Study Proposal Outcome:
Effects of forest harvesting practices and climate change projections on streamflows in the Chehalis River

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Executive Summary

This memo is to serve as summary of the outcome of a study proposal prepared for the Office of Chehalis Basin (OCB) and Washington State Department of Natural Resources (DNR) to quantify the effects of timber harvesting on streamflow regimes, including both peak and low flows in the Upper Chehalis River Basin as affected by timber harvesting practices using Best Management Practices (BMPs) and further to consider such effects under projected climate conditions. A research proposal was developed that required access to Weyerhaeuser Company property (the major upstream landowner) to install 3 streamflow gauging stations with co-located hydrometeorological stations for model forcing, calibration, and validation data. Initially Weyerhaeuser participated on the study design team which suggested a willingness to support the effort. After review of the initial study proposal, Weyerhaeuser declined to provide site access or data for the study and their team member left. This memo gives more detail on these developments and suggests future data collection efforts to support the long-term monitoring plan of the Chehalis Basin Strategy.

Background

A flood on 3 December 2007 on the Chehalis River resulted from exceptionally heavy rainfall (14-25 inches) that was largely concentrated in the Willapa Hills vicinity (upper Chehalis River). The USGS estimated that the Chehalis River at Doty gauge had a peak flow of 63,100 cubic feet per second (cfs), exceeding the previous peak flow of 28,900 cfs observed in February 1996. The December 2007 flood resulted in significant economic and environmental impacts throughout the Chehalis River Basin. As part of the Washington State government's response, the Chehalis Basin Strategy was formed. The Chehalis Basin Strategy is a collaborative, science-based process that was created to address the dual challenges of extreme flooding and degraded aquatic species habitat.

The Willapa Hills have large areas of privately held commercial forestlands including holdings by Weyerhaeuser Company (initial contact made in August 2020) and DNR. The Chehalis Basin Strategy sought to evaluate potential changes in streamflow due to historical forest management practices (i.e., harvesting and road development) and the effect that current best management practices (BMPs) would have on these streamflow changes. OCB sought to answer two specific questions: 1) What are the effects of forest practices on streamflow responses, particularly annual peak and summer low flows? And 2) How will climate change projections affect these potential streamflow changes?

The majority of empirical research on the effects of forest harvesting on both peak flows and low flows has occurred at the small, headwater scale (<1 square mile), with much less research at the larger basin scale. The lack of research at the larger basin scale creates uncertainty about whether the effects in forested headwater may propagate downstream and create detectable changes in the hydrologic regime at the larger basin scale. Despite this, it has been suggested that elevated peak flows in headwater catchments due to forest management activities are most likely to diminish with increasing basin size. Changes in the flow regime are likely to diminish downstream due to several factors, including floodplain storage; transmission losses into the alluvial material of the streambed and proximal shallow groundwater; channel resistance; low likelihood of sub-catchment peak flow synchrony. Furthermore, the proportion of basin area affected by forest practices generally decreases with increasing basin size and there is greater diversity of stand ages at larger scales, both of which can interact to reduce hydrological effects of forest practices at larger basin scales. However, some empirical and model-based studies have suggested that effects may be observable downstream at the large basin scale. This is not surprising as the likelihood of the various factors at attenuating streamflow at the basin scale is likely to differ depending on catchment characteristics, such as specific forest age class mosaics, channel morphology, stream slope, hydraulic roughness, presence of wetlands, and precipitation event characteristics.

The study charge was to determine if and how forest practices may affect hydrology in the Chehalis River at various sub-watershed levels and to determine if these practices, and the general harvest strategies employed by forest landowners in this area can influence peak and low flows measurably beyond the climate signal. DNR asked Stednick to assemble a study team (June 2020). The team included 3 university faculty members with expertise in the effects of forest disturbance (including harvesting) on watershed processes (Bladon, Link, and Stednick), a hydrologist/engineer with expertise in streamflow modeling under climate change scenarios

(Karpack), and a hydrologist from Weyerhaeuser Company (Mark River). Their resumes are in the attached research proposal.

The original proposed study area the team identified was above the inactive USGS gauging station located on the upper Chehalis River above Mahaffey Creek. The upper Chehalis Basin is primarily forested and intensively managed for timber production. The area has been extensively harvested since approximately 1900 and currently is harvested predominantly in clearcut blocks, on a rotation of approximately 40 years. As a result, most of the area in the basin consists of early- to mid-seral stage forests. The study area contains an extensive unpaved road network for resource extraction and fire protection.

Original Scope of Work

The study design was to model streamflow using a set of nested watersheds, the smallest watershed (approximating a single harvest unit) used to calibrate soil parameters in the hydrologic model and then simulate streamflow changes with increasing watershed areas up to the approximately 900 mi^2 watershed above Grand Mound, WA.

The physically-based Distributed Hydrology Soil Vegetation Model (DHSVM) model was selected to predict streamflow responses with timber harvest over time and under climate change scenarios and address these study objectives:

- model the upper Chehalis River basin with no timber harvesting or roads
- model the effects of historical forest practices on streamflows
- determine the effects of current forest practices, including roads, on streamflows
- determine the effects of projected climate change on future streamflows
- determine the effects of changes in streamflow from small headwater to large downstream basins

The model was to be driven by and calibrated using both Weyerhaeuser and public data sources which include watershed characteristics, meteorological data, road layout and history, and vegetation type and age as well as past land use history. Once calibrated, the model would be tested for sensitivity and then used to predict streamflows in a set of nested watersheds, from the headwaters to the Chehalis River at Grand Mound. Initial model development would rely on earlier hydrologic modeling, and additional streamflow and other hydro-meteorological data integrated to refine the model and validate streamflow simulations. The combined effects of timber harvesting, and projected climate change would be evaluated as to their respective contribution to downstream streamflow changes at various locations on the Chehalis River above Grand Mound.

Following its review of the study proposal (March 2021) Weyerhaeuser ultimately decided not to allow access to their properties for the study, and stated any data needs had to be satisfied from publicly available sources. Also at this time Weyerhaeuser's hydrologist left the study team. These developments led to a modified scope of work (February 2022).

Modified Scope of Work

After Weyerhaeuser chose not to allow access to their lands to conduct an inventory of watershed characteristics, the team investigated different remote sensing and geographic information systems databases to obtain the data needed as input for the hydrologic model. It was recognized at that time that streamflow data from a small basin would still be required to calibrate the streamflow model. Other small watershed studies in the area conducted by the state were limited in scope and did not have sufficient available data to meet the needs of the current study. Due to the effort needed to obtain watershed characteristics, the study area was also reduced to the Chehalis River at Doty rather than Chehalis River at Grand Mound. The historical and no BMP alternatives were also dropped from the study.

As a potential workaround for streamflow data, we approached the Chehalis River Basin Flood Authority to use their past streamflow and hydrometeorological data records and to use their watershed access to install and/or reactivate streamflow gauging stations and to co-locate hydrometeorological stations, in collaboration with WEST Consultants. Weyerhaeuser denied that request(July 2022)

Weyerhaeuser had concerns about a basin specific study (as opposed to a regional study), and also felt it would be better for such a study to be reviewed under the Cooperative Monitoring, Evaluation, and Research (CMER) program using the Independent Scientific Peer Review (ISPR) process. The study team had 3 members who had previously participated in the ISPR process. They agreed that that it was time consuming effort for the review and the needed response to review comments. They were eager to start the field study and elected to not participate in that review. OCB and DNR agreed.

Next Steps

The Chehalis Basin Strategy objectives are long-term (30 years) and as such will require long-term monitoring efforts. Future efforts need to address the downstream attenuation of any streamflow response from forest practices (and other disturbances) and separate that signal from climate change effects. Most individual paired watershed studies used a single harvest unit over a large proportion of the small watershed; only recently have studies started to assess the effect of multiple harvest entries over time, but often focused on the smaller watershed size. Larger watersheds with ongoing forest practices over time can be used to better assess flow synchrony, hydrologic recovery, and effects of interacting stand dynamics in a watershed comprised of a complex mosaic of stands. Streamflow changes in larger watersheds with ongoing land uses over time and space may not be detectable given the current accuracy of streamflow gauging techniques and spatiotemporal variations in the drivers of large flow events and may therefore require new and novel approaches to data collection and interpretation.

Ideally, the Upper Chehalis River Basin could still be instrumented with streamflow gauges and co-located hydrometeorological stations to be complimented with the existing data being collected by the Chehalis River Basin Flood Authority. Alternative sites may include the adjacent Stillman Creek basin to the east of the Upper Chehalis River. Ideally, a couple (or more) small watersheds should be identified that are relatively undisturbed and streamflow monitored over time to provide critical data for model calibration. A perfect basin for calibration data would be one that starts out with a mature forest with several years of data collection, then logged followed by several years of additional data collection. Undisturbed watersheds would need to be monitored for long-term data (potentially far into the future). The key would be basins that do not change characteristics over time. It is always difficult to maintain an undisturbed watershed due to economics and the potential for a natural disturbance such as blowdown, fire, insects, or disease. Nonetheless, a control watershed(s) would be most helpful for model calibration and climate change detection. The calibrated watershed model could then be used to model downstream responses in the proposed nested watershed format. Potential sites may exist on DNR properties such as the Capital Forest or the Olympic State Experimental Forest. Also, the University of Washington has a couple of experimental forests, Marckworth Forest and Pack Forest. Sites in Oregon could also be investigated. The proposed experimental design to use nested watersheds to assess the propagation of any signal downstream is the better approach and finding of such a set of nested watersheds would require considerable effort. Perhaps the Pacific Northwest Aquatic Monitoring Partnership could be used as a model, which includes federal, state, private, and tribal lands.

Any streamflow monitoring should have one or more co-located hydrometeorological stations. The streamflow record should be continuously validated by field measurements of streamflow to confirm the stage discharge relationship for each station. A data repository (possibly hosted by DNR or the Chehalis River Basin Flood Authority) could be used for frequent data uploads and accessible to any interested party.