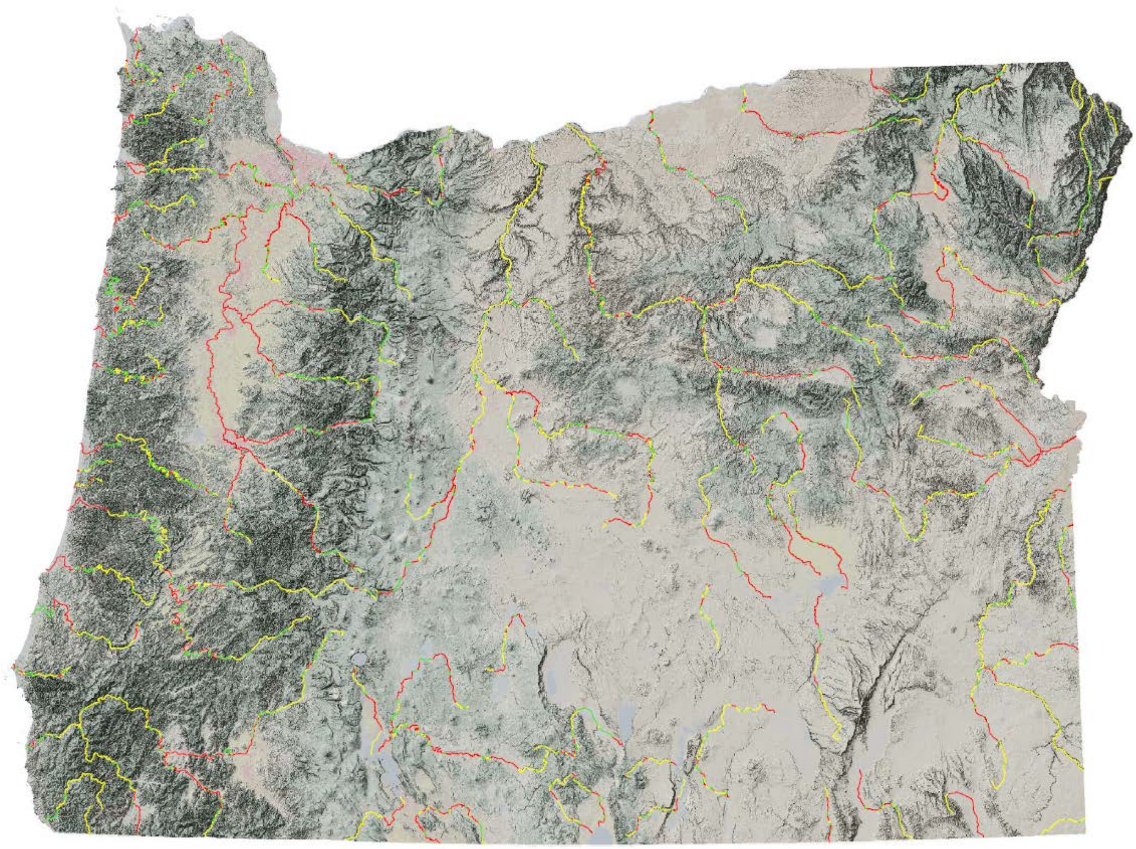
State of Oregon
Oregon Department of Geology and Mineral Industries
Brad Avy, State Geologist

INTERPRETIVE MAP 56

STATEWIDE SUBBASIN-LEVEL CHANNEL MIGRATION SCREENING FOR OREGON



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DISCLAIMER

Cover image: The subbasin-level channel migration screening layer for Oregon overlaid on a 10-m resolution elevation hillshade and 2011 National Land Cover Dataset. The study looked at the lateral migration susceptibility for a given segment, with that potential shown as 'susceptibility.' The screening layer is symbolized by susceptibility with high in red, moderate in yellow, and low in green.

Oregon Department of Geology and Mineral Industries Interpretive Map 56
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MAP PLATE

See the digital publication folder for file.

Plate 1. Channel migration screening overview map of Oregon, scale 1:800,000

GEOGRAPHIC INFORMATION SYSTEM (GIS) DATA

See the digital publication folder for files.
Geodatabase is Esri® version 10.2 format. Metadata is embedded in the geodatabase and is also provided as a separate .xml format file.

Statewide_Subbasin_Channel_Migration_Screening.gdb:

Feature dataset: Screening_Segments

feature class:

Oregon_Channel_Migration_Screening_20150630 (polylines)

Fields:

Stream Name
HUC 8 Code
HUC_8_Name
Drainage_Type
Geometry
Confinement
Pattern
Susceptibility
Gradient
PCT_Gradient
Seg_Lgth_Feet
Z-Min
Z_Max
OBJECTID
SHAPE
SHAPE_Length

Metadata in .xml file format:

FGDC_Statewide_Subbasin_Channel_Migration_Screening.xml

1.0 EXECUTIVE SUMMARY

Channel migration is a geomorphic process by which a stream moves laterally across its floodplain over time. The dynamic forces of erosion and deposition drive the reconfiguration of alluvial channels through scouring of banks and buildup of bars. Channel migration is a known natural hazard in Oregon that poses significant risk to property and infrastructure situated near streams that exhibit certain geomorphic characteristics. However, from a hazard mapping standpoint channel migration has received relatively little attention when compared to other hazards such as landslide, earthquake, tsunami, and flooding. Recent events, like the January 2011 flood and channel migration event on the upper Sandy River (**Figure 2-1),** have highlighted the need for identification and mapping of channel migration zones, but no statewide screening had been performed to determine areas of varying susceptibility, needed to help prioritize mapping efforts.

In August 2014, the Oregon Department of Geology and Mineral Industries (DOGAMI) was commissioned by the Oregon Department of Land Conservation and Development to perform statewide, subbasin-level screening of channel migration susceptibility for first-order streams. The study objectives included:

- Classification of first-order streams into segments of high, medium, and low channel migration susceptibility for each of the 86 subbasins (8-digit hydrologic unit [HUC-8], as defined by the U.S. Geological Survey [USGS]) within or intersecting Oregon.
- Recommendations for further mapping and assessment based on classifications.
- Development of a geodatabase containing the classified stream segments and associated metadata.
- Documentation of methodology and results in a technical report.

A total of 6,913 stream miles were evaluated. Of these, 2,553 miles (37%) were classified as having high channel migration susceptibility, 1,542 miles (22%) as moderate susceptibility, and 2,818 miles (41%) as low susceptibility.

2.0 INTRODUCTION

In 2014-2015 the Oregon Department of Geology and Mineral Industries (DOGAMI) was funded by an Oregon Department of Land Conservation and Development interagency agreement (IAA PS-13032) to perform statewide, subbasin-level screening of channel migration susceptibility. This report describes the methods used to select, map, and classify stream segments. Also included with this publication is a supporting geodatabase and a statewide map (Plate 1) showing channel migration susceptibility classes.

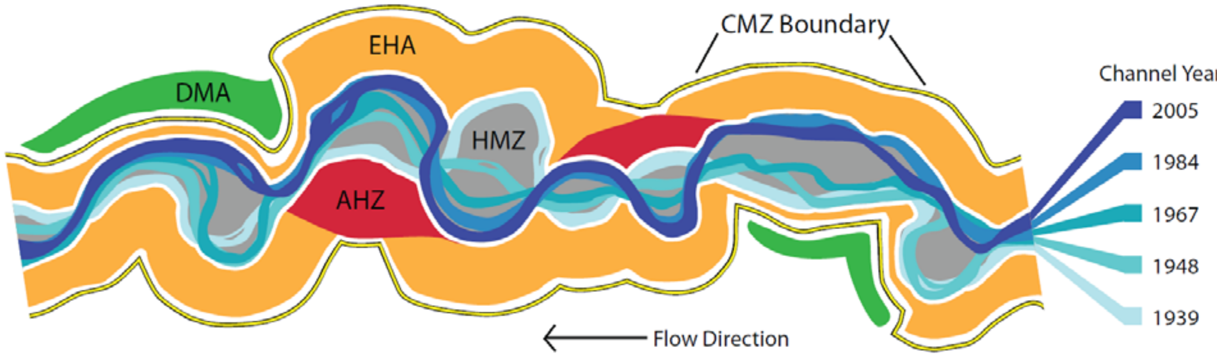
Channel migration is a geomorphic process by which a stream moves laterally across its floodplain over time. The dynamic forces of erosion and deposition drive the reconfiguration of alluvial channels through scouring of banks and buildup of bars. In the Pacific Northwest, fluvial interactions with riparian vegetation, such as the recruitment of large woody debris, can slow or accelerate migration. Similarly, human-made structures can minimize or exacerbate the effects of channel migration (Rapp and Abbe, 2003).

Although typically a gradual process, significant channel migration can occur rapidly, often as a result of high-velocity flows during flood events. Rapid channel migration can and has created hazardous conditions for people and property. In 2011 channel migration destroyed several riverfront homes and caused millions of dollars in damage to infrastructure along the upper Sandy River in Clackamas County (**Figure 2-1**). This event heightened awareness of the hazard and underscored the need to identify other areas of high susceptibility that may present risks.

One response to the 2011 Sandy River event was to perform detailed mapping that (1) identified existing and documented historical channel locations, (2) identified where channels are likely to avulse and create new or reoccupy historical channels, and (3) projected rates of erosion to establish a "channel migration zone" (CMZ) (**Figure 2-2**) (English and others, 2011a; Abbe and others, 2015). Detailed CMZ mapping approaches were developed for the Pacific Northwest by the Washington State Department of Ecology (Rapp and Abbe, 2003; Olson and others, 2014; Legg and Olson, 2015). This was in response to the lack of consideration for channel migration in traditional flood hazard maps—particularly the widely available Flood Insurance Rate Maps (FIRMs) published by the Federal Emergency Management Agency (FEMA) for administration of the National Flood Insurance Program (NFIP)—and to meet the needs of the State of Washington Shoreline Management Act (http://www.ecy.wa.gov/programs/sea/sma/st_guide/intro.html), which requires local jurisdictions to map CMZs.

Figure 2-1. Private residence undercut during a flood and channel migration event in January 2011 on the upper Sandy River in Clackamas County, Oregon (photo credit: J. English, DOGAMI, 2011).

Figure 2-2. Conceptual illustration of the principal components of detailed channel migration zone (CMZ) mapping. These include the historical migration zone (HMZ), avulsion hazard zone (AHZ), erosion hazard area (EHA), and disconnected migration area (DMA). The CMZ is composed of the HMZ, AHZ, and EHA (English and others, 2011a).

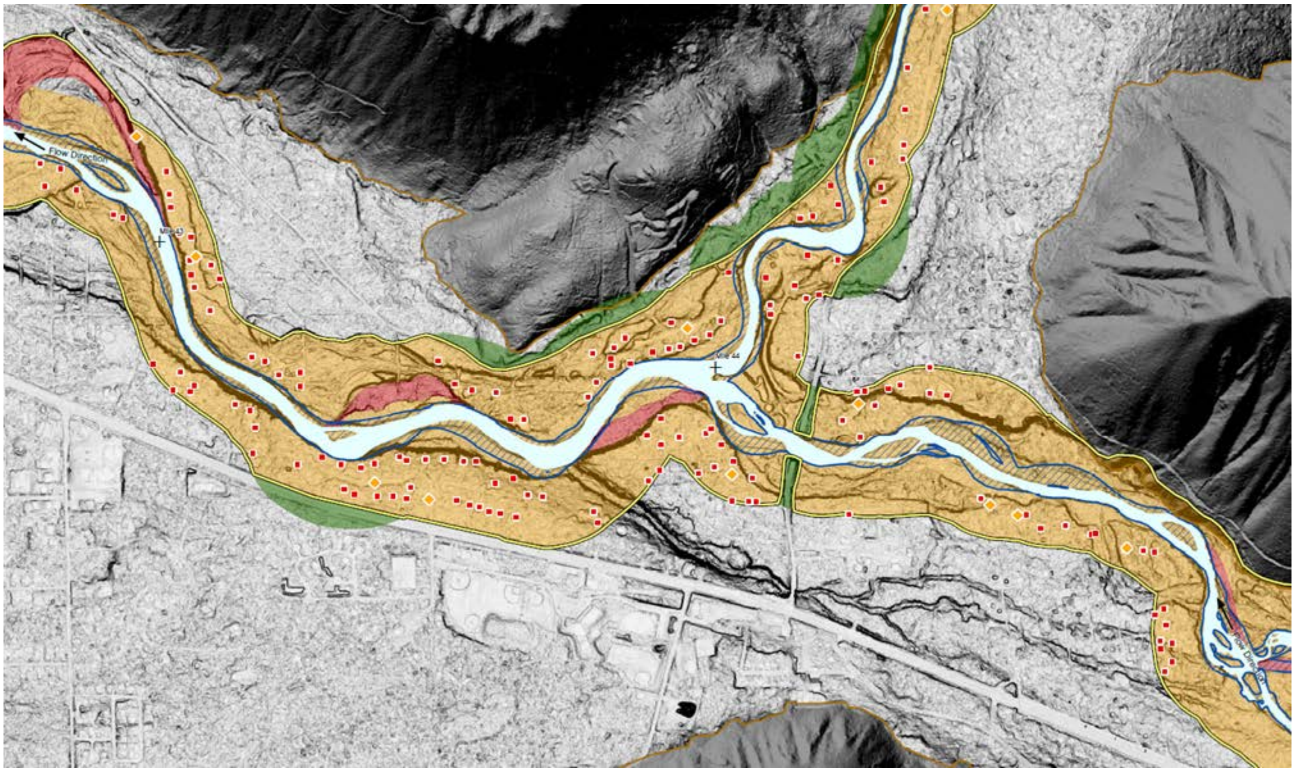


Through its experience with Shoreline Management Act requirements, the Washington State Department of Ecology acknowledged that because susceptibility varies between and across jurisdictions there should be flexibility in the level of effort to map CMZs. A less rigorous "planning-level" mapping approach may be more appropriate in areas of moderate or low susceptibility and is discussed by Olson and others (2014).

Oregon has no regulatory requirements to map CMZs and mapping has been undertaken in only a few instances, driven by combinations of funding availability, local interest due to recent catastrophic events, and DOGAMI's recognition of the need to establish state-level mapping capacity. Following the methodology of Rapp and Abbe (2003), DOGAMI has published detailed CMZ maps for Coos and Coquille rivers (English and Coe, 2011), Sandy River (**Figure 2-3**; English and others, 2011a), and Hood River (English and others, 2011b). An updated study of the upper Sandy River was commissioned by Clackamas County in 2014 to inform restoration and protection measures (Abbe and others, 2015). Because guidance for planning-level CMZ mapping was only recently released (Olson and others, 2015), no such maps have been published in Oregon.

CMZ mapping in Oregon has so far been opportunistic, not strategic. This was acknowledged during the statewide natural hazards mitigation planning process. As part of the 2015 statewide natural hazards mitigation strategy, an action item to "identify, prioritize, and map areas susceptible to rapid channel migration" was included as a priority activity (Oregon State Interagency Hazard Mitigation Team, 2015). This study is the important first step toward identification and prioritization.

Figure 2-3. Example of detailed CMZ mapping at the confluence of the Sandy and Zigzag Rivers in Clackamas County, Oregon (from English and others, 2011a).



LEGEND AND DEFINITION OF MAP ELEMENTS

Channel Migration Zone (CMZ) – is composed of four subzones within the geologic flood plain (Rapp and Abbe, 2003). These zones include:

- **Historical Migration Zone (HMZ)** – the collective area occupied by the channel during the period 1955 to 2009.
- **Avulsion Hazard Zone (AHZ)** – areas potentially at risk from avulsion (catastrophic development of a new channel or reoccupation of an abandoned channel).
- **Erosion Hazard Area (EHA)** – the area outside the HMZ that is at risk of bank erosion from channel migration during the next 100 years.
- **Disconnected Migration Area (DMA)** – the portion of the CMZ where man-made structures physically eliminate channel migration.

Geologic Floodplain – the area adjacent to a stream or river that has been occupied by and shaped by that river during the past 10,000 to 100,000 years.

Sandy River Channel (2009) – the position of the channel in 2009 (shown as a blue zone within the HMZ).

Elevation Contour – 100-foot interval contours.

River Mile – distance in miles upstream from the river mouth.

Structural Asset At Risk – structure that falls within the CMZ.

Road Asset At Risk – road that falls within the CMZ.

3.0 STUDY AREA

The fundamental geographic unit of this study is the subbasin, or 8-digit code hydrologic unit (HUC-8), as defined by the U.S. Geological Survey (USGS). There are 61 subbasins completely within the Oregon state boundary that drain an average of 1,274 square miles. There are also 26 partial subbasins included in this study that drain an average of 760 square miles within Oregon (**Figure 3-1**).

Figure 3-1. Map of study area, illustrating complete and partial subbasins, and primary and secondary streams.

The choice to limit the study scope to the subbasin-level was driven by time and funding limitations. The visual assessment component of this study made it necessary to limit stream mileage. The 6,913 stream miles studied here are a small subset of the roughly 65,000 stream miles in Oregon (U.S. Geological Survey, 2015). However, the studied streams are thought to be regionally significant, consisting of major rivers covering a variety of population, land use, and physiographic characteristics.

A primary stream was selected for susceptibility screening in each complete and partial subbasin. For complete subbasins this was done by identifying the first-order stream draining the entire subbasin or the stream draining the largest proportion of the subbasin. For partial subbasins the stream draining the largest area within Oregon was selected.

A secondary stream was also selected in complete subbasins where the primary stream did not drain the entire subbasin, so as to account for the total subbasin drainage area. In one instance, two secondary streams were selected to account for the total subbasin drainage area (Wilson-Trask-Nestucca subbasin).

Each primary and secondary stream was studied from mouth to headwaters. Stream geometry was manually digitized from Oregon Lidar Consortium lidar (http://www.oregongeology.org/lidar/index.htm), where available, for this study. Lidar base images were derived from 1-m resolution digital elevation models (DEMs) created from point clouds with an average of 8 points/m density (http://www.oregongeology.org/lidar/collectinglidar.htm). Where lidar was not available, flowlines from the National Hydrographic Dataset (U.S. Geological Survey, 2015) were used.

Three partial subbasins (Lower Klamath, Butte, and South Fork Owyhee subbasins) were excluded from the study because only very small portions are within Oregon (24 square miles in total) with too little area to identify streams. One partial subbasin (Middle Columbia-Lake Wallula) with more substantial area in Oregon (829 square miles) was also excluded. The Middle Columbia-Lake Wallula subbasin is dominated by ephemeral streams that hold water only during or immediately after rain events. Such events are rare in this subbasin as it receives an average of less than 10 inches of precipitation annually over much of its area. One perennial stream in the far east of the subbasin, Juniper Canyon, was identified but was not screened for susceptibility due to its relatively small drainage area (75 square miles), remoteness, and extreme confinement.

Only interior (within the state boundary) streams were included in this study; the boundary waters of the Columbia River and Snake River were excluded.

4.0 METHODOLOGY

The screening approach used in this study evolved through consultation with current and former staff at the Washington State Department of Ecology. The initial approach was adapted from methodologies developed in 2013 (Washington Department of Ecology, 2013), where three physical characteristics were evaluated: (1) channel confinement, (2) channel pattern, and (3) channel gradient. Evaluation criteria for these characteristics are described in sections 4.1, 4.2, and 4.3, respectively. Characteristics would then be combined to define classes of susceptibility.

While the study was in progress, analyses published by Legg and Olson (2015) demonstrated that aspects of the initial approach needed to be reconsidered. Legg and Olson asserted that channel gradient alone is not a strong indicator of susceptibility. To incorporate channel gradient into their screening approach, Legg and Olson combined it with stream discharge to calculate a "stream power index," which they equated to erosion potential. In their approach, erosion potential is scaled against channel confinement in a matrix of CMZ mapping effort recommendations.

Due to time limitations, DOGAMI was not able to incorporate stream power indices into its screening methodology. Instead, since channel pattern was evaluated and readily available, it was used as a proxy for erosion potential. Channel pattern is considered a reasonable proxy because it is the geomorphic manifestation of several controlling variables, including channel gradient and discharge (i.e., stream power) (Beechie and Imaki, 2014). Although channel pattern classification is sometimes subjective, it is a more encompassing indicator of channel migration susceptibility than stream power alone. Section 4.2 describes the subjective aspects of channel pattern classification.

Legg and Olson (2015) classified erosion potential for portions of Western Oregon as part of their Channel Migration Potential (CHAMP) layer and provided DOGAMI a dataset with which to compare results. Differences between the two classifications stem from the reliance of CHAMP on coarser topographic data and an automated GIS workflow. GIS models based on the USGS National Elevation Dataset were used to develop stream delineations and estimates of active channel and valley widths for CHAMP. These geomorphic estimates are highly generalized when compared to interactive, lidar-based estimates developed for this screening. As a result, classifications of erosion potential (CHAMP) and susceptibility (DOGAMI screening) disagree along some stream segments in Western Oregon.

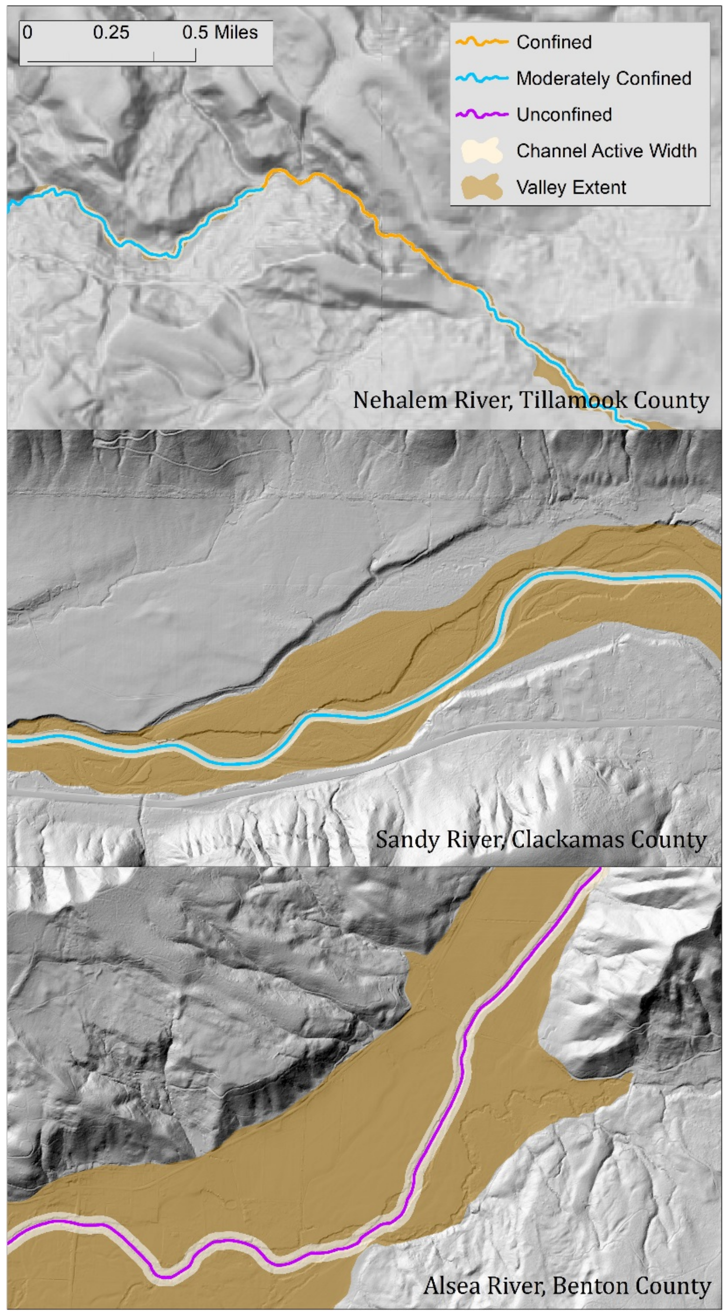
4.1 Channel Confinement

Channel confinement was determined by visual assessment and spot measurements of best available topographic data (lidar or USGS National Elevation Dataset), USGS 7.5-minute topographic maps, and 2014 statewide orthoimagery (NAIP; U.S. Department of Agriculture). Stream segments were classified as confined, moderately confined, or unconfined using the valley width to active channel width ratio defined in **Table 4-1**. Examples of each confinement classification are shown in **Figure 4-1**.

Table 4-1. Channel confinement ratio classes (Washington State Department of Ecology, 2013).

Class	Ratio of Valley Width to Channel Active Width
Confined	<2
Moderately confined	≥2 and ≤4
Unconfined	>4

Figure 4-1. Examples of channel confinement classification.



In some cases there was a level of subjectivity in the evaluation of channel confinement, due to difficulties distinguishing the active channel width or ratios falling on the border between two classifications. Best judgment of the geomorphic setting was used to determine the most appropriate classification.

4.2 Channel Pattern

Channel pattern was determined by visual assessment of best available topographic data, U.S. Geological 7.5-minute topographic maps, and 2014 statewide orthoimagery. Stream segments were classified as one of six channel patterns: braided, meandering, anastomosing (or anabranching), bedrock, deltaic, or straight. Examples of each pattern classification are shown in **Figure 4-2**.

There is no definitive classification of channel patterns, which makes evaluating this characteristic an interpretive exercise that is sometimes challenging. DOGAMI referred to Rapp and Abbe (2003) and Beechie and others (2006) to develop its set of classes, shown in **Table 4-2**, and to help establish consistency.

Table 4-2. Channel pattern classes (modified from Washington State Department of Ecology, 2013).

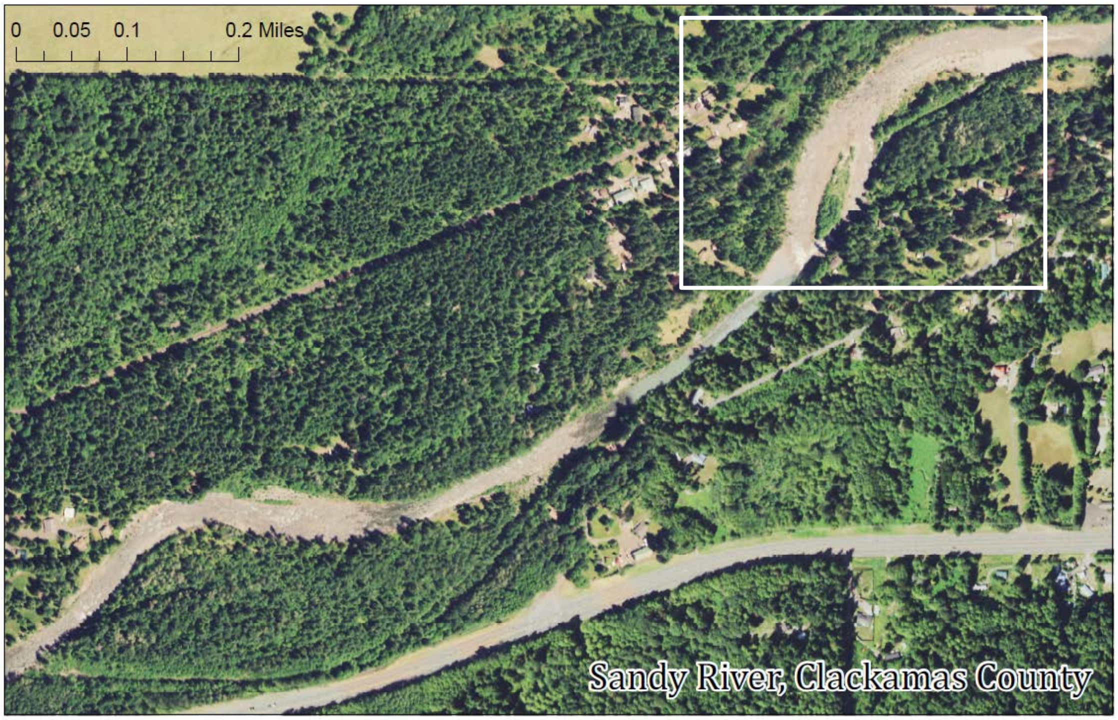
Pattern Type	Description
Braided	Two or more low flow channels divided by bars that are inundated at bankfull stage
Meandering	Well established, sinuous channels that typically occupy wide valleys
Anastomosing	Multiple interconnected channels usually on alluvial deposits, prone to avulsion
Bedrock	Downcutting and predominantly controlled by local bedrock structure
Deltaic	Extreme downstream portion of channel network, broad, low-lying alluvial land subject to frequent inundation
Straight	Steep confined channels, little to no lateral movement potential

Figure 4-2. Examples of channel pattern classification.

Classifying stream segments can be difficult: geomorphic interpretation and best judgment commonly come into play. The following scenarios were resolved as described.

- Anastomosing patterns were sometimes difficult to distinguish from braided patterns. The presence of vegetation on island bars was used to distinguish between the two. When it seemed the vegetation was mature and well established it was classified as an anastomosing pattern (**Figure 4-3**).

Figure 4-3. Example of a stream segment with aspects of both anastomosing and braided channel patterns. This segment was classified as anastomosing due to the presence of island bars with established vegetation present (upper-right, boxed area).



- Braided, anastomosing, and meandering patterns can be difficult to differentiate (**Table 4-2**) due to the presence of relict channels and varying stream discharge throughout the water year. Relict channels are clearly visible on lidar imagery. However, their presence required judgment of whether they were perennially or intermittently active. For these sites, the determination was based on 2014 orthoimagery. The orthoimagery was collected in the summer and shows channels in western Oregon—where this issue was most persistent—nearer to low flow and with greater vegetation cover. With no water visible in relict channels it was difficult to identify vegetated islands indicative of the anastomosing pattern, and therefore classification in these instances skews toward braided or meandering patterns (**Figure 4-4**).
- Meandering and bedrock patterns presented issues where a predominately meandering segment passed through a short (i.e., less than a mile) section of channel confinement. Rather than generalizing the entire segment as a meandering pattern, the smaller sections were classified as a bedrock pattern (**Figure 4-5**). The opposite was true in fewer cases, where a predominately bedrock segment broke out into a moderately confined section with a meandering pattern. In these cases, the meandering pattern was chosen, rather than classifying the entire segment as a bedrock pattern (**Figure 4-6**).

Figure 4-4. Example of a stream segment with aspects of meandering, braided, and anastomosing patterns. This segment was classified as braided due to a lack of established vegetation on island bars and difficulty determining if water is present in relict channels.

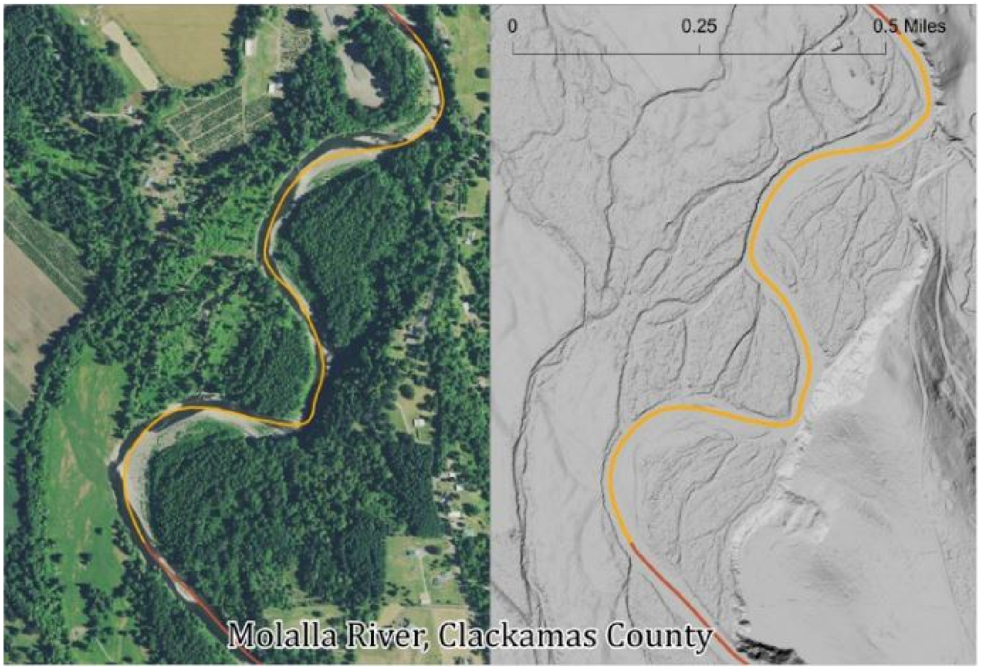


Figure 4-5. Example of bedrock segments that were classified within a broader meandering pattern.

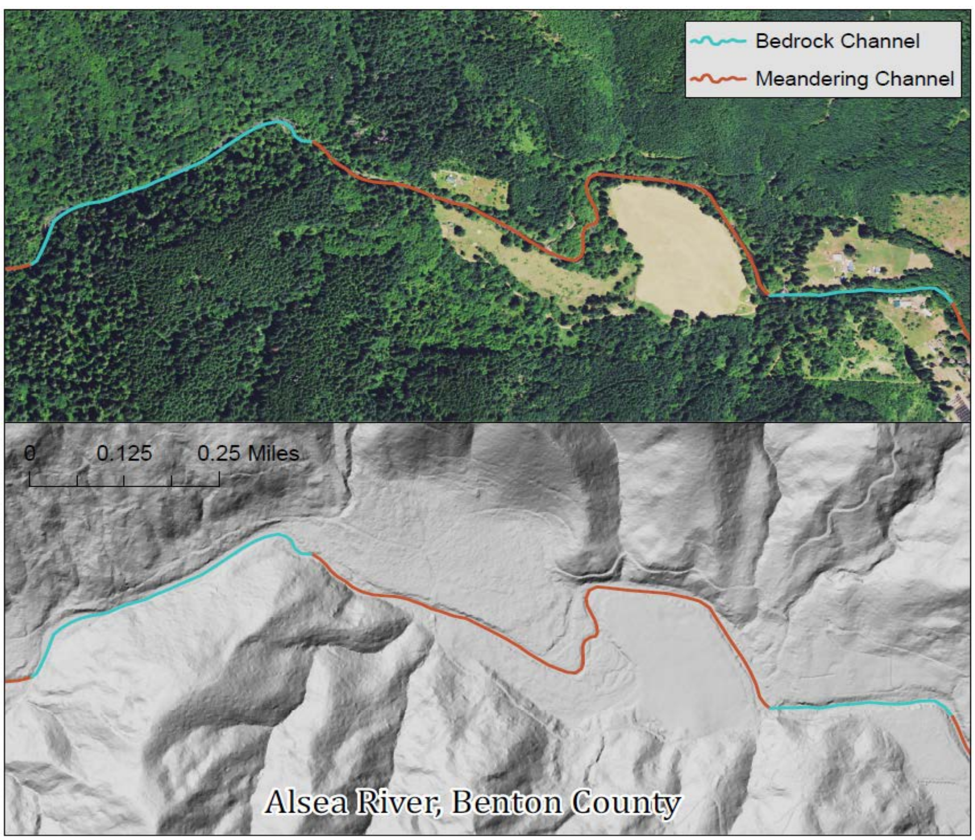
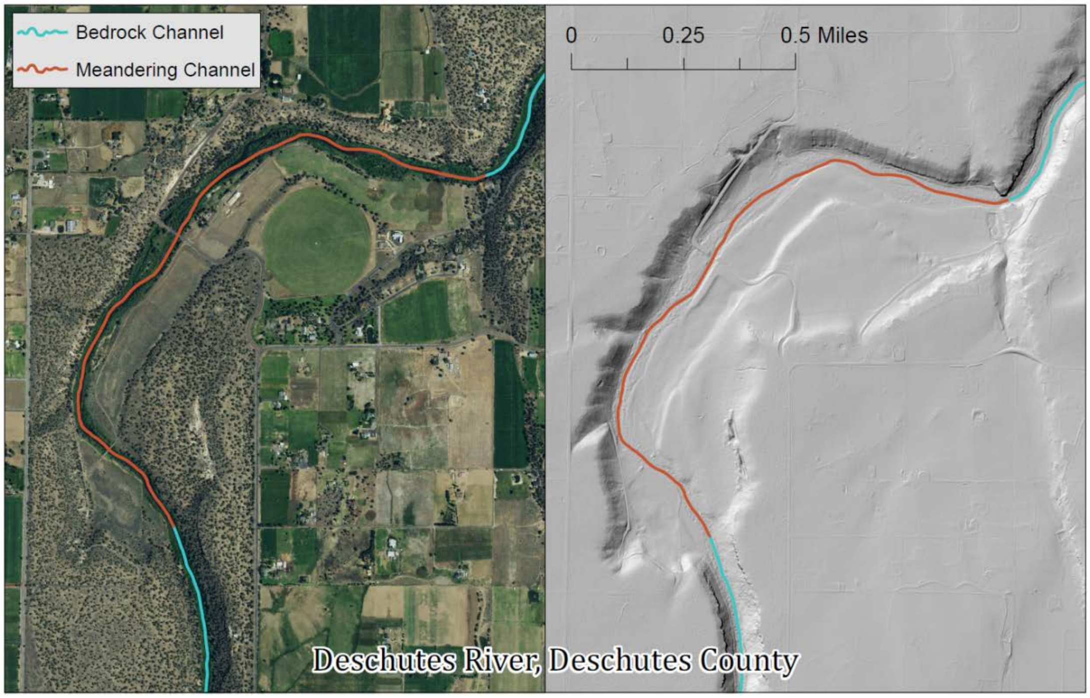


Figure 4-6. Example of meandering segment that was classified within a broader bedrock pattern.



The deltaic pattern is limited to segments just upstream of the Pacific Ocean, Columbia River, Snake River, and large lakes and reservoirs. Judgment was required to determine how far upstream of the larger water body to assign the deltaic pattern. Consideration of the likely extent of influence by the larger water body was used to determine when to switch to a different pattern.

Naturally straight patterns were rare in our evaluation. Most straight patterns are the result of human intervention (e.g., irrigation channels) or where streams traverse reservoirs, lakes, or marshes.

4.3 Channel Gradient

Channel gradient was not ultimately used to screen for susceptibility for reasons described earlier in this section. It was calculated, however, and is included in the geodatabase distributed with this report.

After streams were evaluated for confinement and pattern, each unique segment was classified as having low, moderate, or high gradient using the slope range defined in **Table 4-3**. Slope was determined by identifying the elevation (from 1-m resolution lidar or 10-m resolution USGS National Elevation Dataset) at the upstream and downstream ends of the segment. The downstream elevation was then subtracted from the upstream elevation and the difference was divided by the segment length. In a small number of cases this resulted in a negative slope, due to elevation source inconsistencies or inaccurate NHD flowline delineations; these latter segments were classified as having low gradient.

Table 4-3. Channel segment gradient classes (Washington State Department of Ecology, 2013).

Class	Percent Slope
Low gradient	<2%
Moderate gradient	≥2% and ≤4%
High gradient	>4%

4.4 Channel Migration Screening Matrix

A screening matrix of channel migration susceptibility was adapted from Legg and Olson (2015). In our adaptation, three classes of channel confinement are scaled against three classes of channel pattern to produce nine possible combinations. Each of the nine combinations was rated as having high, moderate, or low channel migration susceptibility (**Table 4-4**). These final three susceptibility classifications were suggested by former Washington State Department of Ecology staff (N. Legg, personal communication, June 12, 2015) to correspond to appropriate management actions (i.e., CMZ mapping level of effort).

Table 4-4. Channel migration susceptibility classification matrix of stream segments.

Channel Pattern	Confined	Moderately Confined	Unconfined
Bedrock or Straight	Low	Low	Moderate
Meandering or Deltaic	Low	Moderate	High
Braided or Anastomosing	Moderate	High	High

5.0 RESULTS

Table 5-1 provides a summary of the 6,913 stream miles screened.

Table 5-1. Summary of channel migration screening results.

	Mileage	% of Total
Susceptibility		
High	2,553	36.9%
Moderate	1,542	22.3%
Low	2,818	40.8%
Total	6,913	100.0%
Confinement		
Confined	2,798	40.5%
Moderately confined	1,605	23.2%
Unconfined	2,510	36.3%
Pattern		
Bedrock	2,572	37.2%
Straight	91	1.3%
Meandering	3,744	54.2%
Deltaic	124	1.8%
Braided	49	0.7%
Anastomosing	333	4.8%

It is useful to consider the results across different physiographic regions of Oregon. Each subbasin was assigned to one of nine hydrologic regions (**Figure 5-1**) and shows that the greatest percentage of high susceptibility stream segments is found in the Klamath Basin (59%), followed closely by the Willamette Valley (55%). The lowest percentage of high susceptibility is found in the John Day Basin (22%). Channel confinement varied greatly across regions, with unconfined stream mileage ranging from 63% in the Klamath Basin to 18% in the John Day Basin. Meandering and bedrock channel patterns tended to dominate, accounting for the largest proportion of stream mileage in all but one region (Willamette Valley). These results are summarized in **Table 5-2**.

Figure 5-1. Map of study area by hydrologic region.

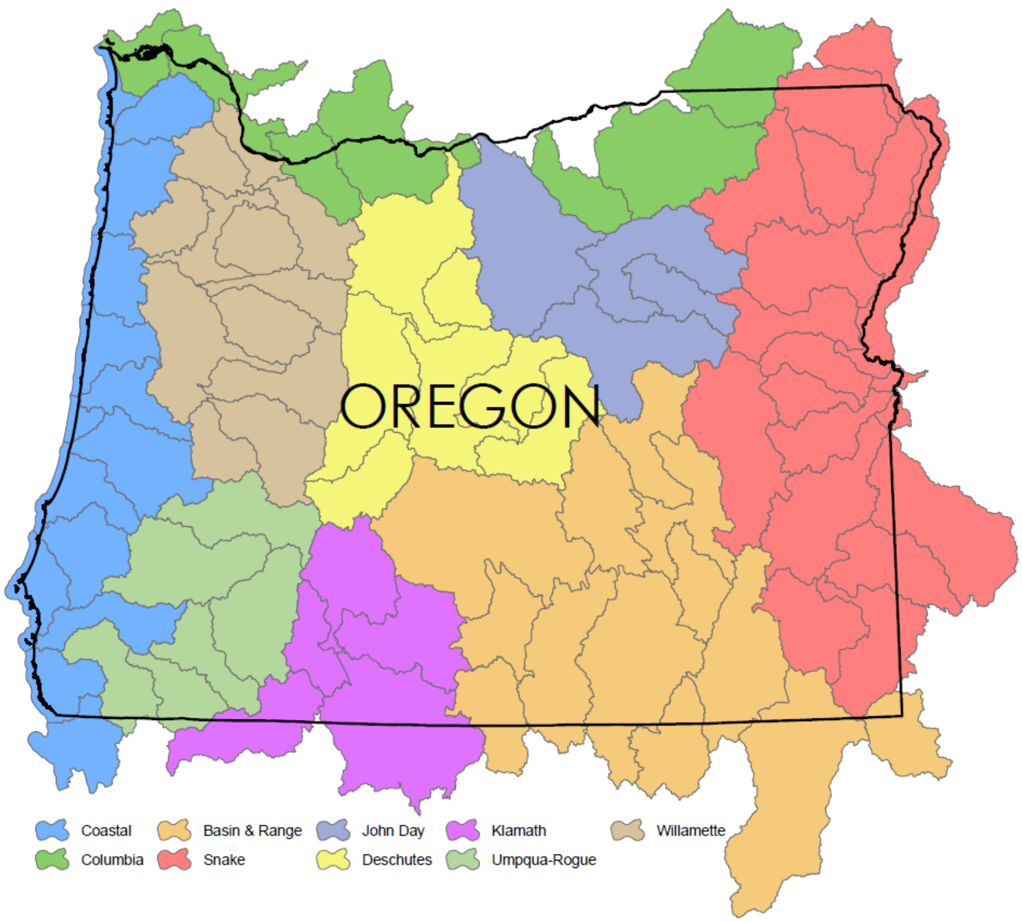


Table 5-2. Summary of channel migration screening results by hydrologic region.

Coastal	Mileage	% of Region
Susceptibility		
High	268	23.5%
Moderate	350	30.7%
Low	521	45.8%
Region total	1,139	100.0%
Confinement		
Confined	518	45.5%
Moderately confined	361	31.7%
Unconfined	260	22.8%
Pattern		
Bedrock	506	44.4%
Straight	4	0.5%
Meandering	529	46.4%
Deltaic	80	7.0%
Braided	0	0.0%
Anastomosing	20	1.7%

Willamette Valley	Mileage	% of Region
Susceptibility		
High	536	55.3%
Moderate	238	24.6%
Low	195	20.1%
Region total	969	100.0%
Confinement		
Confined	192	19.8%
Moderately confined	271	28.0%
Unconfined	506	52.2%
Pattern		
Braided	18	1.9%
Meandering	613	63.3%
Anastomosing	166	17.1%
Deltaic	11	1.1%
Bedrock	148	15.3%
Straight	13	1.3%

Deschutes	Mileage	% of Region
Susceptibility		
High	229	32.5%
Moderate	148	21.0%
Low	328	46.5%
Region total	705	100.0%
Confinement		
Confined	326	46.2%
Moderately confined	150	21.3%
Unconfined	229	32.5%
Pattern		
Braided	0	0.0%
Meandering	395	56.1%
Anastomosing	8	1.1%
Deltaic	3	0.4%
Bedrock	297	42.1%
Straight	2	0.3%

Columbia	Mileage	% of Region
Susceptibility		
High	136	35.4%
Moderate	158	41.2%
Low	90	23.4%
Region total	384	100.0%
Confinement		
Confined	91	23.7%
Moderately confined	178	46.3%
Unconfined	115	30.0%
Pattern		
Braided	19	4.9%
Meandering	236	61.6%
Anastomosing	27	7.0%
Deltaic	12	3.1%
Bedrock	90	23.4%
Straight	0	0.0%

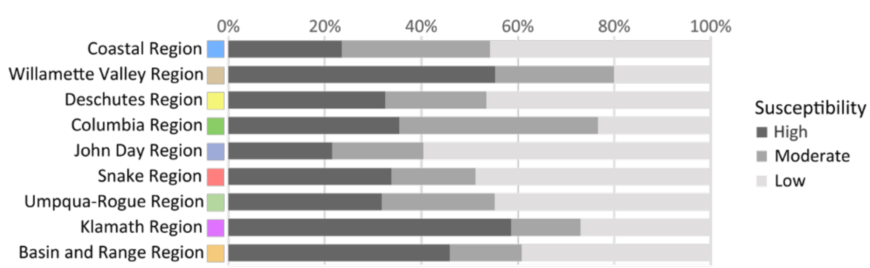
John Day	Mileage	% of Region
Susceptibility		
High	117	21.5%
Moderate	103	18.9%
Low	324	59.6%
Region total	544	100.0%
Confinement		
Confined	325	59.7%
Moderately confined	124	22.8%
Unconfined	95	17.5%
Pattern		
Braided	0	0.0%
Meandering	198	36.4%
Anastomosing	21	3.9%
Deltaic	8	1.5%
Bedrock	317	58.2%
Straight	0	0.0%

Snake	Mileage	% of Region
Susceptibility		
High	482	33.8%
Moderate	248	17.4%
Low	694	48.8%
Region total	1,424	100.0%
Confinement		
Confined	689	48.4%
Moderately confined	258	18.1%
Unconfined	477	33.5%
Pattern		
Braided	13	0.9%
Meandering	753	52.9%
Anastomosing	26	1.8%
Deltaic	5	0.4%
Bedrock	614	43.1%
Straight	13	0.9%

Umpqua-Rogue	Mileage	% of Region
Susceptibility		
High	147	31.8%
Moderate	108	23.4%
Low	207	44.8%
Region total	462	100.0%
Confinement		
Confined	207	44.8%
Moderately confined	113	24.5%
Unconfined	142	30.7%
Pattern		
Braided	0	0.0%
Meandering	233	50.4%
Anastomosing	35	7.6%
Deltaic	1	0.2%
Bedrock	193	41.8%
Straight	0	0.0%

Klamath	Mileage	% of Region
Susceptibility		
High	224	58.6%
Moderate	55	14.4%
Low	103	27.0%
Region total	382	100.0%
Confinement		
Confined	103	27.0%
Moderately confined	40	10.5%
Unconfined	239	62.5%
Pattern		
Braided	0	0.0%
Meandering	250	65.4%
Anastomosing	29	7.6%
Deltaic	3	0.8%
Bedrock	83	21.7%
Straight	17	4.5%

Basin and Range	Mileage	% of Region
Susceptibility		
High	415	45.9%
Moderate	135	14.9%
Low	355	39.2%
Region total	905	100.0%
Confinement		
Confined	345	38.1%
Moderately confined	112	12.4%
Unconfined	448	49.5%
Pattern		
Braided	0	0.0%
Meandering	536	59.2%
Anastomosing	0	0.0%
Deltaic	2	0.2%
Bedrock	325	35.9%
Straight	43	4.7%



6.0 DISCUSSION

This screening effort was completed to inform state and local decisions about the management of channel migration as a natural hazard. The screening matrix (**Table 4-4**) developed here ties directly to recommended actions developed by the Washington State Department of Ecology (Legg and Olson, 2015) that balances level of effort with susceptibility. While the screening matrix provides a relative scale of susceptibility, it serves only as a starting point; every stream segment will require some level of additional mapping scrutiny.

For stream segments classified as having high susceptibility (37% of the primary streams screened), we recommend that detailed CMZ mapping be performed. Such mapping will provide the most precise and accurate identification of the hazard by including field investigation, which is critical in areas of dense or moderate development.

For stream segments classified as having moderate susceptibility (22% of the primary streams screened), we recommend that planning-level CMZ mapping be performed, which makes use of best available GIS data to identify the hazard. The results are typically more conservative than detailed CMZ mapping, due to greater uncertainty, but are much less expensive to produce.

For stream segments classified as having low susceptibility (41% of the primary streams screened), we recommend further visual assessment as a minimum requirement for any level of susceptibility. This screening effort did not consider site-specific conditions and was limited by data availability and scope. For example, in areas where lidar imagery was not available, it is important to further evaluate streams for bank erosion or other indicators of active channel migration using other techniques and/or fieldwork. Legg and Olson (2015) provided a framework for using channel width and pattern to determine if additional mapping may be warranted.

As explained by Legg and Olson (2015), all of these recommendations should be taken into consideration within the broader context of land use and development. For instance, high-density development adjacent to a moderate susceptibility segment may drive the need for detailed CMZ mapping given the potential risk. Similarly, detailed CMZ mapping for a high-susceptibility segment in rural or undeveloped areas with no prospect for increased density would not need detailed CMZ mapping.

7.0 LIMITATIONS

This product should be used as a prioritization tool only and cannot replace recommended additional mapping activities, such as planning-level or detailed CMZ mapping, or site-specific studies.

This effort uses a slightly different approach to define CMZ susceptibility compared with previous screening methodologies developed by the Washington State Department of Ecology (Legg and Olson, 2015). The main difference is its use of channel pattern as a proxy for erosion potential. Evaluation of channel pattern is highly subjective, such that geomorphologists may yield a variety of conclusions as to stream classification. Erosion potential, which is a combination of channel gradient and stream discharge, is a more quantifiable characteristic of fluvial systems that can be determined with greater repeatability. Future efforts should explore erosion potential as another classification parameter.

While regionally significant, the streams included here represent a small fraction of those present in Oregon. Additional screening is needed to achieve a comprehensive prioritization strategy for channel migration management. It is recommended that streams screened in future efforts are selected based on drainage area (i.e., larger drainage areas are given greater weight) and considerations of current and future land use.

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