

Memorandum

February 26, 2025

To: Steve Gray and Rhiana Barkie
Clallam County Department of Public Works

From: David Rice, PE
Bob Montgomery, PE

Re: Review of Dungeness Reservoir WEAP Model Inputs and Results

Introduction

This memorandum provides a summary of Anchor QEA's review of the Watershed Evaluation and Planning (WEAP) model inputs and results prepared for use in evaluating the Dungeness Off-Channel Reservoir project. Clallam County is working closely with stakeholders in the Dungeness River Watershed, referred to as the Dungeness Reservoir Work Group, to design and permit the Dungeness Off-Channel Reservoir project. With input from the Dungeness Reservoir Work Group, Clallam County contracted with Washington Water Trust (WWT) to develop a model to evaluate the reservoir water balance and its impact on flows in the Dungeness River supported by grant funding. The water resources planning software tool selected for this evaluation was the WEAP model. WWT initiated development of the WEAP model to inform project planning, and due to staffing changes and additional expertise needed, WWT subcontracted with Stockholm Environment Institute (SEI) to complete the model. WWT and SEI met with various members of the Dungeness Reservoir Work Group during model development to discuss inputs, parameters, and model scenarios. WWT and SEI also consulted with the University of Washington Climate Impacts Group and the Point No Point Treaty Council (PNPTC) to select flow inputs to be used in evaluating the reservoir water balance and impact on Dungeness River flows under anticipated future climate change conditions. Preliminary model results were presented to the Dungeness Reservoir Work Group in October 2024. Additional model scenarios were developed based on initial feedback from the Dungeness Reservoir Work Group. The updated model results were then presented to the Dungeness River Management Team (DRMT) in December 2024.

Several questions and concerns have been raised by members of the Dungeness Reservoir Work Group about the project and its ability to deliver targeted benefits based on their understanding of the WEAP model results. Specifically, the results suggest that the reservoir may have limited ability to provide a benefit to late summer flows in the Dungeness River under future climate change conditions. The model results are directly related to hydrologic inputs, which include Dungeness River flows forecasted for a series of climate change scenarios by the PNPTC. In order to provide additional perspective for the Dungeness Reservoir Work Group, Anchor QEA reviewed the model inputs, including the flow forecasts provided by the PNPTC, and the model results, including the

potential impact that the reservoir project could have on Dungeness River flows. This memorandum summarizes our review.

Information Reviewed

Anchor QEA's principal water resources engineers reviewed the WEAP model inputs and results, focusing on the climate change inputs used in the model and the corresponding results. The documents reviewed by Anchor QEA include the following:

- A presentation given to the DRMT by WWT and SEI in December 2024 to summarize the current WEAP model results (SEI and WWT 2024)
- A report, *Dungeness WEAP Model Documentation* (SEI 2024), prepared by Doug Chalmers of SEI in December 2024 to summarize WEAP model development and results
- A March 2019 PNPTC report, *Modeling the Effects of Forecasted Climate Change on Fish-bearing Streams in Western Washington State, Final Technical Report* (PNPTC 2019) summarizing climate change streamflow projection modeling
- A memorandum from the PNPTC regarding streamflow projection data use for Dungeness Off-Channel Reservoir modeling and limitations (PNPTC 2023)
- Follow up email communication between WWT, SEI, and the PNPTC with additional hydrologic model calibration plots, provided late in February 2024 (WWT 2024)

The documents reviewed offer a general overview of climate change modeling but did not contain enough detail to fully understand the methodology used by the PNPTC to develop streamflow projections with climate change and how those flow projections were used.

Targeted Project Benefits

Because recent Dungeness Reservoir Work Group discussions regarding WEAP model results have raised questions about whether the reservoir project can provide the benefits targeted for the project, a recap of those targeted benefits is provided below:

- **Dungeness River Flow Restoration:** The proposed reservoir will release water to meet irrigation needs on the east side of the Dungeness River during the late summer, allowing for a corresponding reduction in diversions from the river during that time. This will increase late summer flows and enhance fish passage and habitat conditions in the Dungeness River.
- **Long-Term Agricultural Viability:** Water stored in the reservoir will be released to meet late summer irrigation needs on the east side of the Dungeness River. Stored water will add reliability and flexibility to the irrigation supply system east of the Dungeness River.
- **Climate Resiliency:** Future climate change projections show a trend toward increased rainfall in the winter and early spring, an earlier drop in the hydrograph in the summer, and lower flows in the late summer. The proposed reservoir will allow for capture of water when it is

available, during the winter and early spring, that will then be released to meet irrigation needs in the late summer, when flows in the river are low and irrigation demand is still high.

- **Overland Flow Management:** The City of Sequim has secured a grant from the Federal Emergency Management Agency to investigate the potential for diverting runoff that is captured and conveyed in the Highland Irrigation District (HID) Canal system during peak storm events to an infiltration facility on the reservoir property to reduce potential for flooding downstream, where the HID Canal system flows through downtown Sequim. Clallam County is working on an interlocal agreement with the City of Sequim that will allow this work to be completed by Clallam County in conjunction with the reservoir project.
- **Infiltration:** Water stored in the reservoir could be used to enhance shallow aquifer recharge (SAR). SAR has been used in the Dungeness River Watershed to maintain groundwater hydrology and supplement flows in the Dungeness River and nearby tributaries. The potential for infiltration at the reservoir site will be evaluated as part of the Overland Flow Management assessment noted in the previous bullet.
- **Potential for Public Recreation Opportunities:** The reservoir site is currently used for a variety of recreational activities. Once the reservoir has been constructed, the County will continue to manage the site as a County Park to enhance and preserve recreational use.

Summary of WEAP Model Inputs and Results

Model Inputs

As noted previously, the WEAP model was selected to provide a more robust evaluation of the reservoir water balance and its impact on Dungeness River flows. The WEAP model can evaluate a wide variety of hydrologic conditions, irrigation demand conditions, and other inputs. It is our understanding that the WEAP model uses the following data and input parameters:

- **Upstream Dungeness River Flows:** Both historical and projected flows upstream of the reservoir were used as inputs for water balance modeling, including the following:
 - Historical flows monitored at the Dungeness River United States Geological Survey (USGS) Gage No. 1204800
 - Projected flows from a hydrologic model of climate change forecasts from 2030–2080 developed by the PNPTC
- **Reservoir Filling:** The following inputs and constraints were used to determine when flows were available from the Dungeness River for filling the Dungeness Reservoir:
 - Diversions were constrained by minimum instream flow requirements for the Dungeness River based on the Instream Flow Rule outlined in Washington Administrative Code (WAC) 173-518-040, Table IIA.
 - Diversions for reservoir filling were assumed to be primarily from maximum allocation water, as outlined in WAC 173-518-090, Table VI.

- Excess HID water rights (the portion of HID’s water rights not needed for irrigation at a given time during the irrigation season) were assumed to be available as a secondary source of water for reservoir filling.
- Diversion of water to the reservoir for filling was not allowed when Dungeness River flows were in excess of 1,700 cubic feet per second (cfs; approximately the 1.5-year recurrence flow).
- **Reservoir Operations:** The following inputs were used for reservoir operations and water balance calculations for the WEAP model:
 - The capacity of the conveyance system between the HID fish screens and the reservoir was assumed to be limited to a capacity of 25 cfs, except for one scenario, which evaluated an expanded capacity of 35 cfs.
 - The capacity of the conveyance system that will release water from the reservoir to the downstream irrigation systems for use was assumed to have a capacity of 25 cfs.
 - The water balance evaluated the smallest and largest reservoir configurations that are currently under consideration for design, referred to as the “Option E” reservoir configurations, as follows:
 - Reservoir Configuration Option E1: 959 acre-feet
 - Reservoir Configuration Option E4: 1,610 acre-feet
- **Irrigator Water Use:** Water use was modeled based on the following input and constraint:
 - Water use was assumed to be consistent with diversion records from 2020, which was identified as a recent, representative year with typical water use by HID and WWT.
 - Diversions for irrigation water use were restricted according to the low flow limits established in the 2012 Memorandum of Agreement between the Dungeness Water Users Association and the Washington State Department of Ecology.
- **Downstream Dungeness River Flows:** The impact on downstream flows and compliance with instream flow rules and maximum allocation water limits were modeled based on streamflows monitored on the Dungeness River at Ecology Gage No. 18A050, referred to as the Schoolhouse Gage.

Model Scenarios

Five scenarios were evaluated by SEI using the WEAP model. Each scenario was modeled for streamflow conditions projected by the PNPTC for 10 future global climate change model (GCM) projections and for historical streamflow conditions from 2007 to 2022. The scenarios modeled are summarized in Table 1.

Table 1
WEAP Model Scenarios

Operation Scenario	Reservoir Size	Irrigation Demands	Reservoir Fill Source	Conveyance Capacity—River to Reservoir	Streamflow Projections
No Reservoir	No Reservoir	2020 WY	No Reservoir	N/A	Each scenario run for flows estimated for 10 future climate change projections (2030–2080) and historical flows (2007–2022)
Reservoir E1 (959 acre-feet)	959 acre-feet	2020 WY	Maximum Allocation Water + Excess HID Water Right	25 cfs to reservoir + 2 cfs to fish bypass	
Reservoir E4 (1,610 acre-feet)	1,610 acre-feet	2020 WY	Maximum Allocation Water + Excess HID Water Right	25 cfs to reservoir + 2 cfs to fish bypass	
Reservoir E4 with 35-cfs conveyance	1,610 acre-feet	2020 WY	Maximum Allocation Water + Excess HID Water Right	35 cfs to reservoir + 2 cfs to fish bypass	
Unimpaired	No Reservoir	No Demand	No Reservoir	N/A	

Note:

1. Source of information: SEI and WWT Water Balance Model Results presentation to the Dungeness River Management Team, December 11, 2024.

WY: Water Year

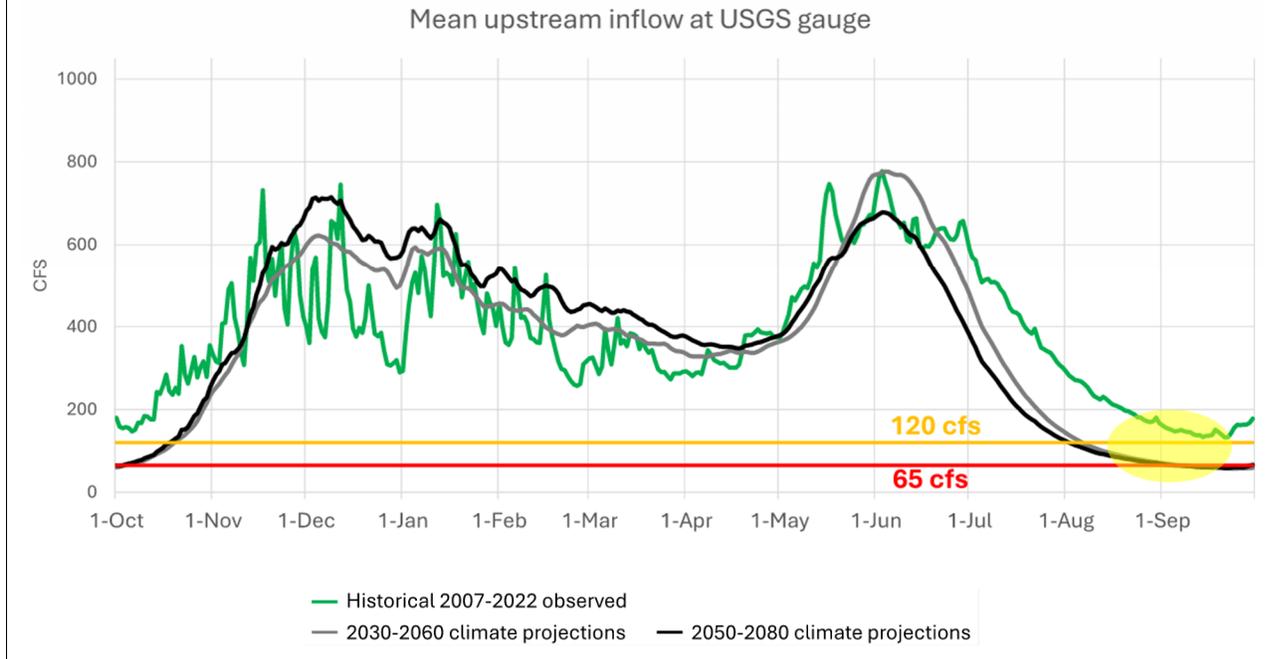
Modeled Dungeness River Flow Conditions

Figure 1 includes a plot generated by SEI of the historical (2007–2022) observed flows in the Dungeness River upstream of the reservoir at United States Geological Survey Gage No. 1204800 compared to the average of the flows modeled by the PNPTC for projected 2030–2060 climate change conditions and projected 2050–2080 climate change conditions. The results project the following key changes in Dungeness River flows resulting from projected climate change conditions:

- An overall increase in the volume of runoff during the winter and spring
- A much earlier and steeper decline of the hydrograph in the summer
- Substantially lower flows in the late summer

It should be noted that the flows plotted in Figure 1 do not include a series representing results from PNPTC’s model run completed to calibrate model results against observed historical flow data for the Dungeness River from 1915–2011. The time frame of that calibration model run does not match with the time frame of the historical flows plotted in this figure. However, addition of those results would be helpful to show how the calibrated PNPTC Dungeness River flow model compares to the observed historical data and projected flows under climate change.

Figure 1
Existing vs. Projected (with Climate Change) Dungeness River Flow Conditions



Note:

1. Source of information: SEI and WWT Water Balance Model Results presentation to the Dungeness River Management Team, December 11, 2024.
2. The plot in this figure does not include a series representing results from PNPTC's model run completed to calibrate model results against observed historical flow data for the Dungeness River from 1915–2011. The time frame of that calibration model run does not match with the time frame of the historical flows plotted in this figure. However, addition of those results would be helpful to show how the calibrated PNPTC Dungeness River flow model compares to the observed historical data and projected flows under climate change.

If the flow conditions in the Dungeness River change as shown in Figure 1 and the limitations established by the 2012 Memorandum of Agreement persist as that shift in the hydrograph occurs, the irrigators' ability to divert water from the Dungeness River for irrigation during the late summer would be impacted significantly. Specifically, the following would occur:

- The flows in the Dungeness River would hit the low flow threshold of 120 cfs much earlier in the year, on average, and more frequently (almost every year). Currently, when flows fall below that threshold, diversions for irrigation are reduced according to the voluntary limits established in the 2012 Memorandum of Agreement.
- The flows in the Dungeness River would hit the extreme low flow threshold of 65 cfs more frequently. Flows did not dip below 65 cfs during the historical period of record used by SEI for the WEAP model (2007–2022). The results of the WEAP model suggest that under climate change, flows would drop below 65 cfs in early August during the driest years. The results also suggest that flows would drop below 65 cfs by the end of the irrigation season during dry to slightly above average years. Currently, if flows were to fall below the extreme low flow threshold, diversions would be discontinued, according to the voluntary limits established in the 2012 Memorandum of Agreement.

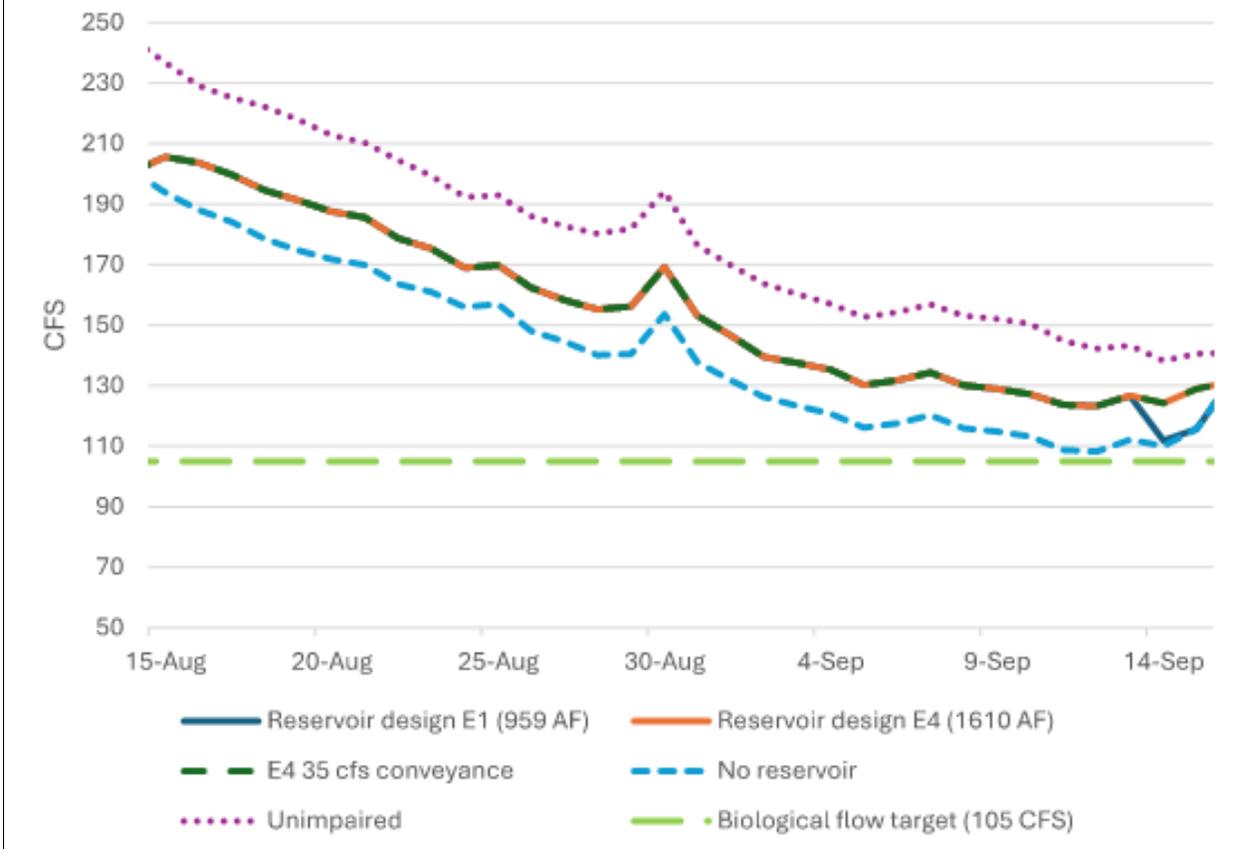
Modeled Reservoir Refill

The WEAP model results indicate that for the flow scenarios modeled, there would be a sufficient volume of maximum allocation water plus excess HID water rights available to fill a 1,610-acre-foot reservoir (Option E4) every year (100% refill ratio). This result is true for both the historical flow conditions and for the projected flow conditions with climate change. There was not a scenario modeled with conditions similar to 2001 or 2005, which were both very dry years with much lower than average precipitation in the winter, much lower than average snowpack, and lower than average spring and summer precipitation. So, the model may not be capturing some of the variability that occurs during extremely dry conditions that could result in not enough water being available for reservoir refill. However, the model results do confirm that a reservoir refilled by water diverted from the Dungeness River as maximum allocation water or as excess HID irrigation water would have a very high probability of refill.

Modeled Impact on Dungeness River Flows

Figures 2, 3, and 4 include graphs illustrating the impact of the reservoir on Dungeness River flows from the SEI WEAP Model results presentation.

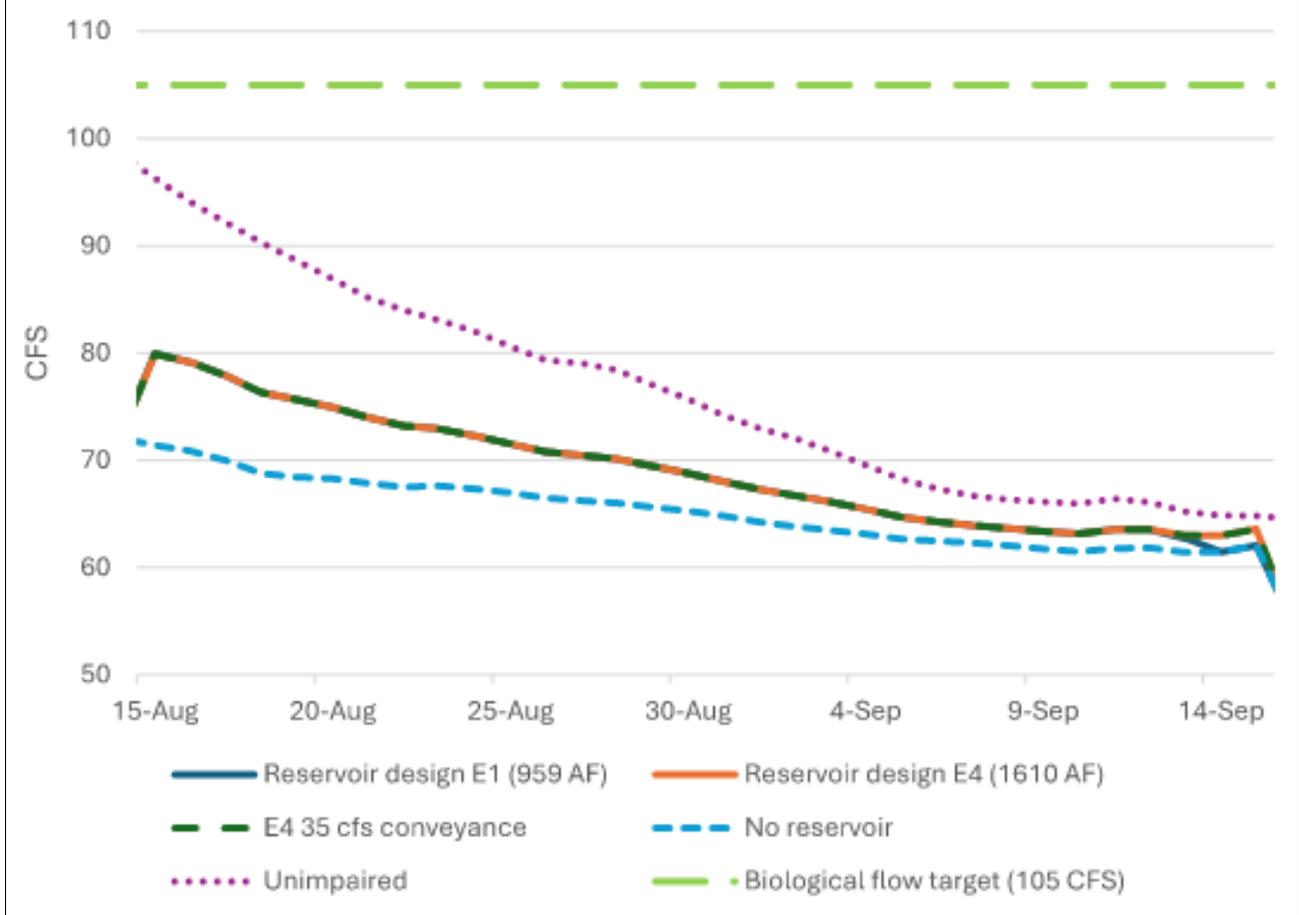
Figure 2
Results of Mean Streamflow at Schoolhouse Gage (Historical, 2007–2022)



Note:

1. Source of information: SEI and WWT Water Balance Model Results presentation to the DRMT, December 11, 2024.

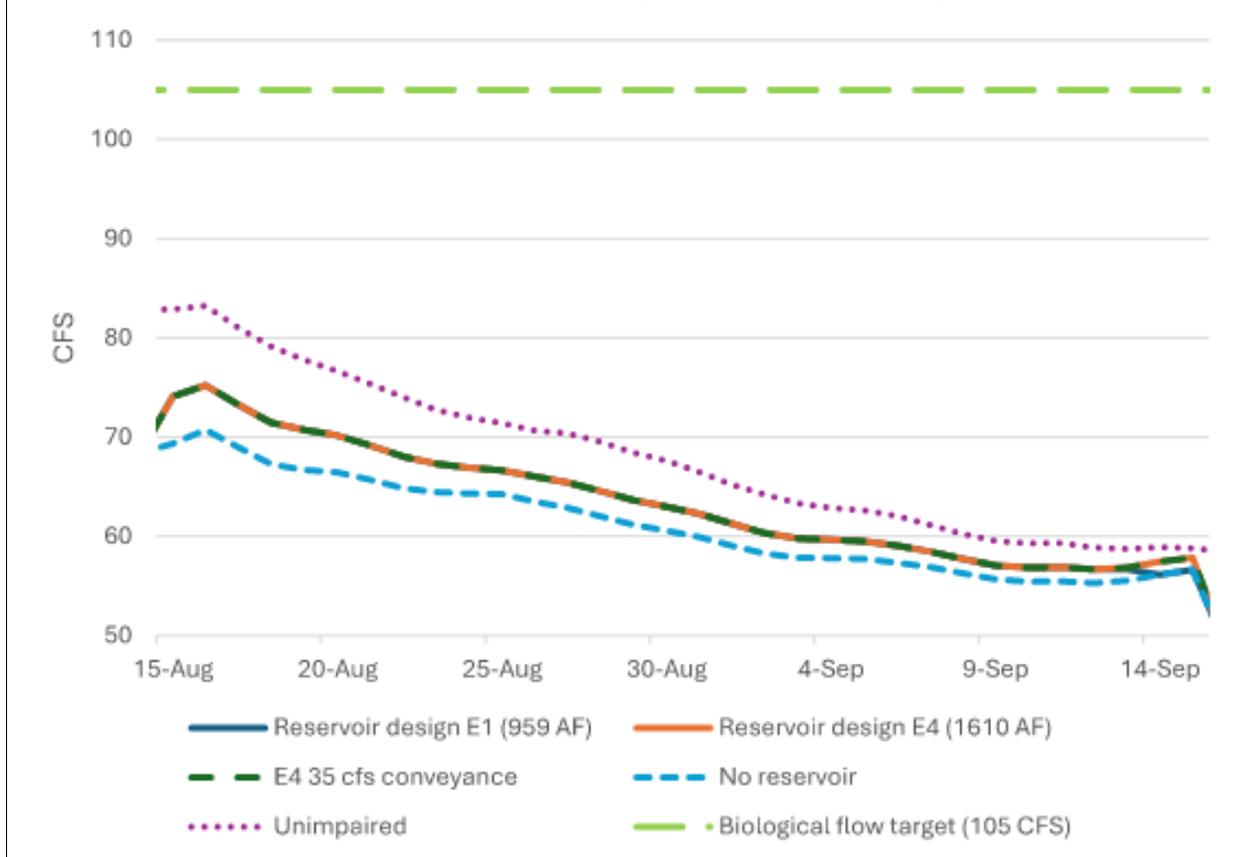
Figure 3
Results of Mean Streamflow at Schoolhouse Gage (With Climate Change, 2030–2060)



Note:

1. Source of information: SEI and WWT Water Balance Model Results presentation to the DRMT, December 11, 2024.

Figure 4
Results of Mean Streamflow at Schoolhouse Gage (With Climate Change, 2050–2080)



Note:

1. Source of information: SEI and WWT Water Balance Model Results presentation to the DRMT, December 11, 2024.

The WEAP model results suggest the following about the potential impact of the reservoir on Dungeness River flows:

- Under historical (2007–2022) Dungeness River flow conditions, water supplied for irrigation from the reservoir would result in a corresponding (roughly 1 to 1) reduction in diversions from the Dungeness River. The results suggest that the mean flow benefit in the Dungeness River would be on the order of 13 to 17 cfs during the last month of the irrigation season, which would generally be equal to the rate at which water would be supplied from the reservoir to the downstream irrigation system for irrigation.
- Under the flow projections developed by the PNPTC for future (2030–2060) climate change conditions, the flow benefit in the Dungeness River would be substantially reduced. The results suggest that the mean flow benefit in the Dungeness River would range from approximately 9 cfs in mid-August to nearly 0 cfs by the end of the irrigation season.
- Under the flow projections developed by the PNPTC for far future (2050–2080) climate change conditions, the flow benefit in the Dungeness River would be reduced even further.

The results suggest that the mean flow benefit in the Dungeness River would range from approximately 5 cfs in mid-August to nearly 0 cfs by the end of the irrigation season.

The reduction in flow benefit projected under climate change conditions is directly related to the projected change in the hydrograph predicted in the PNPTC flow projections that were used as hydrologic input to the WEAP model and the assumption that the 2012 Memorandum of Agreement rules would persist under these conditions. Based on the projected flow conditions that were modeled, if there was no reservoir, very little water would be available for irrigation diversions under projected climate change conditions during the late summer because flows would dip below the low and extreme low flow thresholds. The WEAP model estimates flow benefit by comparing Dungeness River flows in the scenario with no reservoir (see Table 1) to flows estimated for each scenario with a reservoir. Because very little flow would be available for diversion under the flow conditions projected by the PNPTC with climate change, with no reservoir in place, the model predicts that there would be very little opportunity to reduce late summer diversions by building a reservoir.

Under the flow conditions projected by the PNPTC hydrologic model with climate change, if no reservoir was in place, irrigated agriculture would have to change substantially in the Dungeness River Watershed. The growing season would need to shift, crop types would need to change, or agricultural lands would have to be converted to other uses. There would not be enough water to irrigate the lands and crops that currently exist. Under these projected flow conditions, a reservoir would be essential to maintaining agriculture in the Dungeness Watershed.

Review Commentary

Based on our review of the Dungeness River flows used as input to the model, we offer the following comments and observations:

Ensemble of Global Climate Models Used

In their 2023 memorandum, the PNPTC stated that "It is recommended to run a separate simulation for each GCM, then average the outcomes to get a representative ensemble forecast." PNPTC also recommended that, for use in modeling future climate change conditions in the WEAP model, SEI should "aggregate results over a multi-decadal (e.g., 30-year) period to get a representation of future conditions." Based on our discussions with SEI and WWT about the model results and how the PNPTC data was used in the model, it appears that the flow inputs from the PNPTC were used in the WEAP model scenarios according to these recommendations from the PNPTC.

Streamflow Projections Used for Climate Change Modeling

The Dungeness River flow projections provided by the PNPTC were developed by applying meteorological outputs from downscaled GCMs to a distributed hydrology soil vegetation model (DHSVM) which simulates the hydrologic cycle and provides streamflow estimates. The Dungeness

River flows predicted by the DHSVM model for the time periods of 2030–2060 and 2050–2080 were used as inputs to the WEAP model to project the water balance and Dungeness River flows under climate change conditions. A separate WEAP model scenario was also developed using historical (2007–2022) flow records from the USGS gage as input.

The 2023 PNPTC memorandum states that “Potential uncertainties are introduced with the climate forecasts since each GCM makes generalizations about many climate parameters at a coarse resolution. Adjusting parameters of finer-scale processes undoubtedly introduces assumptions that do not hold true in the natural climate system and are not necessarily consistent between GCMs. Additionally, because the MACA downscaled climate forecasting relies on historical weather grids as the training dataset, some historical weather patterns and weather event regularities are assumed to remain consistent into the future. Errors in the historical weather data can be replicated or even enhanced in the downscaling process.” Based on our experience working with climate change projection models in other watersheds, errors in meteorological downscaling to the project’s watershed and errors in hydrologic modeling can result in a wide range of results.

It is our understanding that the flow projections provided by the PNPTC represent the largest effort to project Dungeness River flows under climate change conditions that has been completed to date. While we believe the PNPTC did a thorough job completing the model with the best information that was available to them, we also recognize the significant challenges involved in downscaling meteorological data from the GCMs, applying that data to a hydrologic model, and then calibrating that model to provide accurate results. There are many assumptions that have to be made along the way and the resulting flow projections inevitably reflect errors and inconsistencies in the data available, resulting in model biases and inaccuracies in the results, as noted by the PNPTC in their 2023 memorandum.

Comment about GCM Downscaling

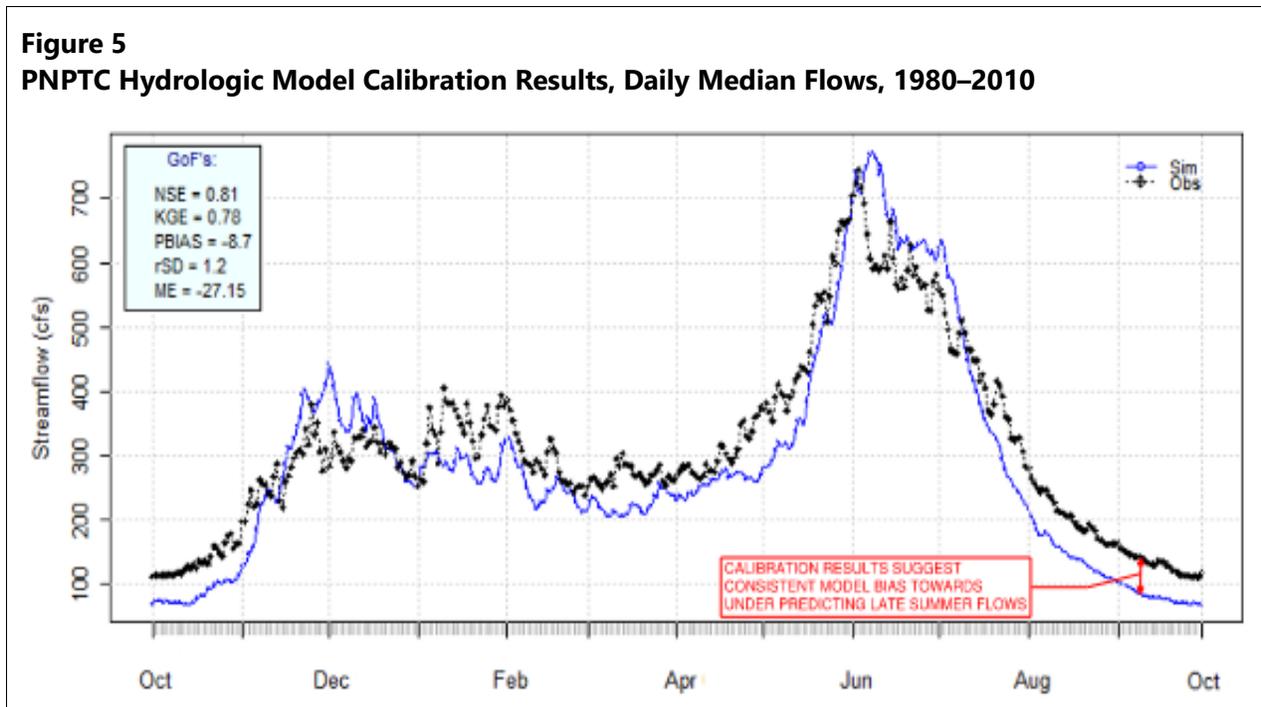
There have been advances in climate change modeling since the PNPTC report was completed in 2019. The statistical downscaling method used (MACA) is being replaced with dynamic downscaling which better accounts for spatial and elevation variability within a watershed, mountain ranges, and topography similar to what is present in the Dungeness River Watershed.

Additional Coordination and Feedback from the PNPTC on Hydrologic Inputs

After our review of the WEAP model inputs, outputs, and related documentation, Anchor QEA and Clallam County met with WWT and SEI to discuss our initial review comments. Our initial review comments included concerns about the level of calibration represented by the PNPTC hydrologic model, as summarized in the 2019 PNPTC report, and the use of the PNPTC flow projections directly as input to the WEAP model. As a follow up to the discussion, WWT reached out to the PNPTC author to discuss these comments. In response, the PNPTC author provided some additional

recommendations and plots of calibration data from the PNPTC Dungeness River hydrologic model for the 30-year period from 1981 to 2010.

Figure 5 includes one of the calibration plots provided by the PNPTC author that has been annotated in red by Anchor QEA. The plot shows the results of the PNPTC model simulation of historical daily median (50% exceedance) flows for the 30-year period from 1981 to 2010 against the observed flows from the USGS gage for the same period.



Note:

1. Source of information: Calibration plots provided by the PNPTC author Ryan Murphy to Hannah McDonough of WWT. The information was share with Clallam County via an email on February 25, 2025 (WWT 2025).
2. The red annotation was added to the plot by Anchor QEA and was not part of the original plot provided by the PNPTC.

Overall, the calibration plot in Figure 5 and other calibration plots and information provided by the PNPTC author suggest the following:

- The mean daily time series results from 1980–2010 showed a better calibration than was indicated for the overall calibration of daily Dungeness River flows against 1915–2011 historical flows at the USGS gage, as reported in the body of the 2019 PNPTC report.
- The calibration data suggests model biases for the Dungeness River Watershed DHSVM model towards the following:
 - Under predicting late summer flows
 - Over predicting late fall and early winter flows

The PNPTC author recommended that “for the ensemble of PNPTC streamflow projections, the best way to ascertain the relative streamflow changes for future periods of time (i.e., trends in flows) is to compare the projected streamflows to the modeled historical flows so that any internal model biases remain consistent through time.” This recommendation seems to agree with a recommendation provided by Anchor QEA in our discussions with WWT and SEI to compare the PNPTC projected flows to the modeled historical flows and apply that relative change to historical observed flow data to develop projected flows to be used as input to the WEAP model. The Anchor QEA recommendations are outlined in the methodology below.

Recommended Alternative Approach for WEAP Model Flow Inputs

Based on our review of the WEAP model inputs, outputs, and related information, it is our opinion that the predicted streamflows from the PNPTC should not have been used as direct inputs to the WEAP model, especially considering the number of rules that are built into the WEAP model around daily diversions and flow rates. A better methodology would have been to develop a streamflow dataset that projects changes in historical streamflows based on the PNPTC’s modeled streamflow projections, as follows:

- Calculate the difference (as a percentage) between modeled daily flows under historic conditions (i.e., the calibration run of historical conditions from the DHSVM model) and modeled daily flows under climate change conditions. In this case, the PNPTC provided streamflow data from a historic conditions model based on meteorological data set from Livneh (Livneh et al. 2013) that was used to calibrate the DHSVM model. The Livneh data set covers the period of 1915–2011. They also provided predicted streamflows resulting from projected future climate change conditions for each GCM from 2030–2080.
- Apply the relative difference or change (as a percentage) in the daily streamflow projected by the PNPTC hydrologic model data to actual historical daily streamflow data (from the USGS and Ecology gages) to provide better estimates of streamflow conditions under climate change for use as input to the WEAP model. One caveat is that the comparison should use similar time frames as the historical conditions used for the WEAP model, as climate change conditions are already occurring and the historical streamflow data used (2007–2022) already shows changes from recent climate change compared to flows from decades past.
- Compare the projected streamflows estimated using this method to the streamflow projections modeled by the PNPTC. This could be done for each projection based on each different GCM, or it could be done for a single projection involving the most representative GCM for the Olympic Peninsula.
- If the daily streamflow projections from the two data sets do not correlate very well (within approximately 10%), use the projected streamflows estimated by this method as input to the WEAP model, rather than using the streamflow projections modeled by the PNPTC.

General Comments About the WEAP Model Results

Regardless of the method used to develop streamflow inputs for the WEAP model, we recommend that the WEAP model results be considered with a level of scrutiny that corresponds with the level of certainty and conservatism represented by the streamflow projections provided by the PNPTC. It is our understanding that the GCMs used as a basis for the streamflow projection modeling are based on the Relative Concentration Pathways (RCP) 8.5 climate change scenario. RCP 8.5 represents a continued increase in carbon emissions that reflects historical trends. While we agree that using RCP 8.5 is prudent for projecting future changes in climate and flow rates in the Dungeness River, we recognize that it is a more conservative climate change scenario. In addition, the PNPTC has acknowledged the potential uncertainties, errors, and biases that exist in the GCM downscaling process, applying that data to a hydrologic model, and then calibrating that model to provide accurate flow projections. The calibration results show a bias towards under predicting late summer low flows, which would result in overstating the impacts of climate change on Dungeness River flows and understating the potential benefit of the reservoir project would have on Dungeness River flows under future climate change conditions.

While we believe the PNPTC flow projections and WEAP model results offer valuable information that can be used to optimize the design and operation of the reservoir to deliver the targeted benefits, we would caution the Dungeness Reservoir Work Group against concluding that the reservoir will offer little or no streamflow benefit in the future, or that other targeted benefits will not be available. We recommend that the results be viewed as a range of potential outcomes, with recognition that flows will be variable over time and that the reservoir will need to be designed and operated so that it can adapt to changing conditions. We know that if the reservoir were in place today, it would provide a substantial late-summer streamflow benefit. We also believe it is prudent to plan for changes in flow that will result from ongoing changes in climate. We acknowledge that the benefits of the reservoir project could change over time due to the impacts of climate change, so adaptation will be required. We believe that the reservoir offers flexibility that will be critical to adaptively managing water in the Dungeness River Watershed to restore and maintain adequate flows and deliver other targeted benefits into the future.

Summary

- Under existing conditions, the WEAP model results suggest that constructing a reservoir would offer a substantial flow benefit (13 to 17 cfs, based on 2007–2022 historical flow data) during the late summer. Although the flow benefit may change over time, there would be a substantial streamflow benefit that would carry into the future.
- Under the flow projections developed by the PNPTC for future climate change conditions, the WEAP model results suggest that the flow benefit in the Dungeness River would be substantially reduced in the future. The results for 2030–2060 climate change projections

suggest that the mean flow benefit in the Dungeness River would be less than 9 cfs in the late summer. The results for 2050–2080 climate change projections suggest that the mean flow benefit in the Dungeness River would be less than 5 cfs in the late summer.

- These results are based on direct input of the PNPTC flow projections into the WEAP model. The errors, inconsistencies, and biases reflected in downscaling the GCM data to fit the Dungeness Watershed, applying that data to the PNPTC hydrologic model, and calibrating the model are perpetuated in the WEAP model results and likely underpredict or overpredict impacts of the proposed reservoir project on daily Dungeness River flows.
- These results assume that the irrigators would continue to voluntarily comply with the 2012 Memorandum of Agreement and reduce or discontinue diversions from the Dungeness River at certain low flow thresholds, rather than withdraw water according to their water rights. Under the flow conditions projected by the PNPTC hydrologic model with future climate change, if no reservoir was in place, irrigated agriculture would have to change substantially in the Dungeness River Watershed.
- We believe that the projected future conditions streamflow data from the PNPTC's DHSVM model should not have been directly used as input to the WEAP model. If the Dungeness Work Group feels that additional analysis of flow inputs would improve the use of the WEAP model as a tool for optimizing the design and operation of the reservoir, we recommend that an alternative approach be considered that would involve the following:
 - Calculate that the relative differences (as a percentage) between modeled future conditions and modeled historic conditions from the PNPTC hydrologic.
 - Apply this relative difference (as a percentage) to actual historical streamflow data from the USGS and Ecology gages.
 - Compare the results to the flow projections from the PNPTC hydrologic model.
 - Use the resulting flows as input to the WEAP model.
 - When applying the relative differences to actual data, similar time periods should be used to account for climate change conditions that have already occurred.
- Regardless of the method used to develop streamflow inputs for modeling, we recommend that the WEAP model results be considered with a level of scrutiny that corresponds with the level of certainty and conservatism represented by the streamflow projections provided by the PNPTC. While we believe the PNPTC flow projections and WEAP model results offer valuable information that can be used to optimize the design and operation of the reservoir to deliver the targeted benefits, we would caution the Dungeness Reservoir Work Group against concluding that the reservoir will offer little or no streamflow benefit in the future, or that other key benefits will not be available.

References

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- WWT, 2024. Email communication from Hannah McDonough to Rhiana Barkie at Clallam County Department of Public Works with attachment showing Dungeness River flow model calibration data results from 1981-2010. February 25, 2025.