Analysis of a Restorative Flood Protection Alternative for the Upper Chehalis River Basin

<u>Proposal for work to be included in Chehalis River PEIS</u>

Natural Systems Design, Inc. on behalf of Quinault Indian Nation 10/6/15

There are two very different ways to create equivalent amounts of flood storage at a watershed scale:

1) Use a relatively small area to hold a lot of water per unit area
2) Use a large area to hold a smaller amount of water per unit area

The first option uses a dam to impound the river into a reservoir so it can be slowly released out, thereby reducing downstream flood stage. This approach directly impacts natural processes needed to sustain salmonids and the river's ecosystem. The second option, referred to as "restorative flood protection" applies to watersheds such as the Chehalis where the original forests and channels have been cleared. Restorative flood protection works by using natural features such as vegetation, wood debris and floodplains to store and slow the flow of water, thereby reducing downstream flood stage (e.g., Abbe et al. 2003; Anderson 2006; Thomas and Nisbet 2006; Abbe and Brooks 2011; Long et al. 2013; Reinhart et al. 2015). Because restorative flood protection involves a large area, it brings a commensurate benefit to restoring fish and wildlife habitat, improving water quality, and eliminating the long-term economic and safety liabilities and costs associated with a large engineered structure.

The current plan for addressing flood hazards and the degradation of salmonid habitat within the Chehalis River watershed includes two separate elements: A) flood protection B) habitat restoration. The flood protection plan is to begin a Programmatic Environmental Impact Statement (PEIS) that will consider three alternatives: 1) no-action; 2) a flood control dam that would either be used solely for flood storage and allow run of the river, and 3) a larger dam that would maintain a permanent reservoir pool to allow for augmenting summer flows with cold water. The proposed dam site is located on the Upper Chehalis about River Mile 109, above the town of Pe Ell (Figure 1). Several stakeholders involved with technical meetings have repeatedly brought up concerns that a restorative flood protection alternative has not been adequately assessed and is not being considered in the PEIS process. This restorative flood protection alternative would include a less-structural option that would use land use changes and limited local flood protection measures.

The purpose of the proposal is to secure support to pursue an objective assessment of a restorative flood protection approach as an additional, integrated, flood and aquatic species restoration alternative in the PEIS that has been authorized. A preliminary scope has been prepared to show the anticipated level of effort expected to deliver the following:

1) Flood Hazard Reduction: A quantitative assessment of flood protection benefits such as reducing flood discharge and stage for selected communities that can be compared directly to a dam alternative.
2) Salmonid Habitat Restoration: A quantitative assessment of habitat uplift resulting from a restorative flood protection approach that includes metrics currently being compiled such as pool frequency, alluvial substrate, channel length, wood loading, and floodplain features including off-channel, side channel, and backwater habitat. Floodplain restoration has been shown to provide significant increases in juvenile Chinook use at restoration sites (O'Neal 2015).
3) Detailed Description of Restorative Flood Protection Approach: A document providing basic elements of restoration actions (what and where) and predicted response. This will include a

summary of the current state of the science and details of data collection and modeling done in the analysis.

A preliminary scope to conduct a restorative flood protection analysis has been prepared by Natural Systems Design, Inc. (NSD) and others on behalf of the Quinault Indian Nation (QIN). This proposal presents a case for considering a restorative flood protection approach that addresses both flood hazards and habitat restoration. The deliverables will include:

1) A restorative flood protection alternative to be integrated into the PEIS
2) Quantitative assessment of flood relief benefits using a restorative flood protection approach
3) Description of historic impacts influencing flow and storage of water
4) Description of restoration actions and extent of channel network to be restored
5) Extent, duration and depth of flooding throughout the study area
6) Prioritization of actions and areas with greatest cost benefit
7) Quantitative description of habitat benefits
8) Cost estimate of restorative flood protection approach
9) Quantitative comparison to dam alternatives

While the science behind quantifying the benefits of a restorative flood protection is new (e.g., Anderson 2006), the basic approach is not and in various forms is at the heart of flood management strategies adopted on small tributaries and large rivers throughout the country. In Washington State it is a central theme of the Floodplains by Design program. In many regions the approach involves levee setback or removal.

In the Chehalis it is primarily an issue of channel confinement and not levees, along with treating large portions of channel network within areas of industrial forest and rural agriculture. Examples of restorative flood protection include reconnecting incised channels to their floodplains by re-establishing stable in-stream wood and riparian vegetation that reduces the effective shear stress within the channel, retains alluvial sediments and raises water elevations (Figure 2). This process increases the inundation frequency and retention time of overbank flows, in addition to increasing the extent and quality of salmonid spawning and refugia habitat (e.g., Abbe and Brooks 2011). Recent research demonstrates that restoring in-stream wood and riparian forests can substantially increase flood storage, reduce flood peak celerity, and decrease both flood stage and discharge downstream (e.g., Anderson et al. 2005; Anderson 2005, 2006; Rutherford et al. 2007; Thomas and Nisbet 2006). Fouty (2013) highlights the historic loss of alluvial sediments from streams and shows how restoring riparian forests and beavers on 38 acres of alluvial valley per mile could increase water storage 23 to over 100 fold on a stream in NE Oregon. Much of the Chehalis channel network would have higher alluvial areas per mile and thus have a higher storage potential. In one example, a degraded stream had only 0.01 acre-feet of storage per stream mile, but with beavers, storage increased to 43 to 54 acre-feet/mile (Fouty 2013).

Stakeholder interest in a restorative approach to reducing flood hazards within the Chehalis watershed is supported by arguments that incorporating an ecosystem approach to basin planning will provide more sustainable strategies for adapting to climate change (i.e., Poff et al. 2015). A dam not only requires a significant initial investment, but long-term maintenance costs and eventually major expenses with regards to removal or renovation. Studies already completed within the Chehalis have underscored how the proposed dam will either inhibit or block salmonid passage as well as dramatically impact the natural flow and sediment regime (e.g., reduction in frequency of geomorphic flows, loss of bed material, downstream coarsening and incision, impacts to benthic fauna, further floodplain disconnection). The dam alternative may also lead to new floodplain development that increases dependence on the dam and long-term liabilities. Instead of focusing on a single site for flood storage, a restorative flood protection approach treats a much larger area to create similar storage and moderate flood peaks. Both a dam and a restorative approach involve a major initial investment, but post-project costs and liabilities are completely different. The restorative approach has negligible long-term costs or liabilities, both of which increase with time for a dam. The restorative approach offers a sustainable long-term alternative simply by allowing natural processes such as reforestation, wood recruitment, and beaver modifications to persist. Recent work to restore floodplain connectivity of the Cle Elum River has shown about a ten-fold increase in water storage and inundated area, along with retention of finer alluvium, more refugia and cooler temperatures (Long et al. 2013). Given the scientific evidence that restoration actions can help to reduce downstream flood hazards, a "restorative" alternative to a dam is justified for the PEIS, particularly given the hundreds of millions of dollars Washington State is investing to restore rivers and remove dams that have outlived their design life and become liabilities to downstream communities (e.g., Condit, Elwha, Mill Pond). A restorative flood protection approach is even more important given the predicted hydrologic changes predicted for Washington State as a result of the warming climate.

The Chehalis has been heavily impacted by industrial timber harvest that included extensive splash damming, removal of in-stream wood and clear-cutting of riparian forests. Agriculture has also impacted portions of the river system due to the use of channelization and riparian clearing to limit floodplain inundation. The cumulative impact of these historic land use practices includes a loss of hydraulic roughness and channel incision that disconnects the river from its historical alluvial floodplain and can aggravate downstream flooding (e.g., Abbe and Brooks 2011; Abbe et al. 2015). Given that a restorative approach involves relatively small influence per river mile when compared to a dam, it will involve treating a large portion of the channel network. Assuming the focus of flood protection is focused on existing communities within the southern portion of the watershed, the analysis will focus on the Chehalis, South Fork Chehalis, and Newaukum River sub-basin networks (Figure 1). Each of these systems has been heavily impacted and each warrant restoration in their own right, so a restorative flood protection approach provides a comprehensive and sustainable alternative with minimal long-term maintenance costs or liabilities inherent in a dam.

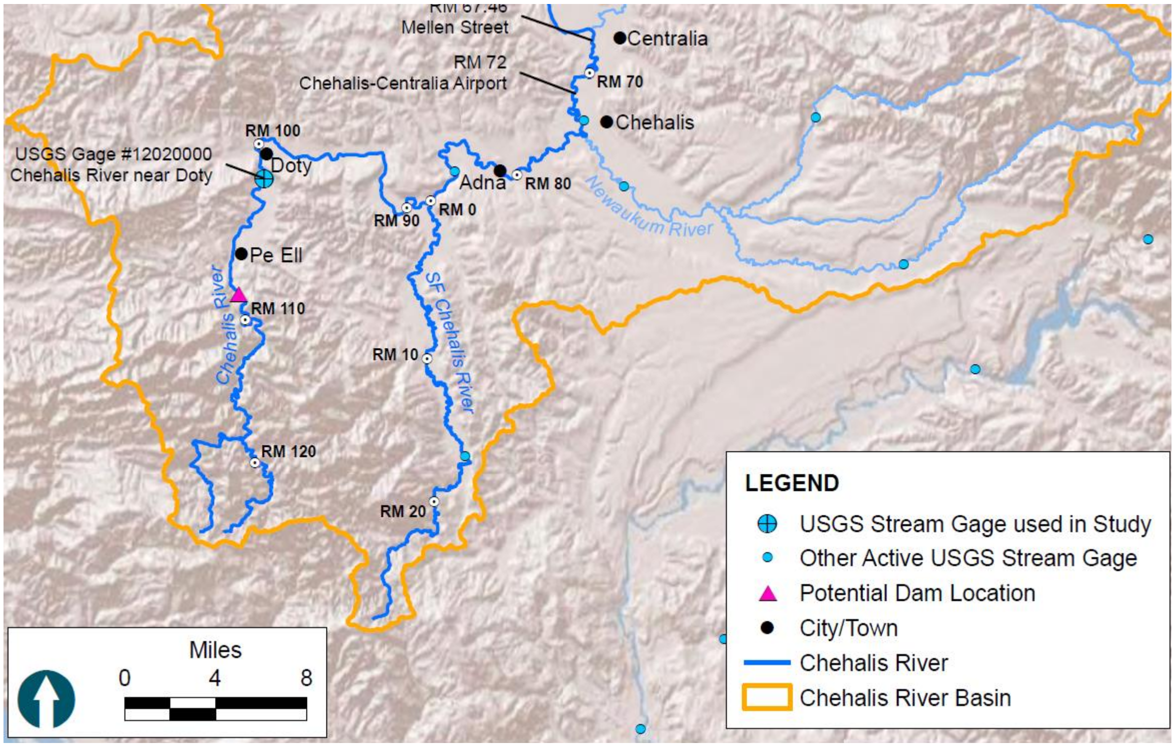

Figure 1. The Upper Chehalis Watershed above the town of Chehalis includes the Newaukum, South Fork Chehalis and Chehalis River sub-basins.

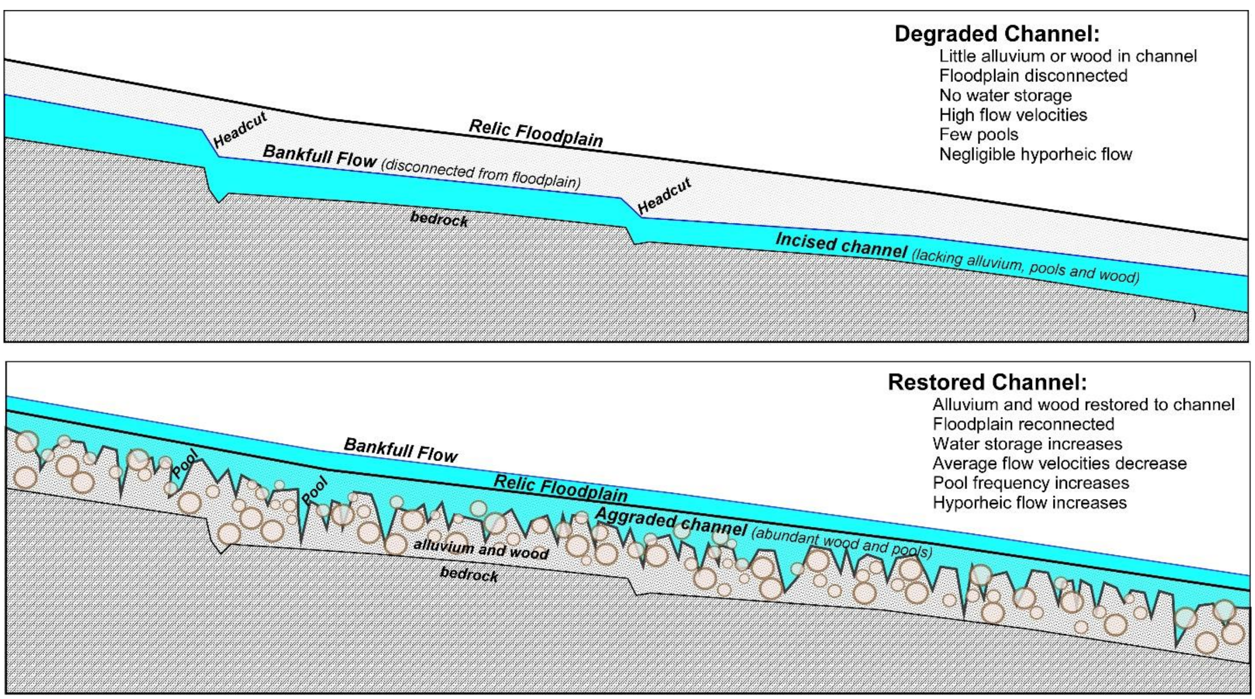

Figure 2 Hypothetical river profile illustrating basic concept of restorative flood protection of slowing flow in channel and reconnecting alluvial forested floodplains.

The consequences of a restorative flood protection approach are aligned with the broader objectives of the Chehalis basin that include:

- Significant increase in extent and quality of aquatic species habitat
- Restored salmonid spawning, rearing and sheltering habitat, both in main stem rivers and tributaries
- Floodwater recharge of shallow aquifers that enhance human water supplies and improve water temperatures during summer for salmon and other aquatic species
- Areas within the watershed will be subject to more frequent, shallow inundation
- Some structures will probably need to be raised, purchased or moved.

Preliminary Scoping

The first task will be to provide the QIN with initial funding to support the development and refinement of the scope and budget of the proposal and to identify the ability to utilize existing information and coordinating with work in progress. This scoping task will also address scheduling work to comply with the PEIS timeline. The cost for this initial task is $26,000. The preliminary scope is provided below.

Task	Description	Why	Cost
1	Data compilation, task coordination with existing work group, and definition of sub-basin for modeling. Determine historic channel conditions.	To improve efficiency with regards to large amount of existing work. Develop benchmark for watershed and floodplain conditions prior to European colonization related to water storage & ecological health of fluvial system.	$ 225,000
2	Compile high resolution 1 ft pixel topography and bathymetry (using existing if possible)	Critical data for modeling. Green LiDAR is needed to accurately document river depths. Existing data can be reviewed, including what was used or HEC RAS modeling.	$ 350,000
3	Scientific foundation for analysis: report on state of the science and linkages to Chehalis	State-of-the-science basis for a restorative approach. This will not only include existing work on the role of riparian vegetation and wood in attenuating floods, but in reconnecting incised channel segments to their historic floodplains	$ 175,000
4	Field documentation of alluvial reaches, channel incision, in-stream roughness, and riparian conditions. Build GIS database.	This is essential portion of field documentation that has not been found in any of existing reports. This is needed to evaluate extent to which channel incision has occurred. Given splash damming, loss of wood and channelization, incision is serious concern with respect to restoration and flood routing.	$ 350,000
5	1D Modeling: ROVER model ("ROughness of VEgetation in Rivers", Anderson et al. 2005, 2006)	A 1-D modeling approach will be done to provide an initial assessment of potential and be comparable to existing work on the Chehalis. It will also be used to compare to 2-D modeling results. Modeling will include both existing and future conditions based on different riparian vegetation scenarios.	$ 200,000
6	2D Modeling 1: setup computational mesh for channel network model, run existing conditions	This is the primary modeling approach that will employ state-of-the-art hydrodynamic modeling using high resolution mesh of sub-basin segments. This will be linked to Habitat Suitability for salmonids.	$ 250,000
7	Estimate of floodplain engagement for proposed conditions	Using field data and existing conditions modeling, physical metrics for restoration will be assembled to create a model of undisturbed pre-historic conditions representing a fully restored channel network. Flow conditions will be linked to salmonid life history. Specific restoration actions to be implemented.	$ 150,000
8	Private property coordination: delineate a reasonable flood corridor	Almost all of the Chehalis watershed is in private ownership and significant areas of floodplain are currently in agriculture, a reasonable compromise for a fluvial flood corridor will need to be established.	$ 175,000
9	2D Modeling 2: proposed conditions computational mesh and simulations	The main goal of the analysis will culminate with modeling of proposed conditions. This will quantify both flood and restorative effectiveness metrics using a restorative flood protection approach.	$ 325,000
10	Ecosystem suitability and uplift of proposed condition (Habitat Suitability Index mapping)	Model output & analogous restoration work will be used to refine predictions of habitat improvement specific to target species and life stage.	$ 175,000
11	Final Reporting	Final reporting edits, responses to comments.	$ 75,000
11	Meetings	Assuming frequent meetings early in project, then frequency similar to current Chehalis working group.	$ 100,000
12	Project Management	Staff, client and stakeholder coordination, admin.	$ 80,000
		TOTAL	**$2,630,000**

References

Abbe, T., Carrasquero, J., McBride, M., Ritchie, A., McHenry, M., and Dublanica, K., 2003. Rehabilitating River Valley Ecosystems: Examples of Public, Private, and First Nation Cooperation in Western Washington. In Droscher, T. (Editor). Proceedings of the Georgia Basin/Puget Sound 2003 Research Conference, Vancouver, B.C., March 31-April 1, 2003. Puget Sound Action Team, Olympia, Washington.

Abbe, T. and Brooks, A. 2011. Geomorphic, engineering and ecological considerations when using wood in river restoration In: Simon, A., Bennett, S. and Castro, J. (editors), Stream Restoration in Dynamic Fluvial Systems: Scientific Approaches, Analyzes, and Tools. Geophysical Monograph Series 194. American Geophysical Union, pp.419-451.

Abbe, T., Ericsson, M. and Embertson, L., 2015. Large river channel incision due to loss of wood. Third International Conference Wood in World Rivers. July 6-10, 2015. Padova, Italy.

Anderson, B.G., Rutherfurd, I.D., and Western, A. W. 2005. Vegetation Roughness and Flood Magnitude: A Case Study of the Relative Impact of Local and Catchment Scale Effects [online]. In: 29th Hydrology and Water Resources Symposium: Water Capital, 20-23 February 2005, Rydges Lakeside, Canberra. Canberra: Engineers Australia, 608-615.

Anderson, B. 2005. Will replanting vegetation along river banks make floods worse? *Water and Food Security-Rivers in a Global Context*. http://brownhillck.org/wp-content/uploads/2011/11/Anderson-replanting-and-floods-2006-RiverSymposium.pdf

Anderson, B. G. 2006. Quantifying the interaction between riparian vegetation and flooding: from cross-section to catchment scale. PhD. Dissertation, University of Melbourne. Melbourne, Australia. 549 p.

Anderson, B. G., Rutherfurd, I. D., & Western, A. W. (2006). An analysis of the influence of riparian vegetation on the propagation of flood waves. *Environmental Modelling & Software*, *21*(9), 1290-1296.

Bureau of Reclamation and U.S. Army Corps of Engineers. 2015. National Large Wood Manual: Assessment, Planning, Design and Maintenance of Large Wood in Fluvial Ecosystems: Restoring Process, Function, and Structure. 628 pages + Appendix. *www.usbr.gov/pn/.*

Fouty, S. 2013. A strategic response to climate change: restoring water storage capability the stream ecosystems on public lands with the help of beavers, wolves and fire. River Restoration Northwest Symposium. *www.rrnw.org*

Long, M., Gerth, D., Abbe, T., Ericsson, M., Hrachovec, M., and Embertson, L., 2013. Restoration of the Lower Cle Elum River Valley, Central Washington. Salmon Recovery Conference, Vancouver, WA May 14-15, 2013.

O'Neal, J. S. 2015. Project Effectiveness Monitoring Program: 2014 Annual Report. Washington Salmon Recovery Funding Board. Olympia, WA, *http://www.rco.wa.gov/documents/monitoring/2014Report.pdf.*

Poff, N.L., Brown, C.M., Grantham, T.E., Matthews, J.H., Palmer, M.A., Spence, C.M., Wilby, R.L., Haasnoot, M., Mendoza, G.F., Dominique, K.C. and Baeza, A. 2015. Sustainable water management under future uncertainty with eco-engineering decision scaling. *Nature Climate Change* 09-14-15. DOI: 10.1038/NCLIMATE2765.

Reinhart, M.A., Nelson, T. and Abbe, T. 2015. Prioritizing comprehensive river restoration projects through levee setbacks: lessons learned in the first decade. River Restoration Northwest. *www.rrnw.org.*

Rutherfurd, I., Anderson, B., & Ladson, A. 2007. Managing the effects of riparian vegetation on flooding. *Principles for Riparian Lands Management. Edited by S. Lovett, and P. Price. Land and Water Australia, Canberra*, 63-84.

Thomas, H. and Nisbet, T.R. 2006. An assessment of the impact of floodplain woodland on flood flows. *Water and Environment Journal*, 1-13. doi: 10.1111/j.1747-6593.2006.00056.x