MEMORANDUM

Date: October 22, 2020
To: Andrea McNamara Doyle, Office of Chehalis Basin
From: Merri Martz and Erik Pipkin, Anchor QEA, LLC
Cc: Chrissy Bailey, Office of Chehalis Basin; Jim Kramer and Ken Ghalambor, Office of Chehalis Basin consultant staff; Bob Montgomery, Heather Page, and Tracy Drury, Anchor QEA, LLC; Larry Karpack, Watershed Science and Engineering
Re: Local Actions Program Near-term Technical Analyses for Office of Chehalis Basin: Potential Options for Delineating Erosion Hazards

Overview

This memorandum is intended to provide options for identifying erosion and channel migration hazards in the Chehalis Basin for potential inclusion in a Local Actions Program. These options may be modified based on input from the Technical Advisory Group at the direction of the Office of Chehalis Basin (OCB) prior to consideration by the Chehalis Basin Board.

The Chehalis Basin Board has agreed upon several outcome measures for a Local Actions Program, with the following being the most directly relevant to erosion and channel migration hazards:

- The number of locations where migrating river channels and bank erosion pose a high risk of near-term damage to valuable structures or loss of economically productive land uses would be reduced by an average of X per year over up to 30 years, while protecting ecological processes (Outcome 4A "Farmland and Rural Structures Protected).
- No new structures would have been developed that are vulnerable to channel erosion or mainstem or tributary flooding from 2080 predicted 100-year flood levels, because all basin local governments have adopted model floodplain management ordinances that exceed the State and National Flood Insurance Programs' minimum requirements; all local government construction and building code standards support flood damage risk reduction through measures such as subdivision set-asides, filling restrictions, freeboard height of new buildings, critical facility placement and protection, and non-conversion agreements; and incentives direct future development out of harm's way (Outcome 8: Prevent New At-Risk Development).

Selection of an erosion hazard and Channel Migration Zone (CMZ) mapping option could support local governments and tribes in the Chehalis Basin in reducing near-term and long-term risks and damages from bank erosion, channel migration, or avulsions. Actions that could be considered include removal or relocation of at-risk structures or infrastructure, localized bank protection measures that are compatible with the overall Chehalis Basin Strategy, combined erosion reduction and habitat restoration measures, or restrictions on construction of new facilities or structures in high-risk areas. In a separate

memorandum that will be presented to the Technical Advisory Group in November, options for how to address current erosion hazards and prevent future ones will be suggested.

After providing some background on erosion hazards, this memorandum outlines six options for delineating erosion and channel migration hazards. The six options offer a range of different approaches and estimated levels of effort, from the most rapid assessment requiring approximately 3 months at an estimated cost of $155,000 to the most detailed analysis requiring approximately 18 months at an estimated cost of $850,000.

Questions for the Technical Advisory Group

Specific questions for the Technical Advisory Group to consider:

1. Do you have additions or changes to the pros and cons of each option that should be considered by the Implementation Advisory Group or Chehalis Basin Board?
2. Are there additional options that should be considered by the Board for the short or long term?
3. What options would you recommend the Board consider implementing in the short and long term?

Background

The purpose of this memorandum is to outline several options for delineating erosion hazards in the Chehalis Basin to assist the Chehalis Basin Board in evaluating the potential for local actions to reduce flood damage. An additional purpose is to provide useful information for local governments and tribes in the basin for use in planning for potential future land use or taking measures to avoid and minimize ongoing and future damages. The options include varying levels of GIS-based mapping and analyses, including an option to complete a detailed CMZ delineation following the Washington Department of Ecology's (Ecology) protocol described in Rapp and Abbe (2003).

Riverbank erosion occurs in many areas of the Chehalis Basin and can affect property and infrastructure adjacent to the rivers and streams and also within the valley bottom or adjacent hillslopes. Depending on the rate of erosion, or during an avulsion or major channel shift, a river could move rapidly outside of its current channel into a new or historical channel. Areas of easily erodible soils, such as sand and gravel deposits from alluvial processes or from past glacial deposition, or loamy soils, are particularly susceptible to bank erosion and channel migration. Areas with limited vegetation cover can also be more susceptible to erosion.

Channel migration is a natural process and the movement of a channel though its floodplain creates new habitats, stores or recruits sediment and wood, and creates bare alluvial surfaces for the regeneration of cottonwoods and other important native riparian plant species. Channels can migrate by moving outside of their existing banks in different directions as a result of different forces. For example, they can move laterally, such as from sediment or wood deposits that build up and cause increased erosive forces on

the channel banks. They can move down valley as a meander moves downstream, and they can rapidly avulse into an adjacent low-lying area, such as a historical channel scar or swale (channel migration processes are described in Legg and Olson [2014]).

Even though channel migration is a natural process and has ecological benefits, human activity can affect where erosion occurs and can also dramatically increase the rate of erosion causing a destabilization of the river system, negatively impacting aquatic species and human investments. The response to erosion and channel migration often includes emergency actions like the placement of rock that does not address the true cause or the interconnected nature of the river system, and can accelerate erosion of the channel bed or adjacent unprotected banks. Identifying areas where erosion is occurring at high rates or threatens human investments will allow for the development of a more holistic and comprehensive strategy to address the problem.

As part of the Chehalis Basin Strategy, a variety of mapping products have been prepared since 2013. Relative Elevation Maps (REM) and historical channel tracing maps have been developed for the Chehalis River from river miles (RM) 0 to 108 (Aberdeen to Pe Ell), and for multiple additional time series from RMs 68 to 114 (Skookumchuck River confluence to the upper extent of the proposed temporary reservoir). Bank erosion points were also mapped in 2014, and the Washington Department of Natural Resources has mapped primary and secondary geomorphic landforms for the Chehalis River from RM 0 to 108. REMs were also developed for the South Fork Chehalis River and several of its tributaries, Stearns Creek, the mainstem Newaukum River and the North and South Forks of the Newaukum River, Elk Creek and Bunker Creek, and the Skookumchuck River and several of its tributaries as part of the Restorative Flood Protection Alternative (Abbe et al. 2016). Most of these maps are currently available on the Chehalis Basin Strategy Webmap (https://chehalisbasinstrategy.com/gis-webmap/). These existing mapping resources and any of the following additional options can be compiled into alternate mapping products that are most useful to local governments and tribes within the Chehalis Basin.

The potential mapping options in this memorandum include several different levels of mapping that provide different levels of detail and precision. The mapping options are defined as follows:

1. Modern valley bottom mapping is the area where channel migration has likely occurred since glaciation or other major geologic events (past few thousand years).
2. Historical CMZ mapping is the area where channel migration has occurred as documented in historical records including aerial photographs (past 80 to 150 years).
3. Avulsion hazard mapping is the area where the channel may not have been in the historical record, but there is a potential for rapid channel migration into low-lying areas in the floodplain.
4. Planning-level CMZ mapping is GIS-based and includes the previous three map products, but also includes mapping of disconnected migration areas, areas of potential slope instability on the channel margin, and identification of geomorphic landforms and other valley bottom characteristics to more comprehensively identify the CMZ.

5. CMZ delineation includes both GIS analysis of the above mapping products and field analysis of soils, channel and valley bottom characteristics, and valley margin slopes to most accurately predict where channel migration has historically occurred and could occur over a designated future timeline.

These potential mapping options would generally follow methods described in several Ecology publications including *A Framework for Delineating Channel Migration Zones* (Rapp and Abbe 2003) and *A Methodology for Delineating Planning-Level Channel Migration Zones* (Olson et al. 2014).

Options for Delineating Erosion and Channel Migration Hazards

This section includes potential options for further delineating erosion and channel migration hazards in the Chehalis Basin. Table 1, following this discussion, summarizes the pros, cons, and potential schedule and level of effort to implement each of the options.

Option 1. Focused Modern Valley Bottom and Avulsion Hazard Mapping

In this option, OCB consultants would interview city and county staff in the Chehalis Basin to further refine known bank erosion areas of concern (see Figure 1, which identifies Newaukum, Satsop, and Wynoochee rivers) from events in the recent past (such as during the 2007 or 2009 floods) or that are currently ongoing. Initial additional input from local jurisdictions conducted from interviews for the hydraulic modeling memorandum (WSE 2020) indicates that areas of erosion concern include portions of the lower Satsop, East and West Fork Satsop, and Wynoochee rivers; Chehalis River near Elma and Montesano; and several specific sites on Cloquallum, Salzer, China, and McCormick creeks.

This in-basin knowledge would also be supplemented by the erosion potential categories identified by Legg and Olson (2015) for Chehalis Basin rivers and streams. This information would be used to focus on up to 100 miles of interest to develop initial maps including: 1) REMs that are constructed by using a LiDAR Digital Elevation Model topographic surface in comparison to the adjacent river or stream water surface; and 2) historical channel tracing maps by using up to six historical aerial photograph time series and digitizing the location of the channel through time (typically from the 1930s to present) to understand the historical CMZ. The historical channel tracing maps would identify the historical CMZ and the REM mapping would be used to identify the Modern Valley Bottom and potential avulsion hazard areas (e.g., historical channels and low-lying areas that could readily be occupied by the river; Olson et al. 2014). This option would not include the further steps involved in developing a planning-level CMZ delineation per Olson et al. (2014).

Existing mapping would be used and updated or expanded, as appropriate, and additional REM and historical channel mapping would be developed in the focused areas of interest. These maps would then be used to develop mapping of the Modern Valley Bottom plus the avulsion hazard area. Parcels and infrastructure data layers would be overlain on the Modern Valley Bottom mapping to inform local governments and tribes of parcels and infrastructure at highest risk of erosion in the near term. It is

estimated for this memorandum that approximately 50 miles of river have existing mapping that would be supplemented and that up to 50 additional miles do not have existing mapping and would require all the previously described mapping to be developed, for a total of 100 miles of focused mapping.

This focused set of maps could be used by local governments and tribes to immediately inform current and near-term permitting actions within areas of highest risk for bank erosion and channel migration. They could also inform the development of potential near-term local actions such as bank protection, road and bridge maintenance or relocation options, other infrastructure or structure protection or relocation options, and near-term funding needs.

Option 2. Local Actions Program Study Area Modern Valley Bottom and Avulsion Hazard Mapping

In this option, the entire Local Actions Program study area (Figure 1) would be mapped using the methodology described for Option 1. It is estimated for this memorandum that 240 miles of river have existing mapping that would be supplemented and that up to 220 miles of rivers do not have existing mapping and would require all the previously described mapping to be developed, for a total of 460 miles of mapping.

This much broader set of maps could be used by all local governments and tribes in the basin to immediately inform current and near-term permitting actions within all areas of interest for risk for bank erosion and channel migration. They could also inform the development of potential near-term local actions such as bank protection, road and bridge maintenance or relocation options, other infrastructure or structure protection or relocation options, and near-term funding needs.

Option 3. Focused Planning-Level CMZ Delineation

In this option, the focused erosion hazard area (assumed 100 miles of rivers) would have a complete planning-level CMZ delineation generally following the Olson et al. (2014) protocol. In addition to the level of effort described in Option 1, this option would include additional mapping of soil survey and geologic map data, GIS-based identification of geomorphic landforms, potential areas of geotechnical instability on hillslopes adjacent to the valley bottom that could erode if the channel migrated to the valley margin, disconnected migration area mapping, and mapping of any other features identified. This planning-level CMZ delineation provides a comprehensive and also conservative estimation of where the channel could migrate and cause erosion hazards over the long term.

This focused planning-level CMZ delineation could be used by local governments and tribes to inform current and near-term permitting actions within areas of highest risk for bank erosion and channel migration. They could also provide the basis for updating specific local critical areas ordinances that would designate the CMZ for long-term regulatory management. They could also inform the development of potential long-term local actions such as bank protection, road and bridge maintenance or relocation options, other infrastructure or structure protection or relocation options, and funding needs.

Option 4. Local Actions Program Study Area Planning-Level CMZ Delineation

In this option, the entire Local Actions Program study area (approximately 460 miles) would have a complete planning-level CMZ delineation following the Olson et al. (2014) protocol, including the elements identified for Option 3.

This broad planning-level CMZ delineation could be used by all of the local governments and tribes in the basin to inform near-term permitting actions within all areas of interest for risk for bank erosion and channel migration. They could also provide the basis for updating local critical areas ordinances that would designate the CMZ for long-term regulatory management. They could also inform the development of potential long-term local actions such as bank protection, road and bridge maintenance or relocation options, other infrastructure or structure protection or relocation options, and funding needs.

Option 5. Focused CMZ Delineation

In this option, the focused erosion hazard area (approximately 100 miles) would be mapped and field-assessed to most accurately delineate the CMZ, generally following the guidance in Rapp and Abbe (2003) and potentially using the tools described in Legg et al. (2014). The difference between this option and Option 3 is that more detailed identification of the rate of channel migration would occur for cross sections along each river reach, and field assessment would be used to more accurately identify soil and vegetation conditions, geomorphic landforms, and revetment and other features present in a reach. This option would likely provide a smaller CMZ than that derived entirely from GIS-based analysis as in Option 3; however, the effort to conduct field assessments and to more formally evaluate the rate of channel migration along each river would be more substantial.

This focused complete CMZ delineation could be used by local governments and tribes to inform near-term permitting actions within areas of highest risk for bank erosion and channel migration. They could also provide the most accurate basis for updating specific local critical areas ordinances that would designate the CMZ for long-term regulatory management. They could also inform the development of potential long-term local actions such as bank protection, road and bridge maintenance or relocation options, other infrastructure or structure protection or relocation options, and funding needs.

Option 6. Local Actions Program Study Area CMZ Delineation

In this option, the entire study area for the Local Actions Program (approximately 460 miles) would be mapped and field-assessed to most accurately delineate the CMZ as described for Option 5.

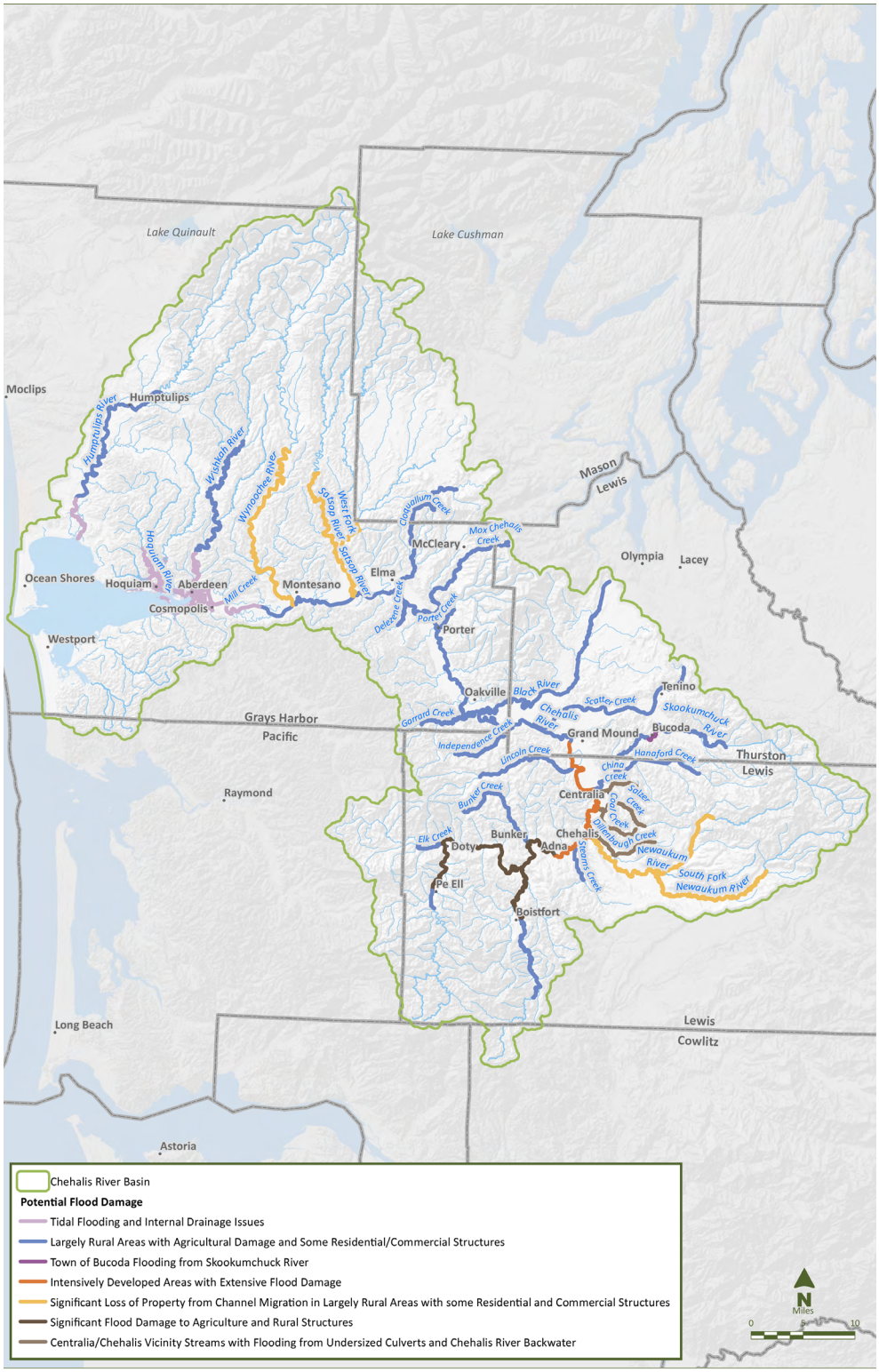
This broad full CMZ delineation could be used by all local governments and tribes in the basin to provide the most accurate basis for updating local critical areas ordinances that would designate the CMZ for long-term regulatory management. They could also inform the development of potential long-term local actions such as bank protection, road and bridge maintenance or relocation options, other infrastructure or structure protection or relocation options, and funding needs over the long term.

Table 1

Pros and Cons of Erosion Hazard and Channel Migration Zone Analysis Options

OPTION	PROS	CONS	POTENTIAL SCHEDULE AND ESTIMATED COST
Option 1. Focused Area Mapping	• Focused on areas currently most at risk • Would not spend time and effort on small streams with limited channel migration that have lesser risk • Can be rapidly completed in the near-term time frame	• May miss areas at longer-term risk for migration	Can be completed in ~100 days (3 months) ~$155,000
Option 2. Local Actions Program Study Area Mapping	• Provides comprehensive coverage based on GIS mapping	• May miss areas at longer-term risk for migration • Medium-term time frame to complete	Can be completed in ~200 days (7 months) ~$500,000
Option 3. Focused Planning-Level CMZ Delineation	• Focused on areas most at risk • Provides longer-term certainty that risks in this area have been identified	• May miss areas at longer-term risk for migration • May overestimate CMZ without field assessment	Can be completed in ~200 days (7 months) ~$210,000
Option 4. Local Actions Program Study Area Planning-Level CMZ Delineation	• Provides comprehensive coverage of all areas of interest and risk • Provides longer-term certainty that risks have been identified	• Long-term time frame to complete • May overestimate CMZ without field assessment	Can be completed in ~1 year ~$650,000
Option 5: Focused CMZ Delineation	• Focused on areas most at risk • Most accurately delineates detailed CMZ	• Medium-term time frame to complete	Can be completed in ~250 days (8–9 months) ~$290,000
Option 6. Local Actions Program Study Area CMZ Delineation	• Provides comprehensive coverage of all areas of interest and risk • Most accurately delineates detailed CMZ	• Long-term time frame to complete	Can be completed in ~18 months ~$850,000

Figure 1
Local Actions Program Study Area



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WSE (Watershed Science and Engineering), 2020. Memorandum to: Andrea McNamara-Doyle, Office of Chehalis Basin. Regarding: Local Actions Program Near-term Technical Analyses for Office of Chehalis Basin: Additional Near-term and Long-term Hydraulic Modeling. October 2020, in progress.