is a specific reason why hydrographs of each creek need to be included, it would be helpful to state the reason and add an introductory paragraph stating that changes are similar across the sub-basins.
- **Sauk River Basin (SW Map 6)**
  - The committee recommends that the map distinctly show the coverage area for the plot and provide greater specificity in the name. If the plot titled "Sauk River" excluded the flows from Sauk River above Whitechuck, the name should specify as such.
  - Given the large size of the Sauk River basin and the anticipated major effects of climate change, consider showing more sub-basins of the Sauk River basin than of the Lower Skagit basin.
  - As the model used in the analysis seems to have included glacial components, it would be interesting to see analysis of how the contribution of glacier melt to summer flow will change in the future. Figure 5 in Frans et al. (2018)[3] could be a good example for this.
- **Upper Skagit Basin (SW Map 7)**
  - The committee recommends that the map distinctly show coverage area and have an updated title to clarify which area each hydrograph represents. It is important to ensure that the "Concrete to Marblemount" hydrograph excludes flow from the Cascade and Sauk rivers.

[3] Frans, C., Istanbulluoglu, E., Lettenmaier, D. P., Fountain, A. G., & Riedel, J. (2018). Glacier recession and the response of summer streamflow in the Pacific Northwest United States, 1960–2099. Water Resources Research, 54, 6202– 6225. https://doi.org/10.1029/2017WR021764

- **Knowledge Gaps**
    - The committee recommends including the effects of dams in the Knowledge Gaps, as much of the Surface Water analysis doesn't seem to have included any of the five dams that affect the timing and magnitude of Skagit River streamflow.
    - Changes in snowline and snow cover could be useful additions to future analyses.

TAB: GROUNDWATER (GW)

- **Overview (GW Map 1)**
    - The following statement in the Overview is confusing: "Throughout the Basin, about 21.8% of precipitation recharges aquifers, with a larger portion (33.4%) becoming recharge in the lower Skagit basin. Groundwater recharge exits the lower Skagit basin as seepage to streams/creeks (65%), withdrawal from wells (3%), and discharge to Puget Sound and evapotranspiration (32%)." It is not clear how groundwater recharge was estimated. If the estimation was calculated by precipitation minus estimated evapotranspiration, it would seem that evapotranspiration is double-counted in the second sentence.
- **Hydrogeology**
    - It would be helpful for the 'Hydrostratigraphy' box to include definitions of aquifer and confining unit, perhaps with an example cross-section diagram to illustrate the two concepts.
- **Groundwater Demands (GW Map 3, GW Figure 1)**
    - It would be helpful to provide more information on State-issued water right points of diversion/withdrawal.
    - It is not clear whether the following title of the right panel of GW Figure 1 "Groundwater as % of all rights" includes both surface and groundwater in "all rights."
- **Groundwater-Surface Water Interactions**
    - The first sentence: "Streamflow and groundwater have the potential to interact along the mainstem of the Skagit River and its tributaries…" should instead be written as: "Streamflow and groundwater interact along the mainstem of the Skagit River and its tributaries…" unless the intent is to qualify the interactions at a very site-specific scale.
- **Groundwater Recharge**
    - The committee recommends moving this section towards the beginning of the tab, as groundwater recharge is referenced frequently in the preceding sections.
    - The link to the "Groundwater Recharge Analysis Methods" document contains the statement: "Predictive equations assume annual downward drainage below the root zone equals annual groundwater recharge." If correct, the committee recommends simply stating that groundwater recharge equals precipitation minus evapotranspiration (and any surface flow that does not infiltrate), to give the reader an idea of the approach that was used. This information could also be pulled out of DHSVM.

- **Historic Groundwater Recharge (GW Map 4, GW Figure 3)**
    - The committee recommends checking for consistency between tabs and sections, and checking for correct water balance throughout. The text of this section states that: "The average annual precipitation for the historic period is about 10.86 AFY", but 10.86 AFY seems far too low. It's possible that the intended statement is "10.86 million AFY", which would be more consistent with the estimated 2.37 million AFY groundwater recharge. In addition, the Surface Water tab states that "The Skagit River transports about 12 million acre-feet per year" – which is greater than the precipitation volume listed in this section. This situation would be impossible over the long term.

- **Knowledge Gaps**
    - Expanded monitoring to understand tidal propagation and salinity intrusion across the Skagit lowlands, and validate and advance groundwater models would help to evaluate the effects of tidal propagation and salinity intrusion on flows, water levels and water quality.

TAB: FISH HABITAT (FH)

- **Overview (FH Figure 1)**
    - The committee has several recommendations to improve this figure showing the life history of fish, as it is currently difficult to follow and in some cases inaccurate.
        - The committee recommends that the figure start with the season of incubation as the "0" year and end with spawning at the appropriate year. The gray color could be used to fill the column before incubation. Indicating "spawning" under the "0" year seems inaccurate.
        - The committee recommends that this figure show the extensive estuary rearing that is a documented component of the life histories of both Chinook and Coho salmon.
        - It is a misnomer to classify habitat use as nearshore rearing and estuary rearing prior to spawning. There is limited "rearing," as time spent in these habitats prior to spawning is likely associated with return migration of mature adults.
        - The committee recommends that this figure show the lengthy holding of spring Chinook in freshwater prior to spawning.
- **Flow & Fish Habitat (FH Figure 2, FH Figure 3)**
    - The committee recommends incorporating new (after the 1999 Duke instream flow study) data about fish habitat into this analysis. While the Duke study may be one of the most comprehensive in linking flow level and fish habitat, the information is quite dated and including new data about fish in the Skagit would strengthen this analysis.
        - Addition of newer information would include an updated understanding of fish life history, habitat needs at different life stages, and habitat links to growth and survival. Including new data would also add critical habitat information such as temperature (which is not addressed in this section) and a finer timescale that is not

available from the Duke study. It seems that some of the habitat-related Knowledge Gaps could be addressed with existing information from more recent studies. A few example references are: Zimmerman et al. (2015) [4]; Greene et al. (2005)[5]; Connor and Pflug (2004)[6]; and Thompson and Beauchamp (2014)[7].

- Changes in temperature broadly, and in the Skagit Basin specifically, has been shown to change migration timing of spawning wild Chinook salmon. It is unclear why temperature is not included in this section. It is identified as a knowledge gap, but without clarity as to why it is not discussed in this section.
- Analyses described earlier in the Story Map that affect fish habitat (for example, surface water) does not seem to have been applied to the Fish Habitat tab.
- If there is particular information present in the Duke study that is not available in newer work, detail about what specific information is being presented would be helpful. In addition, it would be useful for the text to mention the caveats that exist in the Duke report (such as the limited use of transects).
- The committee recommends providing more language about which species, in which parts of the Skagit, would be associated with the flow levels shown. The Duke report includes more specific references to fish species regarding spawning (Chum, Chinook, Pink, and Steelhead) and rearing (Bull Trout, Coho, Chinook, Cutthroat, Steelhead).

- **Fish Distributions**
  - **Distribution of floodplain sensitive species in the Skagit River Basin (FH Map 1a-f)**
    - The committee suggests labeling 'Steelhead Distribution' as Steelhead/Rainbow if the map refers to resident Rainbow, as Steelhead are the anadromous life history of O. mykiss.
    - The committee suggests adding the dams that are barriers to migration to each of the maps.
- **Spatial Analysis**
  - **Local streamflow contributions (FH Map 2)**
    - The committee recommends presenting seasonality of available water, rather than total water, as water demand and flow levels during the summer seem likely to be the time of potential peak stress for fishes in the system. If the annual scale is used

[4] Zimmerman, M.S., Kinsel, C., Beamer, E., Connor, E.J., & Pflug, D.E. (2015). Abundance, survival, and life history strategies of juvenile Chinook salmon in the Skagit River, Washington. Transactions of the American Fisheries Society 144: 627-641.
[5] Greene, C.M., Jensen, D.W., Pess, G.R., Sttel, E.A., & Beamer, E. (2005). Effects of environmental condtions during stream, estuary, and ocean residency on Chinook salmon return rates in the Skagit River, Washington. Transactions of the American Fisheries Society 134: 1562-1581.
[6] Connor, E.J. & Pflug, D.E. (2004). Changes in the distribution and density of Pink, Chum, and Chinook salmon spawning in the upper Skagit River in response to flow management measures. North American Journal of Fisheries Management 24: 835-852.
[7] Thompson, J.N. & Beauchamp, D.A. 2014. Size-selective mortality of steelhead during freshwater and marine life stages related to freshwater growth in the Skagit River, Washington. Transactions of the American Fisheries Society 143: 910-925.

because it reflects current management guidelines, it would be helpful to state this in the text.
        - It is not clear how useful the information about streamflow is in watersheds downstream of dams, as flow regulation will modify the amount of water available in those river reaches.
    - **Flow accumulations (FH Map 3)**
        - The comments for FH Map 2 also apply here.
    - **Water Rights map (FH Map 4)**
        - The committee recommends providing a more visible legend for this map, including visibility on the main page (without having to open the map in another tab).
    - **Points of potential water scarcity (FH Map 6, FH Map 7)**
        - It would be helpful to provide information on the seasonality of water scarcity to better inform understanding of the times of peak water needs and peak stress for fishes. If the annual scale is used because it reflects current management guidelines, it would be helpful to state this in the text.
- **Knowledge Gaps**
    - The committee agrees with the knowledge gaps identified in this section.
    - It is good to see that the concern for seasonality is listed in Knowledge Gaps. To anticipate this question earlier in the text, the committee suggests stating in earlier sections that using a summary of flow information at an annual scale reflects current management guidelines.
    - The committee recommends highlighting the importance of comprehensive temperature data. Temperature is critical for assessment of fish habitat, and currently is mentioned only briefly in the Knowledge Gaps.

TAB: KNOWLEDGE GAPS

- The report's treatment of knowledge gaps is helpful in that it gives the reader a good sense of how further work would improve the understanding of the Skagit basin water supply and demand.
- This Supply and Demand Analysis was constrained to inventorying the state of knowledge of water supply and demand, which revealed several knowledge gaps that could be filled to inform planning for future water needs and resiliency. In addition to the knowledge gaps identified in the Analysis, the committee suggests that further work:
    - Include the effects of the five dams that affect the timing and magnitude of Skagit River streamflow.
    - Expand monitoring to understand tidal propagation and salinity intrusion across the Skagit lowlands to validate and advance groundwater models.
    - Highlight the importance of comprehensive temperature data to assess fish habitat.
    - Incorporate the effects of geomorphic change and channel aggradation across the Skagit River and estuary that are expected to occur as a result of future higher sediment delivery due to runoff and the compounding influence of sea level rise. The effects of these changes

are expected to include changes in flow velocities and flow routing, surface-ground water interactions, and water temperature and stress to fish.
    - Factor in the effects of expected future higher stream turbidity due to higher flows and snow/glacial melt during summer low flows.
    - Include the expected changes to water levels due to future reduced seasonal groundwater recharge and higher evapotranspiration.
    - Investigate potential cascading effects of climate change and land use change to water supply and demand, which have uncertain and non-linear effects on situations such as wildfire, invasive species, or contaminant spills.
    - Evaluate the potential effects to and implications of future water supply and demand changes on ecosystem functions and services, particularly as it relates to planning for resilient water management and adaptation.

ADDITIONAL COMMENTS

- If it is within the scope of this analysis, it would be helpful to add a few sentences that recognize the indirect effects of water supply/demand changes. For example, water temperature and fish habitat are highly susceptible to changes in turbidity and suspended sediment.
- It would be helpful for the text to recognize that the water supply is highly vulnerable to natural hazards such as landslides, which could disrupt water supply and influence the entire network of interacting water relationships.
- The header titles in the text do not all match the corresponding header titles in the navigation bars (for example, “Scarcity and Opportunity” versus “Water Scarcity, Insecurity, & Opportunity”).
- Any opportunity to provide additional navigation information would be welcome. For example, in the Big Picture section, “Water over time & space” contains several subsections and a rich set of information that could be lost if a Story Map visitor does not know to look for them.

APPENDIX A: COMMITTEE ROSTER

For questions related to the peer review process, contact:
Yasmeen Hussain, Program Officer – yasmeen.hussain@washacad.org

Michael Goodchild (Chair) – good@geog.ucsb.edu

Dr. Michael Goodchild is an Emeritus Professor of Geography at the University of California, Santa Barbara. Until his retirement, Dr. Goodchild was Jack and Laura Dangermond Professor of Geography, and Director of UCSB's Center for Spatial Studies. His research interests center on geographic information science, spatial analysis, and uncertainty in geographic data. Dr. Goodchild was elected member of the National Academy of Sciences and Foreign Member of the Royal Society of Canada, member of the American Academy of Arts and Sciences, and Foreign Member of the Royal Society and Corresponding Fellow of the British Academy. He was Chair of the National Research Council's Mapping Science Committee, and of the Advisory Committee on Social, Behavioral, and Economic Sciences of the National Science Foundation. Dr. Goodchild has a PhD in geography from McMaster University, and has received five honorary doctorates.

Rebecca Flitcroft – rebecca.flitcroft@usda.gov

Dr. Rebecca Flitcroft is a Research Fish Biologist and Team Leader in Landscape and Ecosystem Management at the US Forest Service. Her research on watershed analysis and management is focused on statistical and physical representations of stream networks in analysis and monitoring that more realistically represent stream complexity and connectivity for aquatic species along four primary lines of research: multiscale salmonid ecology; stream network analysis; climate change and salmonid life history; and integrated watershed management. Dr. Flitcroft conducts studies to expand the existing knowledge base about the interaction between complex life-history phenology of Pacific salmonids and their environment, particularly in the context of climate change as it relates to available habitats in coastal draining systems. Dr. Flitcroft is involved with local, regional, and state-wide efforts in Oregon to develop coordinated management techniques focused on watersheds. Dr. Flitcroft holds a PhD in Fisheries Science from Oregon State University.

Eric Grossman – egrossman@usgs.gov

Dr. Eric Grossman is a Research Geologist at the Pacific Coastal and Marine Science Center of the United States Geological Survey and a Research Associate at Western Washington University. His expertise includes coastal geology and marine geophysics, coastal ecosystems and restoration, estuaries, hydrodynamics, local and indigenous knowledge, and fluvial and littoral sediment transport. Dr. Grossman is a founding member of the Skagit Climate Science Consortium. He has received the USGS Western States Diversity Award, Washington State Governor's Smart Communities Award, Coastal America Award, USGS Western Region Science

Strategy Success Award, and Department of Interior Partners in Cooperation Award. Dr. Grossman has a PhD in marine geology and geophysics from the University of Hawaii.

Se-Yeun Lee – lees@seattleu.edu

Dr. Se-Yeun Lee is an Instructor in Civil and Environmental Engineering at Seattle University, and was previously a Research Scientist with the Climate Impacts Group at the University of Washington. Dr. Lee has been involved in interdisciplinary research focusing on understanding and modeling the complex interactions between climate, hydrology and natural resource management, and particularly climate change impacts on hydrology in the Skagit Basin. She has authored peer-reviewed research papers, book chapters, and reports, and has worked with and advised managers and decision-makers. Dr. Lee has a PhD in civil and environmental engineering from the University of Washington.

Mark Wigmosta – mark.wigmosta@pnnl.gov

Dr. Mark Wigmosta is a Chief Scientist and Technical Lead for the Computational Watershed Hydrology Team at the Pacific Northwest National Laboratory. Mark is also a Distinguished Faculty Fellow in the University of Washington Department of Civil & Environmental Engineering. He has over 30 years of experience in distributed watershed hydrology, including the potential impacts of land-use and climate change on water resources and renewable energy. Dr. Wigmosta was the principal developer of the Distributed Hydrology-Soil-Vegetation Model (DHSVM), which has been widely used in forest management applications. Mark has authored more than 55 peer-reviewed research papers and book chapters, and his research on renewable energy received an American Geophysical Union Editor's Choice Award. Dr. Wigmosta has a PhD in environmental engineering and science from the University of Washington.

The following are the main topic areas where Ecology staff had comments or concerns about the draft Skagit Supply and Demand Analysis:

1. Inconsistent and incorrect use of terms as defined in state water code
2. Misleading or inappropriate use of water right data
3. Missing contextual information
4. Incomplete/hard to find information about data and data sources
5. Summarizing statements lack sound supporting info
6. Spelling errors and mistakes appear throughout the product

Here are major examples of these topics identified by Ecology staff (draft text from the supply and demand analysis is shown in green while Ecology comments on this text are shown in black):

1. Inconsistent and incorrect use of terms as defined in state water code, missing contextual information about water law, and missing information pertinent to the Skagit Basin
    A. Big Picture tab – water rights, uses, and sources
    "Water is withdrawn from both groundwater and surface water sources in the Skagit Basin and applied for various uses. Like most of the Western United States, most water withdrawals in the Skagit Basin are supported by water rights under the Prior Appropriations Doctrine as well as legislative law and associated administrative rules (references). One special water use allowance is called a groundwater permit exemption, which allows the use of small-scale "permit-exempt wells", primarily for rural domestic use. Another special case of water laws, regulations, and administrative rules pertains to water storage in and release from reservoirs and other storage infrastructure for changing the timing of water flows for instream and off-stream uses, and for the production of hydropower (U.S. Dept. of Energy 2020)."
    -The words divert, withdraw, and water right and have special and specific meanings in Washington state water code. To divert water, in the context of water code, is to take surface water and use it for a beneficial purpose. To withdraw water, in the context of water code, is to take groundwater and use it for a beneficial purpose. A water right is a lawful right to use water beneficially. Not all water right documents are valid water rights. For more clarification you can see how these terms are used in RCW 90.03 and RCW 90.44.
    -It appears that the terms "diversion" and "withdrawal" were used interchangeably, inconsistently, or unclearly in the "Big Picture", "Surface Water", "Groundwater", "Fish Habitat", and "Flow Regulation" tabs. These terms are used both in the body of the tabs, and in charts and maps. Please change the language here to be consistent with RCW 90.04 and RCW 90.44, or define what you specifically mean when you refer to a diversion or withdrawal in each section. Otherwise, someone unfamiliar with these terms (but who has decision making power) will misunderstand or misuse this information.
    -Please define what water right is, and what it is not

    B. Big Picture Tab - Water Scarcity, insecurity, and opportunity

"Hydrologic changes will affect flow regimes in the Skagit River mainstem, lower tributaries, and aquifers underneath, which are the source of the vast majority of municipal and agricultural water withdrawals in the Basin. Municipalities hold substantial inchoate (currently unused) rights for growth – about 80% of their current water rights (Residential Demand tab). Their increased future use to respond to potential increased municipal demand may lead to increased future competition for water."

-What is meant by "competition"? Ecology can't issue new water right permits that would impair the flows established in WAC 173-503. Senior water rights may be exercised before junior rights in times of scarcity. However, only an adjudication in a court of law may determine the non-relinquished quantities and relative priority between different water rights.

C. Big Picture Tab and elsewhere – General observations

-This entire product focuses on the Skagit Basin, exclusive of the Samish River. The Samish river sub basin is part of the Skagit Basin, it has its own water supply issues and controversies, although it is not subject to WAC 173-503. Consider addressing the choice to have this product focus on areas subject to WAC 173-503 more directly and accurately.

-The authors refer to the Skagit instream flow rule, but they don't explain what it is, or provide a link to it in its entirety.

-There is no mention of Swinomish v Ecology in this section, even though it's a case of major interest in the basin

-The Boldt Decision isn't mentioned anywhere in this product. Many readers will need to be reminded that tribal treaty rights are to be respected and have important context in this work.

D. Instream Flow Tab

-The authors discuss the work that lead to the creation of the instream flow rule, and the components of the rule, but they don't provide a link to the actual rule. People who don't have an intimate knowledge of the history in this basin need a clearer path to this information than a bibliography.

E. Fish Habitat tab, map "Multiple sources of impact" and accompanying text.

-The map refers to water diversions, and the text refers to water withdrawals. It's not clear what this map actually represents. What source data are you using? Is it surface and groundwater data?

F. Groundwater Tab

- The maps exclude the Samish Basin and Fidalgo Island, which are part of the Skagit River Basin and have their own water supply issues and controversies. However, these areas are not subject to WAC 173-503. Consider addressing these distinctions more directly and accurately.

2. Misleading or possibly inappropriate use of data, information, and models
   A. Big Picture Tab: Seasonal Water withdrawal graph.
   -it's not clear what's represented in this graph, and it seems like the info in it could be easily misused.
   -What does this agriculture data represent? What does "municipal use" represent? Do these values represent actual use, or quantities in water right certificates or claims?
   -Are these values and source data the same as what's presented in other parts of this product? Please explaining.
   - Is it appropriate to compare different types of data in this graph, or are the sources of this data different enough that an "apples to apples" comparison isn't appropriate?
   -Minimum instream flow values and critical seasons for salmonids are not part of this graph.
   -It's not clear what the intended by the inclusion of muni inchoate and projected muni use in 2040. However, it seems like someone could incorrectly conclude that a muni water right could easily be transferred to another user.

   B. Agricultural use tab

   "Water rights for irrigation
   "The total annual quantity of water rights that list irrigation as a purpose of use within the Skagit River basin is 20,414 AFY. This annual quantity is predominately distributed in the Lower Skagit (89%), particularly in the Skagit Delta - Frontal Skagit Bay (56% or 11,417 AFY). Water rights have an approximately equal split between surface water (49%) and groundwater sources (51%), though surface water is the source for 91% of the total annual quantity of water rights in the upper Skagit River basin. Ten water rights within the Skagit River basin are subject to interruption when instream flow requirements are not met based on the 2001 Instream Flow Rule (Chapter 173-503 WAC). The total annual quantity associated with these interruptible water rights is 6,797 AFY (Rose, 2021)."

   "Irrigation water demand is concentrated in the Skagit Delta - Frontal Skagit Bay, which accounts for 81% of the total irrigation water demand in the entire Skagit River basin. The total annual quantity for irrigation associated with state-issued water rights in this hydrologic unit is greater than estimated irrigation water demand (by 2,964 AFY) when interruptible water rights are considered, but substantially lower than demand (by 3,640 AFY) when these latter rights are not considered. At the other extreme, irrigation water demand in the Upper Skagit (WRIA 4) was minimal (34 AFY) due to the limited acreage of irrigated crops in this area. Total irrigation water demand in several other hydrologic units is substantially lower than the total annual quantity of water rights for irrigation (see map below)."

-Water demand is different from water right document quantities in Ecology's database. There are significant areas of the Skagit Basin which are irrigated without adequate water rights, there are water rights which may no longer be valid due to non-use, and there may be registered water right claims which might not have been valid to begin with. The active records in Ecology's database are simply records of water rights which have not been formally changed or relinquished. Someone might read this section and conclude that water supply issues can be solved by simply changing or moving around water rights.
-The Crop Water Demand section indications that the model hasn't been validated for the Skagit basin, but a justification for using this model isn't provided. The model was developed for a different environment. Please provide justification for using this model.

C. Fish Habitat Tab Maps 5-7

In these maps the authors have attempted to correlate issued water rights to HUC sub basin boundaries and referred to this as water demand, but this doesn't actually represent where water is necessarily taken from the system, where people are seeking water for future use, or where use without water rights is occurring (unlawful use). This is an oversimplification of the situation, and a reader might conclude that getting more water to one place in this map would solve a major part of the supply problem.

D. Groundwater Demand Tab

-The report included in this tab mentions that a significant amount of water is allocated and not being used in WRIA 4, per RH2s work. This could lead someone to conclude that there are water rights readily available to change. A break down of these water rights by purpose (including municipal use which is not subject to relinquishment), and a discussion about relinquishment could help a reader reach a more accurate understanding.

-This tab includes precipitation estimates for the lower Skagit basin, below Sedro-Woolley. Is this estimate correct? Or, rather, does this precipitation estimate include all of WRIA 3 (including upland areas of the lower Skagit, above Sedro-Woolley, which get much more precip?)

- This product mentions the deeper aquifer work done by HDR, but doesn't mention the challenges quantifying impacts of deep aquifer withdrawals on surface water. Please provide more discussion.

-Hydrogeologic cross sections may be useful in the slide show maps. However, the first map doesn't seem to have a clear purpose.

E. Residential Demand Tab

"Currently, most of the 47 water providers examined are not required to publish future estimates of needed water supply or expected demand."

The explanation of why this is the case isn't clear. It has to do with group A Water system plan schedules. The authors of this product could instead provide estimates of consumptive uses by source and purpose. For example the authors could say something like, "based on the data we have x% of residential consumptive use is from groundwater."

3. Missing general contextual information

A. Big Picture Tab

"Water is a scarce resource. People would often prefer more of it than is available for instream and off-stream benefits, especially at certain times and places. Further, the degree of uncertainty and insecurity over water availability depends not only on weather and other natural variables, but on law, regulation, and water rights. Changes in climate, land use, population dynamics, and other factors will change water availability and demand for it in the future, and will affect water users across the basin differently. Nonetheless, opportunities exist to adapt to these changes and make the most of Skagit Basin water resources for people and the environment. What follows is a broad examination of water scarcity and insecurity hotspots – across the basin and water use sectors, and over time seasonally and in the future.

Details and source information supporting this summary can be found in the associated topic sections but will not be cited explicitly here."

-Cite your sources. The information in this section appears to be inconsistent with other information in product

-Seasonality Scarcity graph- does the info here represent water right values, or actual use? What's RCP 8.5? what's the date range for historic median flows?

"A comparison of estimated irrigation water demands and water rights (excluding claims) indicated that water rights volumes are generally larger than the estimated irrigation demands in all areas of the basin (Agricultural Demand tab). However, a significant part of the water rights volume (58%) for the Skagit Delta-Frontal Skagit Bay are interruptible. Additionally, the comparison does not account for the conveyance losses in water distribution systems (a knowledge gap) which would increase estimates of irrigation demands, and uncertainties associated with the crop model and the water rights database must also be considered"

-Define the Skagit Delta-Frontal Skagit bay; consider adding a map. The large interruptible water rights issued to irrigation districts in the last 10 years serve multiple farms in these districts. Previously, many of the farms in these districts, and the irrigation districts themselves, were not operating with any kind of water right. This is an improvement that should be noted.

B. Residential Demand tab

"In 2019, the total estimated municipal water demand was 30, 945 acre feet per year (afy). Based on previous consumption patterns, future demands are estimated to reach 38,729 AFY by 2040".

-It's not accurate to characterize Anacortes' municipal production as primarily residential.

What isn't mentioned anywhere in this report, or in the documents created by the authors, is that Anacortes has two large customers: The Shell and Tesoro Refineries. The water demand from these refineries makes up the majority of the water produced by the City of Anacortes. This isn't typical for most municipal water systems. More detail is in Anacortes' updates to their water system plans (page 9).

https://www.anacorteswa.gov/DocumentCenter/View/6629/Updated-January-2018-Water-System-Plan

Without this context, it looks like per-capita customer water use would be really high for the region.

C. Surface Water tab
-There limited discussion about the Cultus mountain tributaries, which have their own defined instream flows. This is important because the Cultus mountain Tribs are water sources for Skagit PUD. Flows in the tributaries impact how the PUD sources their water throughout the year. What climate change could mean, for Skagit PUD's water portfolio, for example, could be discussed here.
-this tab doesn't include a discussion about total water allocated in water rights. The groundwater tab does. Make these sections consistent, and find a way to show how surface and groundwater are interconnect.

D. Groundwater Demand Tab:
-GW figure 2 doesn't include info about how this data was generated, or underlying assumptions.
-Gaining and loosing reaches of rivers aren't well discussed. Where do we see gaining and loosing reaches? Where does this change?
-Additional Discussion of groundwater contributions to surface water is important, because these are interconnected systems. Please add it.

E. Throughout document: Lots of jargon, niche formatting, and complex diagrams that are hard to understand for someone outside of the industry
-flow graphs and other data are presented in water years (oct-sept) and logarithmic scales which people outside of the water management world probably aren't used to. Define what a water year is, and explain what a logarithmic scale is, and explain why presenting info in this way is useful.
-Interactive maps are feature-rich, which is great, but someone unfamiliar with GIS will have trouble navigating these without instructions. Make the controls easier to find, or provide an easy to find explanation.
-acre feet per month (which shows up in the surface water and irrigation water tabs) isn't a common industry measurement like Acre feet per year, cubic feet per second, or gallons per minute. Even common industry terms like these (particularly acre feet and cubic feet) need to be defined. Visual definitions (like comparing an acre foot to an Olympic-sized swimming pool, which holds just over 2 acre feet) may also be helpful. Additionally, using a term like "acre feet per month" may not wholly illustrate the situation. The effect of groundwater withdrawal 2 miles away from a river, for example, may have a different temporal impact than a surface water diversion on the same river.

4. Incomplete/hard to find information about charts, maps, data and data sources
   A. Throughout document, but particularly in Big Picture tab: Missing or hard to find laws, court cases, and rules
   -As mentioned in #1, laws, case law, and rules frame much of the situation. Assume that your reader doesn't have this background knowledge and may be in position to draft legislation
   B. Groundwater Tab:

-Map 3. Where is this data from? Is it form the well log database, or the water right tracking system database? Are permit-exempt wells on this map? Are Domestic wells the same as permit-exempt wells?

5. Summarizing statements lack sound supporting info
   A. Big Picture Tab

"Opportunities and mitigating factors

While there are several trends that may increase water scarcity and insecurity depending on time, place, and use, several characteristics of water distribution and management may mitigate these trends, and may allow opportunities for actively addressing tradeoffs inherent in allocating scarce water resources across competing uses.

More precipitation could mean more water. Although water scarcity is expected to increase in the summer due to climate change and potential increases in water withdrawals along with population growth in the basin, some climate models project increases in average annual precipitation that could increase groundwater infiltration and aquifer recharge. In parts of the basin, it appears that these increases in recharge have the potential to substantially overcompensate for expected modest increases in municipal water demands drawn on existing inchoate rights. However uncertainty remains in the direction of change in annual precipitation, most models project slight increases but some project slight decreases and year-to-year variability remains large.

Water storage and release is adjustable in the long run. Changes in existing storage and flow releases by major dams, and new storage investments to align seasonal water availability with demand are possible. The hydroelectric projects in the basin operate under FERC licenses that govern storage and releases, and balance multiple objectives related to hydropower generation, flood regulation, instream flows, and recreation. License expiration and re-licensing occurs at regular intervals, about 40 to 50 years for major hydroelectric projects, offering an opportunity to review objectives. For example, the Skagit Hydroelectric Project license finalized in 1995 expires in 2025. The re-licensing process formally began in 2020, and a new license is likely to require different constraints on storage and flow releases depending on how these multiple objectives are balanced. In addition to the infrequent opportunities to modify operations of existing facilities, other forms of storage to capture and re-time release of water are also possible."

-This is misleading. Some models suggest more precipitation in the future, some don't. The ability to store water is uncertain; projects will be constrained by physical, legal, regulatory and financial parameters. The susceptibility of the system to scour during higher seasonal winter flows and to land slides is also not yet well understood, which could affect future usability of land and groundwater storage.

"Water rights are transferable, sometimes. Secure senior water rights are by legal design typically transferable as long as a transfer does not impinge on other water rights. While these senior rights are generally being put to productive, beneficial use, real water scarcity requires real tradeoffs, and water rights leasing and sale may be an available option in some

cases to mitigate the economic and/or environmental impacts of water scarcity. For example, the relatively junior status of the Instream Flow Rule means that few rights are interruptible to mitigate stream flow deficits. However, contemporaneous senior rights can be leased to reduce diversions in order to augment or protect stream flow to the extent that applicable rights exist. Some agricultural water rights may be a candidate for such transfers. However, their diversion points are generally low in the basin, and there are few available transferable rights such as these higher up in the Basin where transfers are most viable as stream flow mitigation. Another example includes the State of Washington Department of Ecology water rights purchase from Seattle City Light in 2019 to provide mitigation for exempt well use (Cauvel 2019)."

-Ecology can't authorize changes to water rights that impair other water rights. Additional legal requirements must also be met.

-Are senior rights generally being put to productive beneficial use? There hasn't been a Skagit Basin Adjudication to determine the extent and validity of these water rights, so it's inappropriate to conclude that conclusion that senior water rights are generally being put to productive, beneficial use . Even Ecology can only conduct tentative determinations of extent and validity when processing water right changes.

-Is the statement **"**the relatively junior status of the instream flow rule means that few water rights are interruptible to mitigate stream flow deficits" wholly accurate? The instream flow rule effectively limits future appropriations of water.

"Local fish populations adapted and locally evolved in the context of unregulated historical stream flows in the basin. Differences in stream flow from historical unregulated flows are therefore a useful benchmark to assess likely effects of fish population viability and health. Future changes in streamflow due to climate change in the upper Skagit Basin represent deviations from historical conditions and therefore suggest suboptimal spawning and rearing flows for species that utilize upper tributaries (Fish Habitat tab). Unregulated stream flows in the lower basin are expected to change less than in the upper basin, but flow regulation via dam operations and water withdrawals for irrigation, municipal, and other uses may contribute to deviations from historical flows (Surface Water and Flow Regulation tabs)."

Climate change may *further* alter changes to the streamflow regime, please elaborate.

B. Groundwater Tab
   -Knowledge gaps mention the need for groundwater monitoring. Emphasizing the need for an expanded monitoring network is good, however, a better message would emphasize a strategic expansion of a well monitoring network or order to focus on specific monitoring goals. Please revise this discussion.
C. Knowledge Gaps Tab

"Improved estimates of actual consumptive use: What: Due to the gaps in the water rights data, as well as a lack of measurements, actual agricultural consumptive use and how it compares with the quantities in water rights for irrigation is unknown. Why: While we have crop model estimates for consumptive use, in addition to model and weather input uncertainties, the models assume "ideal" on-the-ground practices and are not reflective of actual consumptive use - the critical information for planning. How: While the utility of open-source optical and thermal satellite-imagery to estimate actual consumptive use is increasingly becoming apparent, such approaches in the Skagit River basin must address cloud cover issues, which can limit the availability of satellite imagery. Therefore, a combination of optical, thermal, and radiometric (which is not affected by cloud cover) satellite imagery with crop models and measurements to ground truth this remotely sensed data can provide a better estimate of actual consumptive use and how it relates to water rights and water supply in the basin."

-The water right permitting system is over 100 years old, so the provisions and reporting conditions are not uniform. While metering has been proposed as a solution in the past, the variation in water right conditions, identifying current water users, and existing staffing and breadth of other priorities have made it difficult for the state a to adopt a comprehensive and economic metering program. Indirect methods of quantifying human water use also existing, but these are emerging technologies, and their utility and how we can lawfully use them are still being evaluated. More elaboration on why this knowledge gap exists, and the challenges with implementing a broader measurement/metering programs with the resources we have now, may make this product more useful for future discussions.

"Improved understanding of relationship between soil moisture, field accessibility for agricultural equipment, and future planting dates: What: Studies are needed to understand how predicted changes to planting dates due to increased spring soil temperatures under climate change relate to the feasibility of accessing fields with high soil moisture. Why: In the estimation of future crop irrigation requirements, the planting date may change based on changes in temperature relative to required temperatures for germination. This may ameliorate potential increases in crop irrigation requirements to some degree by shifting the growing season earlier in the year. However, in practice, the timing of planting does not depend on temperature alone, and soil moisture levels conducive for field trafficability are a potential barrier to earlier planting dates. How: Existing crop models could be revised to account for the effects of soil moisture on planting dates in addition to the effects of soil temperature, and these revised models could be used to better understand changes to total agricultural water demand with climate change."

-Irrigation water rights have a specific season of use. They vary by the right. Changing these requires a change from the Department of Ecology, and recent case law has made issuing these decisions increasingly complex or impossible. Please also discuss the legal hurdles of changing water rights.

6. Spelling errors and mistakes appear throughout the product

-please conduct a thorough review of spelling and fluency.

From: Larry Wasserman, Swinomish Indian Tribal Community

To: jon Yoder, Jordan Jobe

RE: SITC Comments on Skagit Water Supply Task Force Report

Date: May 20, 2021

Big Picture

I would first like to say that I think the report was very well done, and particularly liked the format. It was easy to read and navigate, and provided the necessary links to further investigate topics of interest.

I am attaching with this response two documents written by Dr. Joel Massman, our consulting geohydrologist. His comments pertain to both the groundwater section and the Aspect Report regarding flow statistics.

The first suggestion I have is that I think the report should clearly state with each reference included in the body of the document whether the reference was peer reviewed or not. There has been some controversy regarding some of the document stated, so I think it is important to be clear the degree of scrutiny associated with each.

Rights and Rulings related to Instream Flow

The following statement is not factual:

"These tribal treaty rights are a foundation for a great deal of Washington State judicial, legislative, and administrative water law of broad relevance to water management in Washington State, including the IFR itself (references)".

Tribal treaty rights had no bearing on the specifics associated with the Skagit instream flow rule and includes no recognition of Federal water rights held by Skagit Basin Tribes. It is fact only in very rare instances (the Yakama adjudication being one of the few) that Washington State judicial, legislative or administrative water law has considered Tribal Water rights. To support the statement mentioned above, the report should detail where Tribal water rights have been incorporated into Washington State decisions.

The refence section listed in this section contains a Swinomish document (Skagit River Water Allocation) that I am unaware of and is unretrievable.

The reference : Skagit River Interruptible Water Rights by Rose 2021 is not available

Opportunities and Mitigating Factors General Stream Adjudication should be listed as an opportunity. This would clarify existing water rights and would be an opportunity to permanently protect instream flows. Another opportunity is for Ecology to more readily exercise its discretion to implement relinquishment and abandonment actions.

Diversion Rights Across the Basin: Samish is misspelled in the first sentence

Surface Water

This section was very well done. Graphics were easy to understand and provide a sufficient level of detail. However, please see comments from Dr. Massman. He points out errors in the calculations for flow statistics for both the Skagit River and Grandy Creek.

Groundwater

Please see Joel Massman's attached review. He points out a number of significant errors associated with the HDR analysis, both its conclusions and methodology.

Flow Regulation

Knowledge Gaps:

1. Instream flow studies to examine the relationship between instream flows and fish habitat has only been conducted for very few tributaries throughout the basin, resulting in a knowledge gap about tributary stream flows and fish needs.
2. There is a knowledge gap regarding the magnitude of the Federally reserved Tribal Water Right in the Skagit Basin.

Agricultural Demands

HIghlights The document states that there are 11,417 afy of water rights in the Skagit Delta. It also states that 6603 afy are interruptable. This leaves 4814 afy of uninterruptible water rights in the Delta. Demand is stated to be 8453 afy. There should be some discussion of if and how this shortfall is currently being met.

Residential Demand

Overview: The following statement is incorrect: "With few senior water rights available to offset new permit-exempt wells, a near-moratorium arose on the development of rural properties…".

There is not a near moratorium. There have been a variety of agreed upon mitigation measures that allow for new development. These include but are not limited to a water bank at Big Lake, mitigation water provided by Seattle City Light , extensions of PUD waterlines, and the use of trucked water.

Municipal Demand: The analysis of municipal demand should be based on the same definition as defined by the Municipal water law, and should include Group B systems, which are numerous throughout the Skagit Basin.

Rural Demand I don't believe that the Aspect 2019 was peer reviewed. In particular, I am unaware of any peer review of the recalculation of the 7Q10 analysis. Please see attached Joel Massman review.

KETA WATERS
1912 33rd Ave S.
Seattle, WA 98144

(206) 236-6225
(206) 919-1363 (cell)
joel@KetaWaters.com

MEMORANDUM

To: Larry Wasserman
Swinomish Indian Tribal Community
11404 Moorage Way
La Conner WA 98257

From: Joel Massmann, Ph.D., P.E.

Date: May 17, 2021

Subject: Upper Skagit River Flow Statistics developed by Aspect (2019)

This memorandum describes my review of recalculated flow statistics for streams in the Upper Skagit basin. These recalculations are described in Aspect (2019). The 2019 Aspect report was prepared for the Department of Ecology and includes a section that describes their review and reassessment of low-flow statistical analyses that had been previously conducted in support of Ecology's 2006 Skagit Rule Amendment (Ecology, 2006). Aspect presents revised low-flow statistics for the Upper Skagit River and for Grandy Creek. The Upper Skagit River low-flow estimate is based on analysis of data collected at the USGS Marblemount gauge. The Grandy Creek low-flow estimate is based on extrapolation of data from Alder Creek.

A. Aspect's recalculated flow statistics for the Upper Skagit River

Table 3.1 in Ecology (2006) lists the estimated low flow for the Upper Skagit River at Marblemount as 3,879 cfs. This flow is characterized by Ecology as "Estimated Low Flow (September 90% Exceedance Flow)." Aspect gives an estimated low flow for the Upper Skagit River at Marblemount as 3,240 cfs based on data through 2019. This flow is characterized by Aspect as "the 90 percent exceedance probability for the Upper Skagit subbasin." Aspect notes the difference between their revised estimate (3,240 cfs) and Ecology's original estimate (3,879 cfs) and suggests this difference may be due to "differences over recent years in dam operations upstream of the Marblemount gage that may have impacted flows on the mainstem." Aspect also states that "Based on updated data, the revised low flow estimate on the mainstem of the Upper Skagit decreased from 3,879 to 3,240 cfs." This is a wrong interpretation for reasons described below.

Table 1 below lists flow statistics calculated using data collected at the Marblemount gauge (USGS Gauge 12181000). Two sets of 90% flow exceedance values are included. The first set is based on data collected during the month of September. This is based on Ecology's description of their low-flow statistic as the "September 90% Exceedance Flow."[1] The second set is based on data from the full year. The right two columns list estimates of the flow statistics. The column labeled "Keta Waters" gives my estimates based on daily flow data downloaded from the USGS website.[2] The column labeled "USGS" gives the 90% exceedance values that were calculated by USGS and included on their website.[3] The USGS site does not include estimates of the September 90% exceedance flows.

Table 1. Flow statistics calculated using data collected at the Marblemount gauge (USGS Gauge 12181000).

Flow statistic	Data period	Estimated flow (cfs)	
		Keta Waters	USGS
September 90% exceedance	1943-2005	2,578	n.a.
September 90% exceedance	1943-2019	2,670	n.a.
September 90% exceedance	1943-2020	2,670	n.a.
Full 90% exceedance	1943-2005	3110	3200
Full 90% exceedance	1943-2019	3220	3220
Full 90% exceedance	1943-2020	3230	3230

The flow statistics included in Table 1 indicate that Ecology's 2006 low-flow estimate for the Upper Skagit at Marblemount was significantly larger than the true value. My estimate for the September 90% exceedance flow based on data that were available in 2006 is 2,580 cfs. The value used by Ecology in 2006 for calculating the instream-flow reservations (3,879 cfs) is approximately 50% larger than this estimate.

To check if my method for calculating the September 90% exceedance flows was consistent with Ecology's methods, I also calculated September 90% exceedance flows for the gauges at Concrete (USGS Gauge 12194000) and Mount Vernon (USGS Gauge 12200500) using data through the 2005 water year.[4] The results, which are listed in Table 2, show good agreement between my estimates and Ecology's 2006 estimates for these

[1] Ecology (2006) states that "7Q10 is the lowest consecutive seven-day flow to occur an average of every ten years and is generally comparable to a 90% exceedance flow during a low-flow month." It appears Ecology intended the September 90% exceedance flow to be an approximation of the 7Q10 for the Upper Skagit at Marblemount.

[2] https://nwis.waterdata.usgs.gov/wa/nwis/current/?type=dailydischarge&group_key=NONE. Accessed May 10-11, 2021.

[3] https://waterdata.usgs.gov/nwis/inventory/?site_no=12181000&agency_cd=USGS. Accessed May 10, 2021.

[4] This data period was assumed to be the same data that would have been available to Ecology when they developed their 2006 analysis.

two locations. This agreement for the Middle and Lower Skagit suggests that Ecology's low-flow estimate for the Upper Skagit was an error, and not due to differences in methodologies.

Table 2. September 90% exceedance flows for locations included in Table 3.1 from Ecology (2006)

Location	USGS Gauge	Estimated flow (cfs)		
		Keta Waters	Ecology (2006)	Difference
Skagit-Upper	Marblemount	2,580	3,879	+50.3
Skagit-Middle	Concrete	5,260	5,270	+0.19%
Skagit-Lower	Mount Vernon	5,979	5,970	-0.15%

It is clear that Ecology intended to use the September 90% exceedance flow for calculating reservation quantities. Aspect calculated a 90% exceedance flow using year-round data and compared it to Ecology's incorrect September 90% exceedance flow at Marblemount and concluded that "the revised low flow estimate on the mainstem of the Upper Skagit decreased from 3,879 to 3,240 cfs."

The correct low-flow statistic (i.e., the September 90% exceedance flow) based on data that were available in 2006 is 2,580 cfs. The updated value for this statistic using data through the 2020 water year is 2,670 cfs. This suggests a small (3%) increase in the September 90% exceedance flow during this period.

B. Aspect's recalculated flow statistics for Grandy Creek

Ecology's 2006 estimate of the 7Q10 for Grandy Creek is based on the calculated 7Q10 from nearby Alder Creek. The approach involved multiplying the Alder Creek 7Q10 times the ratios of the precipitation rates for the two watersheds and the areas of the two watersheds:

$$7Q10_{Grandy} = (7Q10_{Alder})(\text{Precipitation Ratio})x(\text{Area Ratio}) \quad [\text{Eq. 1}]$$

Ecology calculated the 7Q10 for Alder Creek as 6.3 cfs. The Alder Creek drainage area is 10.7 square miles and Ecology used a watershed precipitation rate of 58 inches. The Grandy Creek drainage area is 17.5 square miles and Ecology used a watershed precipitation rate of 64 inches. Based on these values, Ecology calculated the 7Q10 for Grandy Creek as 11.4 cfs:

$$7Q10_{Grandy} = (6.3 \text{ cfs})(64/58)x(17.5/10.7) = 11.4 \text{ cfs}$$

Aspect (2019) describes their approach for updating this 7Q10 for Grandy Creek as follows:

> *In the 2006 Skagit Rule Amendment, Alder Creek was used as a basis for creating a synthetic 7Q10 estimation for the Grandy Creek due to its proximity and similar geological conditions. Alder Creek is still ungauged, so the 2006 7Q10 statistic*

> *calculated with data from up to 1971 remains the best available low flow estimate. However, new precipitation data available from Oregon State University's PRISM High-Resolution Spatial Climate Dataset was used to re-scale the Alder Creek 7Q10 statistic to Grandy Creek.* ***A 30-year normal annual precipitation value (1981-2010) that is geographically specific to the Grandy Creek subbasin was used for scaling as it was thought to be most representative of modem, long-term, average precipitation conditions.. Based on applying an annual precipitation value of 75.45 inches for 2018, the Grandy Creek low flow estimate increased from 11.4 to 13.5 cfs.*** (pages 23-24, emphasis added).

Based on a precipitation rate of 75.45 inches for the Grandy Creek watershed, Aspect's estimate of the 7Q10 is calculated as follows:

$$7Q10_{Grandy} = (6.3 \text{ cfs})(75.45/58)x(17.5/10.7) = 13.5 \text{ cfs}$$

There are several problems with Aspect's estimate that revolve around the precipitation rates that were used in this equation. First, Aspect's description of the basis for their revised precipitation rate for Grandy Creek is ambiguous. They first indicate that they used a 30-year normal annual precipitation rate and then they indicate they used the annual precipitation rate from 2018.[5] It is assumed that the 75.45-inch value used in Aspect's calculations is from 2018 data, but this is unclear.

Aspect's 7Q10 estimate of 13.5 cfs for Grandy Creek uses precipitation data for Alder Creek collected between 1930 and 1957 while apparently using a single year of data (2018) for Grandy Creek.[6] It is not clear that the 75.45 inch precipitation rate used by Aspect is representative of current typical precipitation in the Grandy Creek watershed.

Table 3 below compares precipitation estimates from several different sources. The first row gives the precipitation data from Ecology (2006). Ecology (2006) references the USGS (1978) as the basis for their precipitation values. The precipitation values used in USGS (1978) are from a 1965 U.S. Weather Bureau report that is based on precipitation data from 1930-1957. Both the Alder Creek and Grandy Creek precipitation data used by Ecology (2006) are from the period 1930-1957.

The second row in Table 3 gives the precipitation data from Aspect (2019). This mixes data from 1930-1957 for Alder Creek with 2018 data for Grandy Creek. The third and fourth rows give precipitation data from the USGS StreamStats website.[7] StreamStats

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[5] A close review of the last two sentences from the excerpt provided from Aspect's report suggest that text may have been deleted between these sentences. This is suggested by the double periods between the two sentences and the conflicting statements regarding what precipitation value was used.

[6] Ecology's original 2006 estimates of 7Q10 are based on flow data collected between 1943 and 1971 and precipitation data collected between 1930 and 1957. While this is not ideal, at least a consistent set of precipitation data were used to extrapolate the flow data by using the 1930-1957 precipitation data for both Grandy Creek and Alder Creek.

[7] https://streamstats.usgs.gov/ss/

reports average precipitation using both the 1965 U.S. Weather Bureau data and the PRISM 30-year normal values (1981-2010). Finally, the last row gives my estimates for each watershed based on the 1981-2010 PRISM 30-year normal values. The ratios of precipitation values are also provided in Table 3.

Table 3. Comparison of precipitation estimates for Alder Creek and Grandy Creek.

	Precipitation (inches)		Ratio
Source	**Alder Creek**	**Grandy Creek**	
Ecology (2006)	58	64	1.10
Aspect (2019)	58	75.45	1.28
USGS StreamStat/1965 data	63.4	71.5	1.13
USGS StreamStat/PRISM data	88.5	124	1.40
Keta Waters/PRISM data	87.5	124	1.42

It is unclear if changes in estimated precipitation within the Grandy Creek and Alder Creek watersheds are primarily due to changes in data analysis and data availability or whether the changes are actual changes in precipitation. A comparison of the Ecology (2006) estimates and the StreamStat/1965 estimates shows that at least part of the difference is due to data analysis as both estimates are based on the same underlying data.

The most reliable estimate for the Grandy Creek 7Q10 is likely the original Ecology (2006) value. This value is based on streamflow data and precipitation data that were collected during the same general timeframe. Although the period for the precipitation data (1930-1957) does differ from the period for the streamflow data (1943-1971), there are some years of overlap. The technical basis for using a single year of precipitation data to calculate a statistical measure like 7Q10 (as Aspect apparently did) is unclear and their resulting estimate for 7Q10 should be viewed with some skepticism.

References

Aspect (2019). Upper Skagit Basin Rural Growth Permit-Exempt Well Assessment (Project No. 150304-110-Task 4). Aspect Consulting. https://apps.ecology.wa.gov/publications/parts/1911088part2.pdf

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U.S. Weather Bureau, 1965. Mean Annual Precipitation, 1930-1957, State of Washington: Portland, OR, U.S. Soil Conservation Service, map M-4430.

Washington State Department of Ecology (Ecology), 2006, Skagit Rule Amendment Rule Making Criteria: Background on the Reservations, Closures, and Hydraulic Continuity. Prepared in support of the amendment to: Chapter 173-503 WAC Instream Resource Protection Program – Lower and Upper Skagit Water Resource Inventory Area (WRIA 3 and 4).

KETA WATERS
1912 33rd Ave S.
Seattle, WA 98144

(206) 236-6225
(206) 919-1363 (cell)
joel@KetaWaters.com

MEMORANDUM

To: Larry Wasserman
Swinomish Indian Tribal Community
11404 Moorage Way
La Conner WA 98257

From: Joel Massmann, Ph.D., P.E.

Date: May 15, 2021

Subject: Draft Skagit Basin Water Supply and Demand Synthesis
ESRI Story Map Series[1]

I have reviewed the "Groundwater" section of the Draft Skagit Basin Water Supply and Demand Synthesis referenced above and offer the following comments.

A. Format

I appreciate the format that is used for the overall "*Water in the Skagit Basin*" report, with the highlights, the menu for different sections, and links to underlying documents. I found it effective.

B. Groundwater demand section

The report prepared by RH2 (2019) organizes and presents water right data and information in a clear way. The glossary descriptions of topics included in Ecology's Water Right Tracking System should be helpful to people not familiar with this system. I did not go over the irrigation water estimates in a lot of detail, but the approach looks defensible and the results reasonable. I think this report by RH2 is contribution and is consistent with what had been proposed for this Task Force study back in 2019.

With regard to the work done by HDR on groundwater demands, the discussions regarding areas for future development are limited to this: "*Areas identified for future development of groundwater include east of Concrete, and between Concrete and Sedro-Woolley (Pacific Groundwater Group, 1991)*." Surely there are better references than

[1] https://www.arcgis.com/apps/MapSeries/index.html?appid=f92309aff2d64203843212b2be8dd4b2

this draft appendix from the 1991 Coordinated Water Systems Plan for Skagit County. It would be helpful to identify the current projected growth areas that are outside of water service areas and to describe projected growth rates. These might be derived from forecasts from the Washington State Office of Financial Management (OFM) or other sources.

C. GW-SW Interactions

My main concern with the discussions in this section relates to the October 25, 2019 HDR memorandum that is included as a link.[2] The following is from the Executive Summary of that memo: *The motivating study question is whether or not aquifers exist that are completely disconnected from surface water by fine-grained (low-permeability) bounding hydrostratigraphic units.* Focusing the study on finding or documenting aquifers that "are completely disconnected" introduces a bias in a study that is entitled "Middle and Upper Skagit River Valley Hydrostratigraphy Characterization."

On the one hand, the memo does acknowledge groundwater surface interactions by including the following quote from a USGS document: "*It is not reasonable to expect that pumping beneath an extensive confining unit will eliminate depletion. Water does move vertically from one aquifer to another through confining units, and drawdown from pumping can propagate through confining units as well*." However, the HDR memo then goes on to include extensive discussions and analyses of "hydraulically disconnected aquifers."

An example of discussions regarding the Grandy Creek watershed describes what I view as this bias:

> *Overall, the potential for hydraulically disconnected aquifers for this site is ranked as moderate. The evidence from previous studies suggests that a deeper aquifer is overlain by a thick confining unit that has the potential to hydraulically disconnect it from the Skagit River. However, the cross section constructed for this study (Figure 7) provides no definitive evidence of an extensive confining unit that would be capable of disconnecting groundwater from the Skagit River, and therefore such a confining condition cannot be extensive and some degree of connection between deep aquifers and the Skagit River or its tributaries may occur.*

It is unclear why this watershed is described as having "moderate potential for hydraulically disconnected aquifers?" It is unclear what that even means.

The GW-SW Interactions section also gives a somewhat biased view of effects of pumping on tributaries. The following is included in the discussions:

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[2] Nathan Rossman, Brittany Duarte, Chad Wiseman, HDR, Inc. (2019). Memorandum to Austin Melcher, Washington State Department of Ecology, Water Resources Program, dated October 25, 2019, Subject: Middle and Upper Skagit River Valley Hydrostratigraphy Characterization, https://apps.ecology.wa.gov/publications/parts/1911088part3.pdf

> *Similar groundwater modeling performed for the middle Skagit River valley indicates that wells located within 600 feet of the Skagit River capture greater than 90% of their pumped water from the Skagit River (HDR, 2017).*

This is quote is out of context. The following is also included in the referenced HDR (2017) report:

> *In areas where there are tributary creeks, the model results show that wells pumping near the tributary creeks would capture water from the creek. Generally, within 500 feet of the creek boundaries, at least 50 percent of the captured water comes from the tributary creeks and within one-quarter to one-half mile from the creeks at least 75 percent of the captured water comes from the tributary creeks.*

This is a very important aspect of pumping in alluvial aquifers in the Skagit River valley. Impacts can occur to tributaries that are much larger than the 10% that is suggested in the GW-SW interaction section. A more balanced discussion would include these results.

D. Recharge

This section on groundwater recharge is by far the weakest and least defensible section in the document. Groundwater recharge is the most important variable in assessing groundwater supply in the Skagit Basin. The approach that is used is to estimate recharge is described in an undated, draft document that is entitled "Groundwater Recharge Analysis Methods" with the authors listed "HDR, Inc., Groundwater Team."

The approach used to estimate groundwater recharge in the Skagit Basin (with a reported drainage area of 2,800 square miles acres, much of it mountainous) is based on a study that was done in four small watersheds (average area 2.4 square miles) on or near the Bangor Submarine Base in the Puget Sound lowlands. In addition to the vastly different scales and geography, the two areas (Skagit Basin versus Bangor Submarine Base) also have very different precipitation patterns (temporally and spatially), dprecipitation forms (i.e., snow versus rain), vegetation and land cover, topography, temperatures, and geological conditions. None of this is taken into account in the approach used to estimate recharge in the Skagit Basin.

In my opinion, there is no technically defensible basis for using the Bidlake-Payne recharge estimates (the approach used by HDR) in this context. The recharge estimates (including estimates of what might occur between 2020 and 2050) are potentially misleading. I recommend this section be deleted from the report.

TO: Jonathan Yoder
School of Economic Sciences
State of Washington Water Research Center
Paul G. Allen School for Global Animal Health
Washington State University

FROM: Thomas D. Mortimer, Skagit PUD Representative
Skagit Water Supply Task Force

SUBJECT" Skagit PUD Comments re: Skagit Basin Water Supply and Demand Analysis

DATE: May 19, 2021

GENERAL COMMENTS

The following document summarizes the comments of PUD No. 1 of Skagit County regarding the Water Supply and Demand Synthesis ESRI Story Map Series (report)..

General Comment 1

The story map is missing an overall/consolidated accounting summary of supply and demand estimates by use sector. There are numbers and statistics scattered throughout the report, but very little consolidation of a message supported by a unified data profile. We recommend a supply and demand report that summarizes supply against demand. This could include a graph/chart and numerical tables of the Skagit river flows with a breakout for fish needs, muni use, ag use, etc.

General Comment 2

"Municipalities hold substantial inchoate rights. Municipalities hold about 73% of diversion rights in the basin. Most of these rights – about 80% by volume – are currently inchoate (unused) rights held for planning and future growth. These inchoate rights amount to almost 60% of all diversion rights in the basin and represent an important source of potential future water withdrawal expansion, with ramifications for future water availability for other water use sectors in the future (Residential Demand tab)."

"Their increased future use to respond to potential increased municipal demand may lead to increased future competition for water."

"One category of water rights important for future water use is municipal inchoate rights, which are large in terms of volume and if fully utilized could have substantive impacts on water availability for other uses."

Narratives throughout the report, including the above statements, put forward a negative emphasis on the magnitude of municipal inchoate water rights, and clearly imply their future perfection will result in the significant degradation or impairment of existing rights/instream flows and habitat, by their ostensible role in "causing" increased competition and scarcity.

It is important to note that all municipal rights were issued subject to a determination by Ecology that water was available for their appropriation, no impairment would occur, and that the issuance was in the public interest. The report does not reference that reality nor the fact that Ecology is responsible for the appropriating of water rights after the issuance of senior municipal rights that increased stress on Skagit River resources.

The document does not acknowledge that significant quantities of municipal inchoate rights (PUD) are subject to the terms of the 1996 Memorandum of Agreement that preclude impacts by existing senior diversions to key Skagit Tributaries and related habitat.

Existing inchoate municipal water rights represent appropriated quantities that have yet to be applied to beneficial use in large part due to municipal systems engaging in water conservation/water use efficiency measures consistent with law, policy, and their own operational practices. This circumstance is not recognized in the report. Many past land use/water demand projections over the past 25 years have produced flawed and inaccurate data that do not correlate to actual declines rather than increases in capita (gpd) water use resulting from conservation, water use efficiency measures, inclined rate structures, and landscaping changes.

Delays in beneficial use of inchoate rights via conservation/water use efficiency, have enabled municipal water systems – again consistent with law/policy, to prolong the use of existing supplies, reduce impacts on water resources/habitat, and avoid the need for new appropriation. This reality and circumstance is not reflected in the report.

The study statement that inchoate rights will “cause” increased competition and availability problems for other user groups is put forward without meaningful context or definition. It also disregards the fact that the PUD and other municipal systems are diligently working to put their inchoate rights to use for use by other user sectors/population groups consistent with demand and water use efficiency factors, and in a manner that provides the greatest benefit from a regional standpoint in order to avoid new permit exempt wells and new appropriations.

Well before existing inchoate municipal supply is beneficially used and perfected, it is reasonable to conclude, based on current and evolving regulatory conditions, that no new water will be available to serve new population, industry, or commercial enterprise in Skagit County absent that derived from greater water use efficiency measures. Consequently, the retention and beneficial use of inchoate municipal water rights will be required to meet community needs and the public interest. The implication that the natural consequence of such beneficial use will cause harm is premature and should be revisited.

General Comment 3

In the subsection "Water Rights and Water Security/Tribe rights are influential for instream flows", the text inaccurately indicates that the Tribes have an off –reservation instream flow treaty right. Although this issue has been raised in Boldt II sub-proceedings, such a treaty based right has yet to be established by federal court ruling. This issue may come before the Washington State Supreme Court in the upcoming adjudication of the Nooksack River Basin.

Per the related text in the further Fish Habitat subsection, the text in this regard clearly suggests that with the growing impact of climate change, reduction of upper basin tributary flows, and significant loss in optimal spawning flows, the use of inchoate municipal water rights will cause significant negative impact (flow/temperature) to salmonid fisheries and habitat. This conclusion is speculative and should be revisited given the interest of municipal systems in appropriate resource management protection actions and agreements.

General Comment 4:

Agriculture uses 10,000 afy, permit-exempt well consumptive use is 286 afy (with only another 300-400 afy anticipated from future estimated growth). The report doesn't take adequate effort to point out the small proportion of consumptive use from permit-exempt well uses compared to other uses, and how this is not in balance with the attention that is given to impacts from permit-exempt well use.

General Comment 5:

While the exclusion of claims in the water rights analysis is understandable, this results in a great lack in confidence in the numbers. There are likely claims that would be found valid, and the exclusion of these from the numbers greatly under represents the actual water rights in place.

STORY MAP REPORT COMMENTS

Big Picture/Rights, uses & sources Tab:

Comment 1: As previously noted, the text below broadly, vaguely, and inaccurately suggests that the Tribes have a specific reserved federal treaty right to off –reservation instream flows, which is distinguished from the right to take fish and relating Culvert decision holdings. Further, the text is overly generalized and does not distinguish between the reach of on-reservation Winter's Rights (which may transcend reservation boundaries to support a primary purpose to take fish) and off-reservation instream flow claims within a larger U and A fishing area which have yet to be adjudicated or judicially determined. Strongly suggest that the above language be significantly revised per consult with a WA State AAG so it properly represents tribal treaty rights, post Culvert Decision to the public and task force.

"the Tribes of the Skagit Basin hold rights in relation to stream flow that derive from reserved fishing rights (references). These tribal treaty rights are a foundation for a great deal of Washington State judicial, legislative, and administrative water law of broad relevance to water management in Washington State, including the IFR itself"

From <https://storymaps.arcgis.com/stories/1b17862d7da04712b5abb6de31763667>

Comment 2: Swinomish v. Ecology was not decided based on tribal treaty fishing or off-reservation instream flow rights, but instead on the ultra vires exercise of Ecology authority in establishing water reservations in a new rule that unlawfully impaired prior senior instream flow rights through use of the OCPI impairment exception. Recommend statement below be deleted or substantially revised to more accurately reflect the decision.

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"These characteristics of tribal rights to fishing have been the basis for a series of very influential legal findings, some centered in the Skagit (e.g. Swinomish v. Ecology, 2013)."

From <https://storymaps.arcgis.com/stories/1b17862d7da04712b5abb6de31763667>

Comment 3: The below statement should be clarified/modified to note how later-issued water rights would be junior to the IFR, and could be made interruptible, but not necessarily prohibited. Mitigation is also an option for water rights junior to IFR.

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"It also provides the basis for closing the basin for issuance of new water rights."

From <https://storymaps.arcgis.com/stories/1b17862d7da04712b5abb6de31763667>

Comment 4: BP Map 3 doesn't appear to correctly show the District's diversion rights (proportionally incorrect).

Scarcity and Opportunity

Comment 5: Revise very overbroad statement to be more balanced and identify multiple factors that affect instream flows to fall below rule-based minimums during summer months. Also, provide appropriate reference to fact that minimum flows set based on flow regimes that may exceed capacity of natural system in order to create protective flow buffers for fish when flow conditions are depleted due to natural and diversion conditions. Other areas of the story map detail the very small percentage of river flows that withdrawn by water users.

"The net effect of these seasonal water supply and water use patterns is exemplified by the fact that Skagit River flows frequently fall below the Skagit Instream Flow Rule levels from late July through November, reflecting stress for river-based ecosystem services and valued salmonid fisheries that the Instream Flow Rule was designed to help protect (graphic above, and in the Flow Regulation tab)."

From <https://storymaps.arcgis.com/stories/1b17862d7da04712b5abb6de31763667>

Comment 6: Support the statement below with data. Summer irrigation is necessary regardless of potential changes in climate, as this region naturally has a very dry summer season. Changes from historically "dryland" farming practices has also increased agricultural irrigation. Show data that supports a longer irrigation season, as the summers are already effectively absent of rain.

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"Irrigation demand is projected to increase in response to climate change."
From <https://storymaps.arcgis.com/stories/1b17862d7da04712b5abb6de31763667>

SURFACE WATER Tab - Overview

Comment 7:

Comment: Statement below that a substantial portion of "residential water demand" is downstream of Mt. Vernon is not accurate. Skagit PUD's Skagit River diversion point is at Sedro-Woolley, not downstream of Mt Vernon. Cities of Burlington and Sedro-Woolley are upstream of Mount Vernon. The City of Anacortes' diversion is at Mount Vernon.

"A substantial portion of the agricultural and residential water demand is downstream of Mt Vernon."

From <https://storymaps.arcgis.com/stories/a01cc311c9db4cfd8e8bd854b0bcd5c0>

Climate Change and Surface Flow

Comment 8: Which climate change scenario was used for the general statements throughout this section? Low or High?

"Climate models make projections of future precipitation and temperature based on two future scenarios of greenhouse gas (GHG) concentrations, low (RCP 4.5) and high (RCP 8.5)."

from <https://storymaps.arcgis.com/stories/a01cc311c9db4cfd8e8bd854b0bcd5c0>

Comment 9: The statement below conflicts with statements elsewhere indicate summer rain reductions will be small with estimated impacts from climate change

"but will still see a decrease in summer streamflow due to higher temperatures and less summer rain."

From <https://storymaps.arcgis.com/stories/a01cc311c9db4cfd8e8bd854b0bcd5c0>

Comment 10: Recommend the report provide citation supporting the following statement when/if glacier melt will decrease in the future.

"water from melting glaciers will provide some buffer for decreases in late summer streamflow, until glaciers are reduced beyond a critical point and glacier melt water also decreases."

From <https://storymaps.arcgis.com/stories/a01cc311c9db4cfd8e8bd854b0bcd5c0>

Fish Habitat Tab

Comment 11: Multiple Skagit PUD surface water diversions (Turner and Mundt Creeks) are included in FH Map 7, but the withdrawals are subject to instream flows (even senior rights) and only activated during flows in excess of IF (withdrawals do not occur during low flow conditions). Also, these rights have a dual diversion point at the Skagit River, and the bulk of withdrawals does/will happen at the river due to stream IF constraints. This is likely the bulk of "demand" calculated by the study that results in an inaccurate assessment of "scarcity" in this portion of the basin. Did this statement/analysis consider winter/high flow withdrawals from these sources in the resulting statements comparing demand to supply in the East Fork Nookchamps? The potential for these circumstances to skew results was called out in the knowledge gaps portion of the fish habitat tab.

"The East Fork of the Nookchamps, where potential demand may be as high as 25% of supply, nevertheless has 75% of its median annual flow maintained in-river on average. Is this sufficient to sustain fish habitat, especially in light of seasonal and interannual variation in supply? This basin has suffered recently from high summer temperatures that can endanger resident salmon (Cauvel 2019), and low flow is one factor that can increase water temperatures."

From <https://storymaps.arcgis.com/stories/06fd88c135fe488e9a59b1e20e5613af>

"The East Fork of the Nookchamps, where potential demand may be as high as 25% of supply, nevertheless has 75% of its median annual flow maintained in-river on average. Is this sufficient to sustain fish habitat, especially in light of seasonal and interannual variation in supply? This basin has suffered recently from high summer temperatures that can endanger resident salmon (Cauvel 2019), and low flow is one factor that can increase water temperatures."
From <https://storymaps.arcgis.com/stories/06fd88c135fe488e9a59b1e20e5613af>

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Hydroelectric Projects

Comment 12: Correct/revise the following statement for historical accuracy. Skagit County may have requested the rule amendment, but narrative should clarify that Ecology negotiated and agreed to issue the amendment to the 2001 rule in the new 2006 rule which provided reservations of water for new uses. This amendment was then struck down by the 2013 Swinomish decision.

"In 2006, Skagit County sought to amend the rule to provide uninterruptible future water supplies to property owners, but a counter-suit by the Swinomish Tribe prevailed with the state Supreme Court, and the rule reverted to its original form."

From <https://storymaps.arcgis.com/stories/8f4c2251b67243ffb3a0793c74ff489c>

Comment 13: PUD water rights at these tributaries include rights that were originally issued senior to the IFR, but 1996 MOA allowed for conditioning of these rights to be subject to/junior to Cultus stream IFR.

"The Skagit Instream Flow Rule also specified minimum in-stream flow levels for four tributaries flowing from Cultus Mountain, which provide water supply for the Skagit Public Utilities District through a water right junior to the Instream Flow Rule. Diversions occur at the flow gage location, and open only when IFR flows are met."

From <https://storymaps.arcgis.com/stories/8f4c2251b67243ffb3a0793c74ff489c>

Residential Demand Tab

Comment 14: Tab is labeled "Residential". Municipal supply serves more than residential needs, such as industry. There isn't a tab for the significant uses of water besides agricultural and residential. Consider renaming the tab.

In Figure 3 it's showing that permit exempt use will increase from 1,258 to between 1,400 and 1836 by 2040. Is this implying that there will be more permit exempt wells, or that the withdrawal rates will be higher? Based on the moratorium of new wells, this graph is not clear.

Overview

Comment 15: support the following statement with data. For example, show a breakdown of all uses in the basin by total cumulative volume (residential, industrial, agricultural, etc.). As already stated, this report lacks in summary tables to support the generalizations that are stated throughout the document.

"The volume of water used inside and outside of homes is relatively small compared to other water sectors (e.g., agriculture, industry)"

From <https://storymaps.arcgis.com/stories/382a2724de7e41b5a37072571045f7fc>

Comment 16: The source for Anacortes is also surface water. The following statement should clarify that the water PUD gets from Anacortes is also a surface water source

"The primary water source for the Judy Reservoir system is **surface water**, although the system also has an intertie with the City of Anacortes"

From <https://storymaps.arcgis.com/stories/382a2724de7e41b5a37072571045f7fc

June 28, 2021

Jon Yoder, PhD
State of Washington Water Research Center
Washington State University

RE: ESSB 6095: Water in the Skagit Basin Sources and Uses, Present and Future Draft Storyboard

Dear Dr. Yoder,

Thank you very much for the opportunity to review the Water in the Skagit Basin Sources and Uses, Present and Future Draft Storyboard (Draft Storyboard). Overall, we are very pleased with the quality and depth of this investigation and appreciate the level of detail and information developed by you and your team. We have the following general comments.

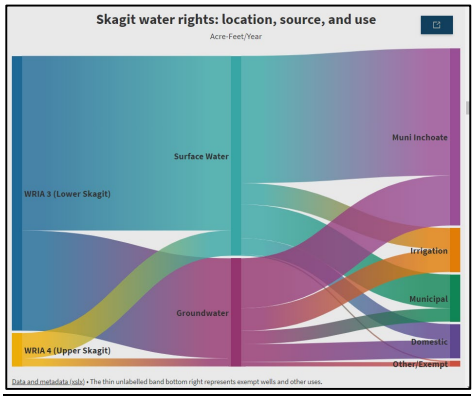
- The term "scarcity" is used throughout the Draft Storyboard without context or a clear definition as to its meaning. We believe a more precise definition of scarcity is warranted. The Skagit River is the largest U.S. tributary to Puget Sound. Based on information provided in the Draft Storyboard, the Skagit River has a mean annual volume of 12 million acre-ft with an additional 2.4 million acre-ft of groundwater recharge annually: it appears that less than 2 percent of the total annual volume of the river has been allocated under existing surface and groundwater rights, and the total existing and future consumptive demand is significantly less. A summary of water rights, current and future demand, and consumptive use as compared to total supply will be helpful and relevant in providing context for the term "scarcity." Another option is to use a word that would be a better fit.

- The spatial relationship between supply and demand is important, but not described sufficiently throughout the Draft Storyboard. The three largest allocations of water rights (Anacortes, PUD, and Agriculture) occur near or below the point of compliance in Mount Vernon. Significant withdrawals occur in the tidally influenced portion of the river, leaving the remainder of the upstream watershed largely unaffected. Accurate and detailed mapping of the spatial distribution of water rights and water demand will make it easier to understand the relationship between instream resources and consumptive uses.

- Natural conditions and conditions arising from potential changes in hydrology due to climate change are portrayed as "impacts" throughout the Draft Storyboard, implying that consumptive uses exacerbate these "impacts." Please clarify the baseline condition used for this characterization of impacts to instream resources. Please include a discussion of how hydropower operations that modify the natural condition have been incorporated into the definition of baseline condition.

In addition to these general comments, we have prepared the following specific comments on the Draft Storyboard.

Big Picture Tab. Figure BP Figure 1. Skagit Basin and Water Rights: Uses and Sources



We find this figure confusing and potentially misleading. We believe it would provide more context if this graphic were revised to include the total annual natural water supply.

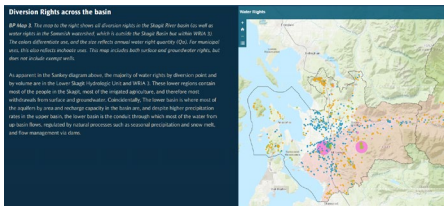
Based on information provided in the Draft Storyboard, it appears that the water rights are less than 2 percent of the total annual volume of water in the system and even less if estimated demand or consumptive uses are reported. Revising this figure would provide some perspective as to the relative volume of water allocated for municipal, irrigation, domestic, and other uses, and provide context for the use of the term “scarcity.”

Please consider revising the text and performing the proposed additional analyses.

Out of the 6,055 total water right documents pertaining to WRIAs 3 and 4 in the Washington State Department of Ecology's water rights database, 4,489 of them (74 percent) represent claims rather than permits or certificates. The fact that claims make up a super-majority of the water right authorizations in WRIA 3 and 4 is a significant source of uncertainty in understanding the water budget. While a Superior Court Adjudication is the only way to resolve this issue with finality, a simple GIS screening technique can be used to separate potentially valid claims from those that may not be valid. For example, please screen the priority date of all surface claims after 1917 (or after 1932 if adjacent to the river) and all groundwater claims after 1945 as potentially invalid because they post-date the adoption of the surface and groundwater codes. For claims that were mapped by Ecology, please perform a GIS comparison of their places of use to identify likely overlaps, thus avoiding double-counting the same water use. This methodology would reduce the number of claims from 4,489 to X. This doesn’t mean that the Y claims excluded are invalid, or that the X claims included are valid, but it

is likely a closer representation of the magnitude of actual vested water use than simply taking all claims at face value. The limited information on the status of claims remains a substantial source uncertainty around the Skagit Basin's water rights portfolio and associated water use.

Big Picture Tab. BP Map 3. Diversion rights across the basin



The information provided in the Draft Storyboard is summarized by WRIA. Please revise this map to match SW Map 1, which ends at Mount Vernon (HUC 9).

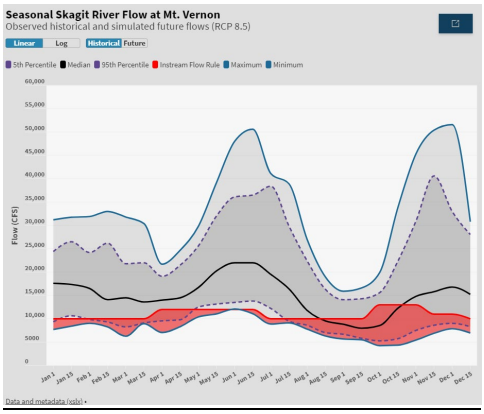
Instead of symbol size, please consider using a percentage to represent the relative size of the water right. Also please include existing demand and consumptive use.

Please include the location of the USGS Mount Vernon Gage as the point of compliance.

The associated text states that "the lower basin is where most of the aquifers by area and recharge capacity in the basin are." Our understanding is that much of the area below Mount Vernon is strongly influenced by tides and high groundwater and does not influence the river or shallow aquifer. Please use a more spatially explicit description of where recharge is occurring in relationship to points of withdrawal.

Please clarify how the 2001 Instream Flow Rule accounts for diversions below the point of compliance in Mount Vernon. This comment is related to the recent work performed by the Academy of Sciences review of the Estuary Study in the Duke 1999 Report.

BP Figure 2. Seasonal Skagit River Flow at Mt. Vernon



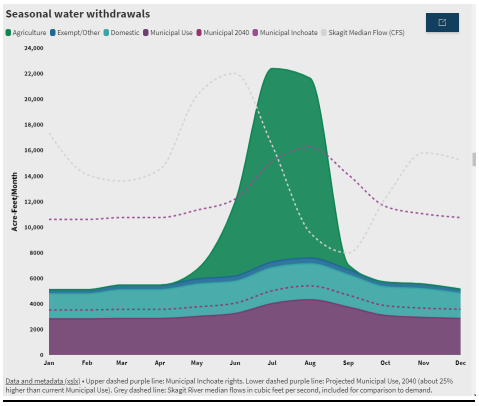
As discussed in the text, both Puget Sound Energy and Seattle City Light operate hydroelectric projects in the basin. As part of their operations, they re-time hydrographs as compared to natural conditions.

Please revise this figure and change observed historical with ***regulated*** historical Skagit river flows. Also, please add information to this figure that displays the modeled historic ***unregulated*** flow at Mount Vernon.

Puget Sound Energy gave a presentation to the Water Task Force in 2018, explaining that their new operating license that went into effect in 2008 requires them to discharge 1,000 cfs during summer as compared to their previous requirement of 80 cfs.

We believe it is important to include information about how hydropower projects influence observed historic flows, as well as current flows in the river as compared to unregulated flows. Please describe how the changes in hydropower operation are accounted for in the 2001 Instream Flow Rule, which was based on an analysis of flow records prior to 2001.

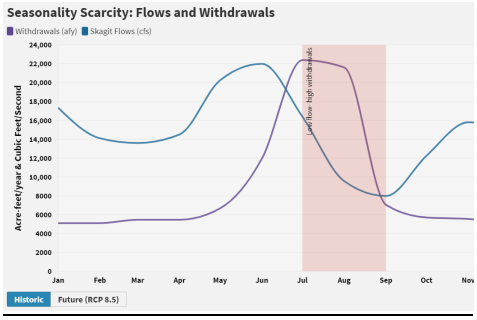
BP Figure 3. Seasonal Water withdrawals



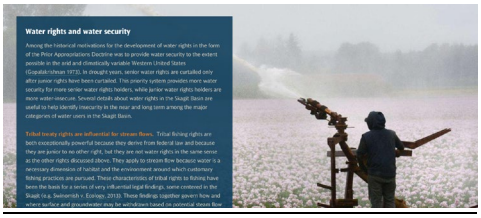
It is difficult to understand the relative importance of seasonal water withdrawals when they are reported in acre-ft/month and supply is estimated using cfs. Please revise these figures to use a consistent unit of measurement.

In addition, it would be helpful if this information were provided at several locations in WRIA 3 and 4, as much of the water withdrawal is below the point of compliance in Mount Vernon.

Using consistent units of measurement and spatially explicit reporting will provide context for the use of the term "scarcity" and will better illustrate the relationship between seasonal water withdrawals and instream habitat and salmon life histories.

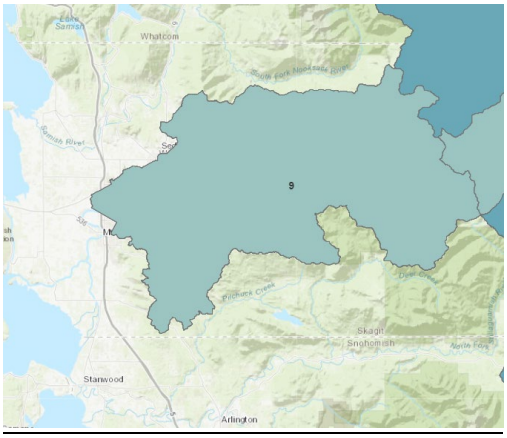


Background image: Big Picture Water rights and water security



Please change the background image to be neutral. Associating a picture of big gun irrigation with the text regarding treaty rights may inadvertently perpetuate the perceived conflict between agricultural and tribal interests.

SW Map 1. The interactive map to the right displays percent contributions by sub-basin to surface water for the Skagit River at Mount Vernon

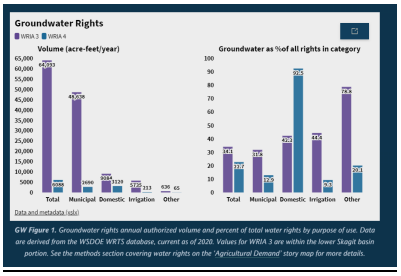


Given that most of the water demand and major diversions are in the extreme lower reaches or downstream of HUC 9, please provide context around the importance of tributaries and habitat upstream in the upper portion of HUC 9, the HUCs upstream of Sedro-Woolley in the 100+ miles of wild and scenic river, and tributaries that seem relatively unaffected by water demand.

In terms of watershed area and quantity of water as a percentage of flow, this figure and the supporting text appear to show that approximately 95 percent of the contribution of flow is upstream of virtually all the known water rights/demand.

Please revise the text to clarify the differences between tributary and mainstem flows. Many of the major diversions are on the mainstem and reflect cumulative water supply, unlike tributaries that are more closely related to HUC or sub-watershed supply.

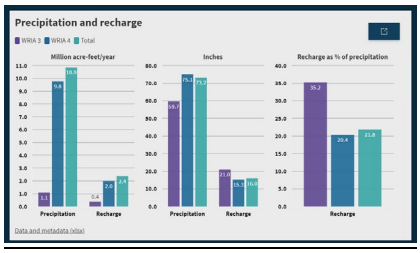
GW Figure 1. Groundwater rights annual authorized volume and percent of total water rights by purpose of use.



If groundwater resources are replenished annually from precipitation (see comment GW Figure 3), can you please estimate the annual groundwater supply as compared to the annual demand to provide context? The Draft Storyboard reports an annual groundwater recharge of 2.4 million acre-ft, with an annual consumptive use of 286 acre-ft per year, which is about 0.012%. This information relates to our general comment about the use of "scarcity" to describe water supply in the Skagit.

Can you please clarify which portion of the groundwater rights/water demand is in the tidally influenced portion of the watershed in the area that has been identified as exempt from the 2001 Instream Flow Rule?

GW Figure 3. Average annual precipitation and recharge for the historic period (1981–2010)

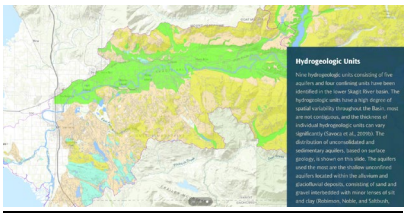


It appears there is a surplus of rainfall; more detail on the relationship between precipitation, groundwater recharge, and surface runoff would be helpful.

Can you please add a total groundwater budget based on inputs from precipitation and outputs?

Can you clarify if annual precipitation is enough to recharge the aquifer or if the aquifers are being impacted by withdrawals that are not replenished annually?

GW Map 2 Geography - The Skagit River (1981–2010)

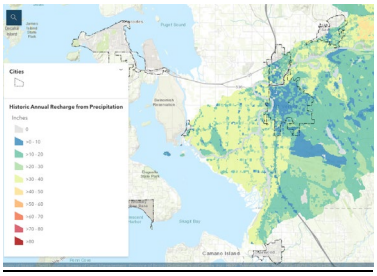


The Draft Storyboard text associated with this map states that "*Groundwater withdrawals are heaviest in the shallow unconfined aquifers of the lower Skagit River basin, with municipal and irrigation being the two largest uses of groundwater. Groundwater-surface water interactions occur along the Skagit River and its tributaries, which can lead to streamflow depletion up to the full amount of water pumped by a well. The strong stream-aquifer connectivity and high recharge rates play a moderating role on groundwater levels.*"

Can you please:

- Provide context about the relative importance of demand/consumptive use as compared to supply; the text seems to indicate large uses of groundwater in the unconfined aquifers relative to the supply.
- Clarify if some of the geologic units that are highly connected to the river are recharged by surface water sources or primarily through precipitation?
- Include cross sections that illustrate how groundwater resources are recharged?
- Better explain the effect of the hydropower projects and modified summer low-flow hydrographs on shallow aquifers/floodplain water table?
- Clarify if it is possible that hydropower operations result in higher-than-natural stream flows in the summer and also result in higher-than-natural shallow/floodplain aquifer elevations in the summer?
- Clarify how the work performed by Ecology for the SCL Water Mitigation Agreement relates to shallow aquifer recharge and water availability?

GW Map 4. Distribution of historic period (1981–2010) annual average groundwater recharge from precipitation in inches per year

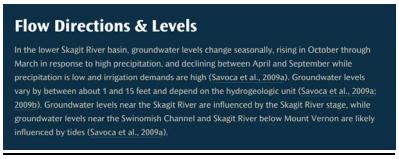


This seems like a very high level of recharge in the delta – this area is below mean high tide and the groundwater table is at or very near the surface most of the year.

Can you please clarify which portion of the groundwater rights/water demand is in the tidally influenced portion of the watershed in the area that has been identified as exempt from the 2001 Instream Flow Rule?

Can you provide a cross section?

GW Flow Direction & Levels



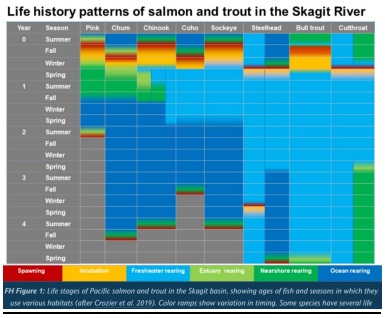
This text states that *"In the lower Skagit River basin, groundwater levels change seasonally, rising in October through March in response to high precipitation, and declining between April and September while precipitation is low and irrigation demands are high (Savoca et al., 2009a).*

Please revise this statement to clarify that Savoca et al. is the source for the conclusion that the connection between decline groundwater levels is related to irrigation demands, and provide more specific information about the relative importance of precipitation as it pertains to seasonal groundwater level as compared to irrigation demand.

Based on the summary of groundwater rights provided in the Draft Storyboard, irrigation is a small fraction of the overall demand (see GW Figure 1). Is there conclusive data that irrigation demand is causal to groundwater decline?

Please provide more information about how groundwater recharge in the delta below the point of compliance in areas where groundwater levels are influenced by tides and unconfined salt water is relevant to an evaluation of water supply and demand.

FH Figure 1: Life stages of Pacific salmon and trout in the Skagit basin



FH Figure 1: Life stages of Pacific salmon and trout in the Skagit basin, showing ages of fish and seasons in which they use various habitats (after Crozier et al. 2019). Color ramps show variation in timing. Some species have several life

This figure is confusing because it includes too much information. Please use several figures to clarify the difference(s) (if any) between estuary, nearshore habitat, tributaries, and mainstem habitats.

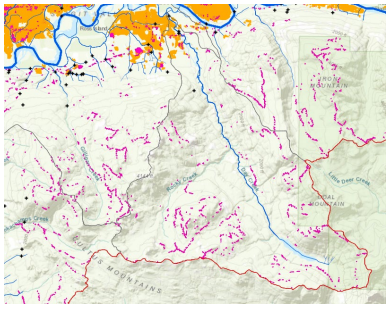
Please remove the information related to ocean rearing. We believe it is not relevant to water supply and demand.

Please clarify if nearshore and estuary life stages are in Skagit Bay or in the lower tidally influenced freshwater river reaches. If habitat associated with nearshore or estuary life stages are not influenced by the volume/flow rate of water from the Skagit River, please consider removing this information from the figure. This comment is related to the recent work performed by the Academy of Sciences review of the Estuary Study in the Duke 1999 Report.

Please include a figure/map that describes the life history patterns and spatial and seasonal distribution of Pacific salmon and trout in the watershed and distinguishes between mainstem and tributary life history patterns, including the lower mainstem Skagit.

Please clarify which, if any, river reaches are primarily used for migration.

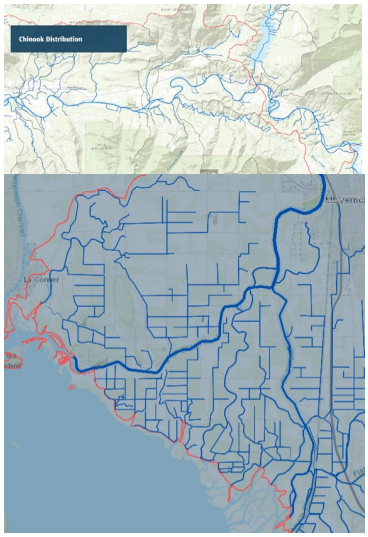
FH Map 4. Water rights across the basin by land-use class and in relationship to fish habitat



The municipal land-use data layer seems to indicate that logging roads are a municipal land-use that would require water. Please revise the data layer as needed to better reflect land uses that are likely to use water.

It is unclear why the distribution of floodplain-sensitive species was used as a proxy for impacts. The WDFW SalmonScape database shows a significantly larger network of streams/habitat and fish distribution. Is there a reason this dataset wasn't used?

FH Map 1. Distribution of floodplain sensitive species in the Skagit Basin



The distribution of Chinook salmon includes Lake Shannon and some of the steeper tributaries in some locations and seems to exclude lower gradient larger streams in other areas.

Please clarify how this data layer of Chinook/other floodplain-sensitive species distribution was developed and how it supports the statement that:

"all anadromous species use the lower reaches of the Skagit River and many of the lower tributaries. Steelhead and bull trout physically utilize a greater spatial extent of the basin, and more so than the Salmon species, physically utilize the upper reaches of many of the sub-basins."

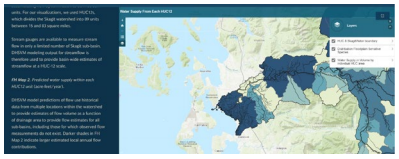
Please provide more spatially and seasonally explicit information about the life history stages of salmonids that utilize the lower reaches of the mainstem Skagit River as opposed to tributaries or other types of habitat that is available.

The WDFW SalmonScape database shows a significantly larger network of streams/habitat and fish distribution. Is there a reason this dataset wasn't used?

Many of the lower tributaries are not mapped correctly. WDFW has classified almost all these as artificial drainage and irrigation ditches that are not tributaries to the Skagit River; please correct the maps that rely on this data layer.

Are there documented locations where salmon habitat is impacted by low-flows beyond what naturally occurs in the system?

FH Map 2. Predicted water supply within each HUC12 unit (acre-ft/year)



The purpose of this figure is to illustrate "*estimated local annual flow contributions"* and states that "*from the perspective of fishes in the Skagit River, larger tributaries offer inherently more water to support fish habitat forming processes."*

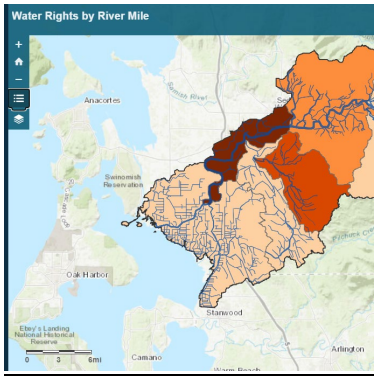
FH Map 2 is confusing because the color coding doesn't account for accumulation of flow in larger tributaries with multiple HUC basins' contributing flow.

It is unclear how this FH Map 2 supports the statement in the text without showing cumulative flow in the mainstem and larger tributaries.

The text states HUC12 was used but the map states HUC8. This extent of FH Map 2 should be consistent with SW Map 1 that ends at HUC 9.

Please clarify that habitat in the lower river is also influenced by tides and input of saltwater, and that at lower flow rates the importance of tides increases. This comment is related to the recent work performed by the Academy of Sciences review of the Estuary Study in the Duke 1999 Report.

FH Map 5. Potential water demand (water rights summed by volume) by river mile, summarized for each HUC12 unit



It is our understanding that the purpose of FH Map 5 is to illustrate that water withdrawals by volume are generally largest in the lower basin, thereby impacting fish.

It is clear from the Draft Storyboard that most of the withdrawals are in the lower river and are mainstem diversions (Anacortes/PUD, Ag). Please provide consistency in the map coloring to either include cumulative river flow or water rights/demand specific to the HUC identified. It is important to revise the Draft Storyboard to provide clarity in terms of mainstem supply and demand as compared to tributary supply and demand, particularly in the context of potential impacts to fisheries.

Would it be possible to present the relationship between supply and demand/consumptive use as a ratio or percentage indicating the relative importance as it pertains to instream habitat?

A spatially explicit description of points of withdrawal and points of return is important to better characterize the relative importance of supply vs. consumptive use. Particularly in the upper watershed, the Draft Storyboard suggests that most of the estimated water demand is almost immediately returned to the river, thereby reducing the potential effect to a spatially explicit reach.

The seasonality of water demand/consumptive use needs to be better explained in the context of impacts to fisheries: Do the withdrawals have the same impact throughout the year or are they concentrated on a specific species and/or life-history stage?

Please revise the tributary network in the lowest HUC: most of the blue lines are artificial ditches that drain directly to salt water.

Please be consistent with SW Map 1 that ends at HUC 9.

Flow Regulation

This section header in the Draft Storyboard is confusing because the use of "*regulation*" has two very different meanings.

As it pertains to the role of hydropower to re-time the hydrograph, please provide more information about how the regulated hydrograph was accounted for during the 2001 rule making/IFIM process and how it relates to the baseline condition by which impacts are compared.

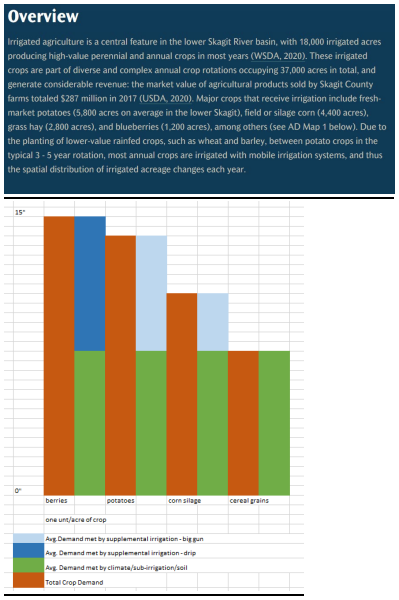
The Draft Storyboard text states that:

"for the Baker hydroelectric project, minimum required flows are 1,000 cfs for August 1 to October 20 and 1,200 cfs from October 21 to July 31. These required minimum flows make up about 10% of the flows associated with the Skagit Instream Flow Rule (IFR) at Mt. Vernon for August to October."

It is important to note that this requirement did not go into effect until after the 2001 Instream Flow Rule was established. See our comments on BP Figure 2.

Please explain the relationship between increases in hydropower low-flow discharge rate requirements, the instream flow rule, and water availability.

Ag Overview

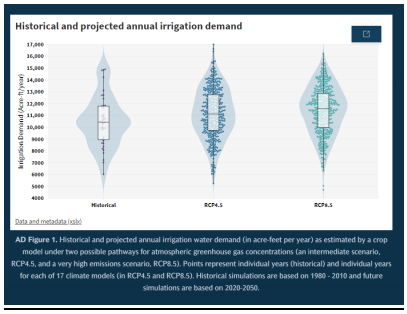


It is important to point out that only about half of the crops grown in any given year require supplemental irrigation. Unlike eastern Washington/California, this is supplemental irrigation, with some portion of the crop irrigation needs met by soil and climate conditions.

A more comprehensive ag water demand picture is needed. Please include a bar chart (see adjacent example) of CropSyst output to illustrate the water budget for each crop shown on AD Map 1 and the range of the crops' water needs that are met through soil moisture/climate and then supplemental irrigation.

Please include impacts to yield from deficit irrigation. A more comprehensive water demand picture is needed.

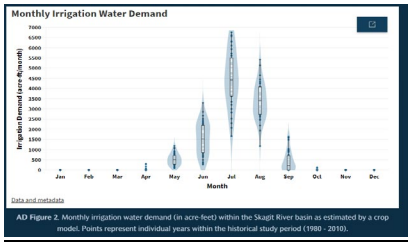
AD Figure 1. Historical and projected annual irrigation water demand



Given the recent trend in increasing agricultural irrigation demand, as noted in the Draft Storyboard, please include a future annual irrigation demand based on climate change scenarios and a shift in the annual mix of the types of crops grown from lower-value crops to higher-value crops.

Please clarify whether monthly irrigation water demand was calculated based on plant growth and did not include other factors related to soil preparation, harvest, and soil health.

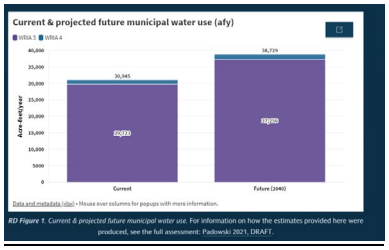
AD Figure 2. Monthly irrigation water demand



Please include a summary figure showing both demand and Jr. and Sr. Supply.

In addition to the hyperlink to the other segment of the storyboard, please provide more detail to the chart to illustrate when and where junior irrigation water rights are impacted by the 2001 Instream Flow Rule.

RD Figure 1. Current and Projected future municipal water use



Please provide more context for municipal growth. The Draft Storyboard text states that only about 15 percent of the total municipal water rights are currently being used. How much growth is expected in Skagit County given the current Comprehensive Plan? How does the estimate of future municipal water use relate to the existing municipal water rights?

Under the 1996 MOU and 1999 Coordinated Water System Management plan, were senior municipal water rights intended to support growth outside Skagit County? Please clarify if future growth includes expansion of service areas outside Skagit County and/or new water intensive industries.

Thank you for your consideration of our comments. We very much appreciate the opportunity to review and comment on the Draft Storyboard and are available for additional discussion/follow-up questions.

Sincerely,

Jenna Friebel
Executive Director
Skagit County Drainage and Irrigation Districts Consortium
jfriebel@skagitdidc.org
360-708-0344

Allen Rozema
Executive Director
Skagitonians to Preserve Farmland
allenr@skagitonians.org
360-336-3974

cc:

Co-Chair Senator Keith Wagoner; Washington State 39th Legislative District
Co-Chair Representative Debra Lekanoff; Washington State 40th Legislative District
Dave Christensen; Washington State Department of Ecology Water Resources
Austin Melcher; Washington State Department of Ecology Water Resources