APPENDIX E

Calapooia River Watershed Analysis
Stream Channel Assessment

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INTRODUCTION

The purpose of this analysis is to assess historic, current, and potential future stream channel conditions and morphologic sensitivity to inputs. Channel morphology is a product of the transport of water, sediment and wood, and therefore reflects the processes operating in a watershed (Montgomery and Dietrich 1989; Sullivan et al 1986). This assessment divides the channel network into areas that respond to disturbance and inputs in a similar fashion based on similarities in channel-forming processes. The products from this assessment provide the context for evaluating the effects of land management on fish, water quality and public works.

This assessment addresses several key questions critical to understanding channel processes:

- *What is the spatial distribution of channel response types?*
- *Is there evidence of channel change from historic conditions?*
- *What do existing channel conditions indicate about past and present active geomorphic processes?*
- *What are the dominant channel- and habitat-forming processes in different parts of the channel network?*

Working hypotheses of channel condition, generated early during the watershed assessment are a vital tool for extrapolating local channel conditions and interpreting potential causal relationships because most of the watershed could not be directly observed.

Discussions of historic and current channel condition, as well as future condition, are stratified into geomorphically derived units known as Geomorphic Map Units (GMUs). GMUs encompass stream reaches and their associated valleys that display similar morphologic character and function. As a result, habitat forming processes are inferred to be generally distinctive in each GMU. This approach aids integration and synthesis of data collected during remote sensing and field work. Since most of the segment clustering into GMUs involves considerable extrapolation, those attributes that are remotely sensed in the assessment (i.e., map gradient, confinement, and relative drainage area or network position) are the primary variables used to define GMU boundaries.

General Geomorphology

The Calapooia River watershed is located in the western Cascades and is carved by steep, highly confined high energy mountain streams. Steps occasionally punctuate longitudinal profiles where channels cross more resistant bedrock and form cascading waterfalls. Landslides that turn into debris flows are naturally a dominant mechanism of erosion in the western Cascades, and route sediment and wood to downstream reaches (see Appendix A, Mass Wasting). Small and large debris jams are currently present in the system and play an important role in upstream channel aggradation and pool formation. Coarse sediment and bedrock are the dominant substrates in most of the channels and boulders currently dominate pool formation. However the lower end of the watershed is dominated by fine sediment substrates. The majority of the Calapooia tributaries are high gradient (greater than 8% in slope). Stormflow response to rainfall is rapid in the steep, shallow soil topography of the mountainous areas. Channel morphologies are expected to rebound quickly to the high energy physical processes that express themselves in the watershed, however, a recent storm event (February 1996) which left many of the tributary channels debris torrented, is still evident by scoured out channels and riparian areas.

Hypotheses

The following hypotheses provide a baseline for understanding how the stream system in this watershed processes sediment, water and wood based on the regional and geologic location.

Coarse sediment loads are high in the watershed because the local geology and steep slopes supply and transport coarse sediment. The high number of miles of source and transport reaches in the watershed (Figure E1) indicate that the Calapooia River watershed has a high probability of routing a large amount of coarse sediment to downstream reaches.

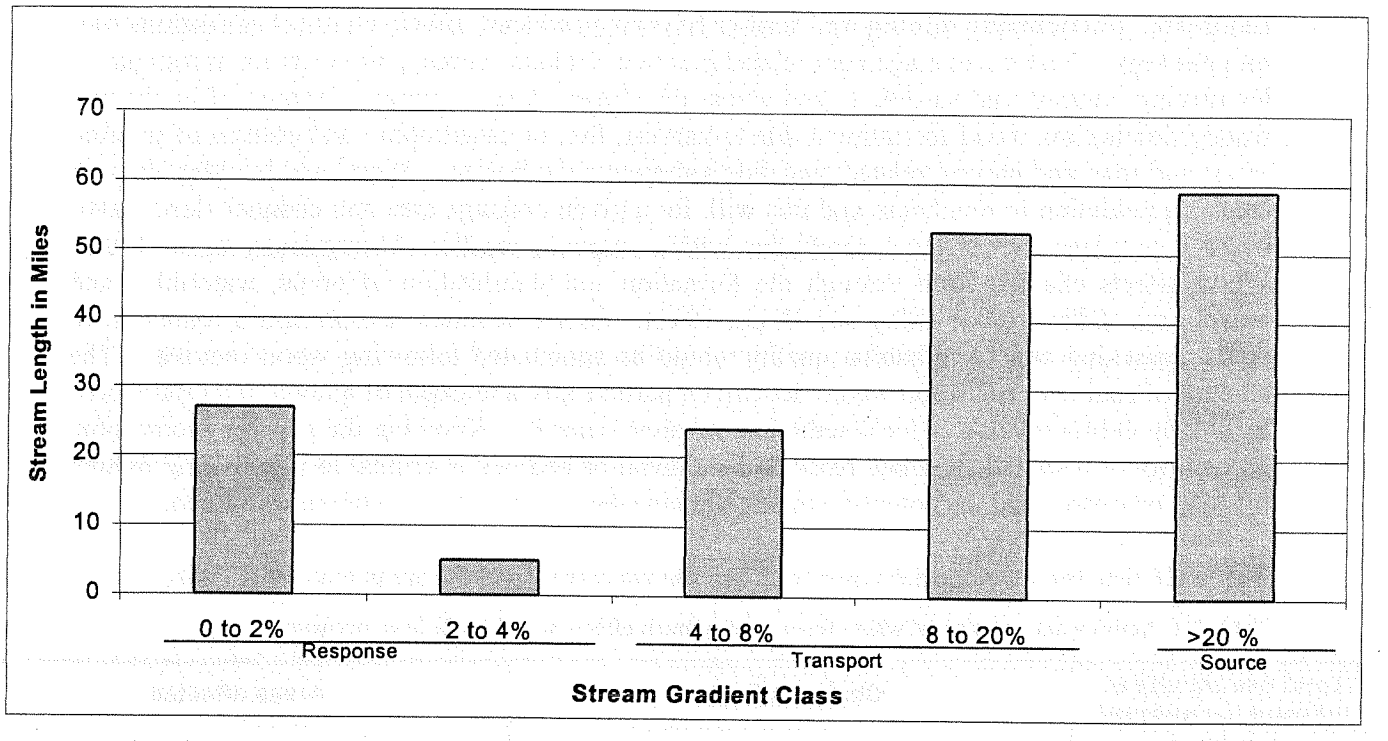


Figure E1 Length of stream channels as a function of gradient class. Gradients were initially reach averaged through DEM data and were corrected using USGS 7.5 minute topographic maps (40 ft. contour interval).

High coarse sediment loads could impose morphological channel changes to response reaches and temporary sediment storage volumes may be relatively high (Montgomery and Buffington, 1993). Coarse sediment introduced to the Calapooia mainstem, which is a response reach, may increase fish habitat complexity and create spawning gravel patches. The mainstem is confined, but there are segments along the mainstem which are moderately confined (loosely confined) and these areas may allow gravel bar development at meander bends and low velocity points. In areas of high confinement a lack of roughness moves the bedload through the system rapidly.

Channel morphology reflects high energy stream systems where streamflow responds quickly to rainfall events and debris flows are common. An alternating cycle of aggradation and degradation occurs historically within channels that commonly experience debris flows. Deposition by debris flows subsequently erodes and develops a boulder lag deposit. Once this sediment is depleted, channel bedrock is easily exposed with some armoring by coarse sediments, cobbles and boulders, until deposition occurs again (Benda, 1990).

Land-use, particularly mining and timber harvest practices, affects channel conditions and morphology. Historic management related practices include: mining, downstream splash dams, log driving, logging and yarding to and across the stream channel, stream cleaning of in-channel woody debris; low wood recruitment due to harvest, fire, or catastrophic disturbance of riparian areas; and road and harvest related landslide sediment contributions. Wood and boulder removal creates a reduction in roughness and this will, for a given drainage area and channel slope, favor bedrock or plane–bed channel conditions within response reaches (Montgomery et al. 1996). Wood affects channel form through the formation and stabilization of pools, waterfalls, and gravel bars (Bilby, 1981; Bilby and Ward, 1991). Coarse sediment export and a reduction in pools, spawning and riffle habitat quality would be anticipated following wood removal. The amount of sediment reduction would depend on particle size and depth of alluvial material stored by woody debris relative to local sediment transport capacity. Knowing the general geomorphic probability of a specific channel reach to be alluvial or bedrock is critical to interpreting habitat forming processes and the potential impact of management practices on stream morphology.

Table E1 lists the land use activities found in the watershed and the areas that are affected.

Table E1 Activity and location of where forest management effects would likely have occurred

Land use activity or inherent geomorphic condition	Channel affects	Areas affected
Splash dams	Bed scour, change in base level leading to degradation	Downstream of watershed boundary
Roads/bridges/culverts	Fine sediment inputs, hydraulic changes increase shear stresses (confinement) causing downstream scour, upstream deposition	Stream crossings and stream adjacent roads impinging on the channel. Mainstem channel altered in 1970s because the mainline was washing out above King Creek
Railroad Logging	Related logging activities	Dollar Camp and downstream
Logging Camps	Related logging activities	Dollar Camp, King Camp
Log Drives	Bed scour from wood removal, boulder removal increasing shear stresses	Documented from Dollar and downstream
Stream cleaning	Wood removal causes increased stream power: flushing of fine and coarse sediment, loss of peak flow dampening effects. Reduction in pool volume and spacing.	Variable, occurred throughout the watershed. Documented to have occurred through 8 miles of river upstream of Dollar and 0.8 mile of North Fork in 1959
Mining	Streambank erosion, displacement and suction of gravels altering pool volume and depths	Headwaters severely affected by placer mining, other tributaries also placer mined
Riparian harvest	Coarse and fine sediment inputs, loss of wood roughness increases stream power, bank erosion	All drainages
Road & harvest related catastrophic events (i.e., debris torrents)	Coarse and fine sediment inputs causing aggradation, routing of large amounts of LWD to streams increasing debris jams	Transport and source reaches

METHODS

The critical questions, assumptions, and methods used in this assessment are detailed in the Standard Methodology for Conducting Watershed Analysis, Version 3.1 (Washington Forest Practices Board, 1996).

Stream Channel Partitioning

The stream network was defined using Digital Elevation Models (DEMs). USGS 7.5 minute topographic maps were utilized to correct the DEM gradient calls. The blue line U.S.G.S. streams were divided into segments based on reach average gradient and confinement. Confinement classes were visually estimated from topo maps, aerial photographs and field checking.

The distribution of segments in the watershed as a function of gradient, confinement and probable channel morphology is provided in **Form E1** located in Attachment E1. **Map E1** displays the location of channel segments in the basin and the distribution of response (<4 percent gradient), transport (4-20 percent gradient), and source (>20 percent gradient) reaches.

HISTORIC TRENDS AFFECTING CHANNEL CONDITION

Through historic documentation and interviews, morphologic adjustments to the stream channel can be identified. The following are documented activities, which impacted the stream channels within the watershed.

- The first impacts to the headwater streams include hard rock mining which began during the mid-1800s. Today there are over 150 mineral claims in the headwaters of the Calapooia River. Placer mining and suction dredging continue to occur along the stream channel (Haberkorn, pers. communication, U.S.F.S., 1998).

- Logging began to impact the stream channels by the late 1800s. In the 1850s, sawmills began to spring up along the Calapooia River near Holley. By 1906, the Thurston Brothers Lumber Company had a "River Camp" twelve miles up the Calapooia River from Crawfordsville (placing it just downstream of Big Creek at Dollar—within the watershed). The camp was headquarters for the log drive crew that drove the logs down the Calapooia River to their mill at Crawfordsville (Repetto, 1970). A log drive in smaller streams and rivers generally meant shorter logs (**Photo E1**). Log drives scoured out the lower end of the mainstem channel from Bigs Creek downstream. Steam donkeys were used to bring logs to the river and a large boom held the logs at the Thurston sawmill. Dynamite was used to blast boulders, hung up logs and dams built with dirt and logs in the mainstem channel (Reece Watkins, pers comm., 1998).

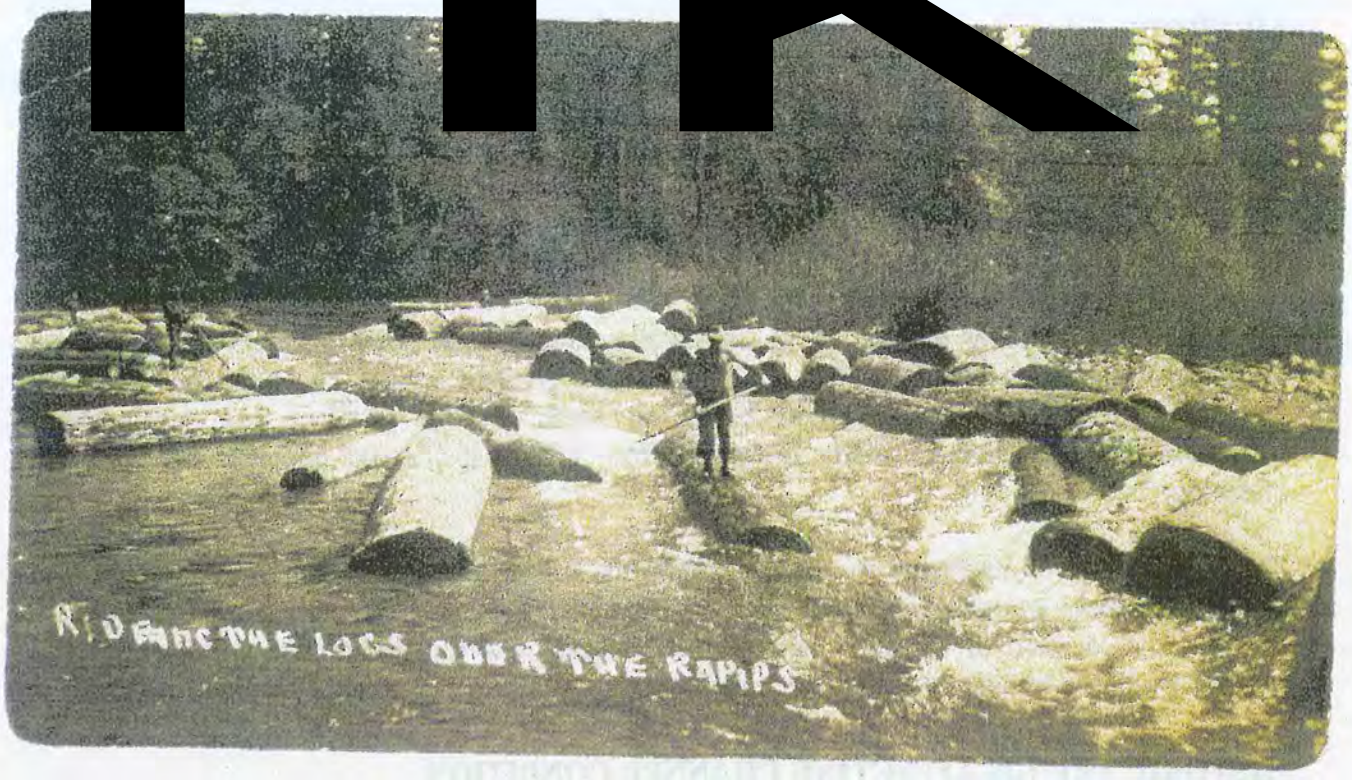


Photo E1 Postcard photograph taken by P.A. Caverly & Wife, Brownsville, Ore., illustrating a typical log drive on a western Oregon River.

The clearance of log jams to approximately 8 miles above Dollar and 0.8 miles of the North Fork was completed by the Oregon fish commission in 1959 (Willis et al, 1960), further simplifying the channel.

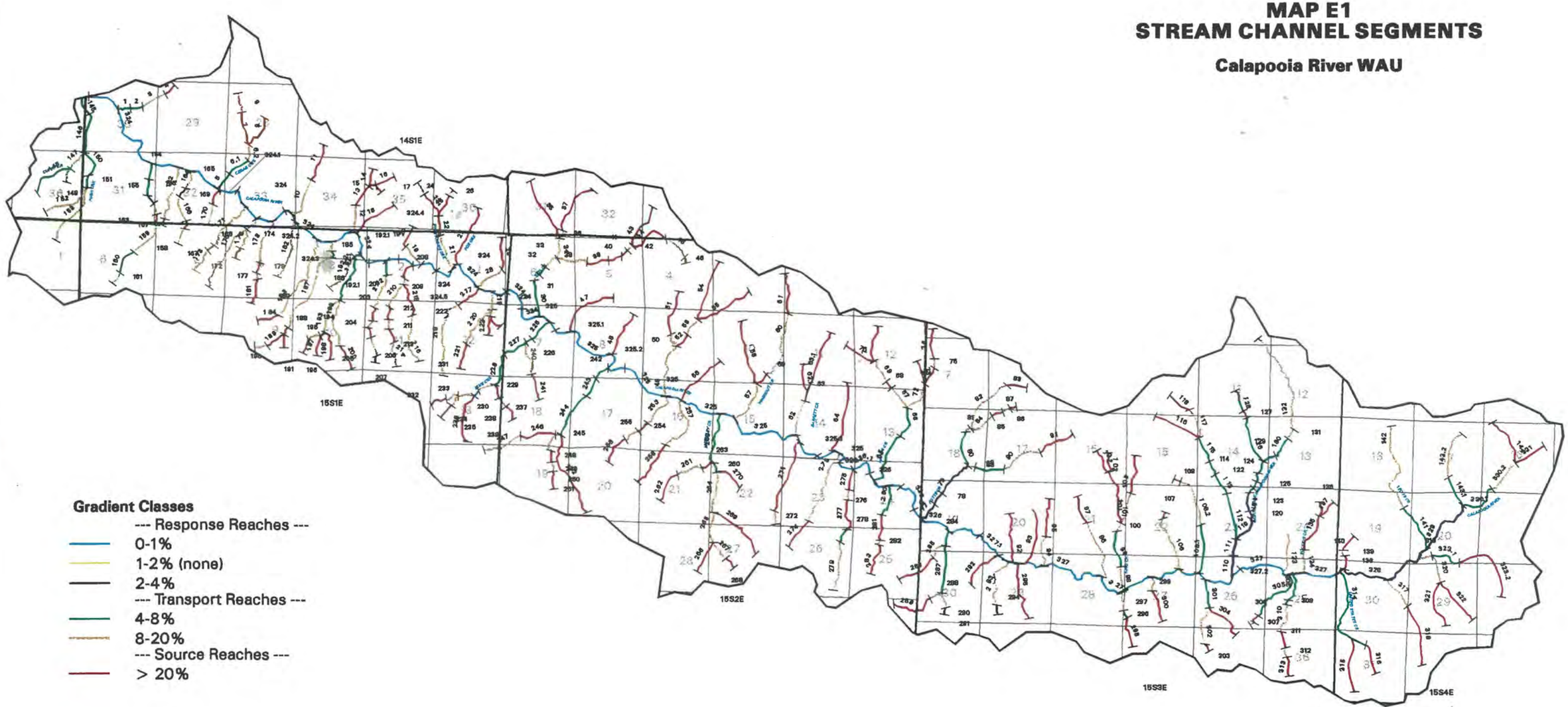
- Weyerhaeuser placed a shear boom in the Calapooia River just above Bigs Creek. It was present in 1965 and was probably used to collect any large pieces of wood floating downstream (Atkinson, pers. comm. Weyco, 1998). A loader took logs captured by the shear boom out from the north bank (Gehrman, pers. comm., 1989).

- Major instream channel work was done on the mainstem by bulldozer to protect the mainline road in the late 60s, at a spot between North Fork Calapooia Creek and King Creek (Atkinson, pers. comm., Weyco, 1998).

- Other channel impacts and fish impacts included Finley Dam, built in 1847 (10 feet high) near Crawfordsville, which blew out in the winter of 1948-49, and which was a block to migratory fish for over 100 years (downstream impacts to fish are addressed in Appendix F, Fish Habitat Assessment).

MAP E1
STREAM CHANNEL SEGMENTS

Calapooia River WAU



Gradient Classes

--- Response Reaches ---

0-1%

1-2% (none)

2-4%

--- Transport Reaches ---

4-8%

8-20%

--- Source Reaches ---

> 20%

1:90000

1 inch = 7500 feet

Map E1 Stream Channel Segments

Weyerhaeuser

DATE: 08/12/98

Evaluation of Historic Changes in Channel Morphology

Aerial photographs were viewed to determine if changes in the channel width and/or channel pattern occurred in any of the segments between 1949 and 1996. Photo coverage examined included photo years 1949, 1967, 1978, 1987 and 1996. Photo years were examined in part or in whole, depending on the resolution, flight elevation and harvest patterns of each year, for historic channel changes. **Form E2**, the Channel Condition and Disturbance worksheet, is found in Attachment E1 of this assessment.

In 1949, timber harvesting was limited to adjacent slopes of the mainstem near the bottom of the Calapooia River watershed and along larger tributaries such as Potts and King Creek. High reflectance along the channels indicate sediment inputs and some channel braiding was evident in the less confined reaches of the mainstem. In photos after 1949, typical changes that occur in channel and riparian conditions as a result of timber harvest and/or flood induced disturbances include opening of the riparian canopy, high reflectance of stream channels indicating a possible increase in fill (sediment storage) along the channel floors, and debris slide tracks indicating landslide materials delivering to the stream channels. Roads and landings extended further and higher into the watershed.

Throughout the air photo record, the tributary channels are visible only after a timber harvest. As each drainage was harvested, removal of trees occurred within the riparian area and high reflectance in air photos along the channel indicates sediment inputs and some channel braiding occurs in less confined channel reaches. In the 1996 air photo, large sediment inputs have occurred in the mainstem from debris flows issuing directly into the channel from transport and source streams. Numerous landslides and scoured tributaries are visible.

Routing

In general, the effects of the historic removal of wood and debris torrents is evident in the channels with the presence of large particle sizes and lack of morphologic complexity within the stream system. Fine sediment is quickly routed out of the watershed, except for localized areas and in the lower end of the watershed where geology and slope play a dominant role in fine sediment production and deposition. Coarse sediment is easily routed through the mountainous upper end of the watershed, and with high sheer stresses, eventually migrate downstream through the confined mainstem. Wood is routed from upstream source areas, but individual large pieces of wood are limited in field-visited reaches. Most in-channel wood that was observed was cut wood from logging debris. The recent flood of February 1996 (Figure E2) scoured many stream channels and left wood stranded high on hillslopes and channel terraces. These individual pieces may eventually be recruited, but most riparian areas have limited recruitment potential because of past harvest of riparian areas. Tree cores taken of hardwood trees lining streams which were not debris torrented during the 1996 storm event frequently dated to the 1972 and 1965 (Dec. 1964) water year storm events (Hydrology Appendix C).

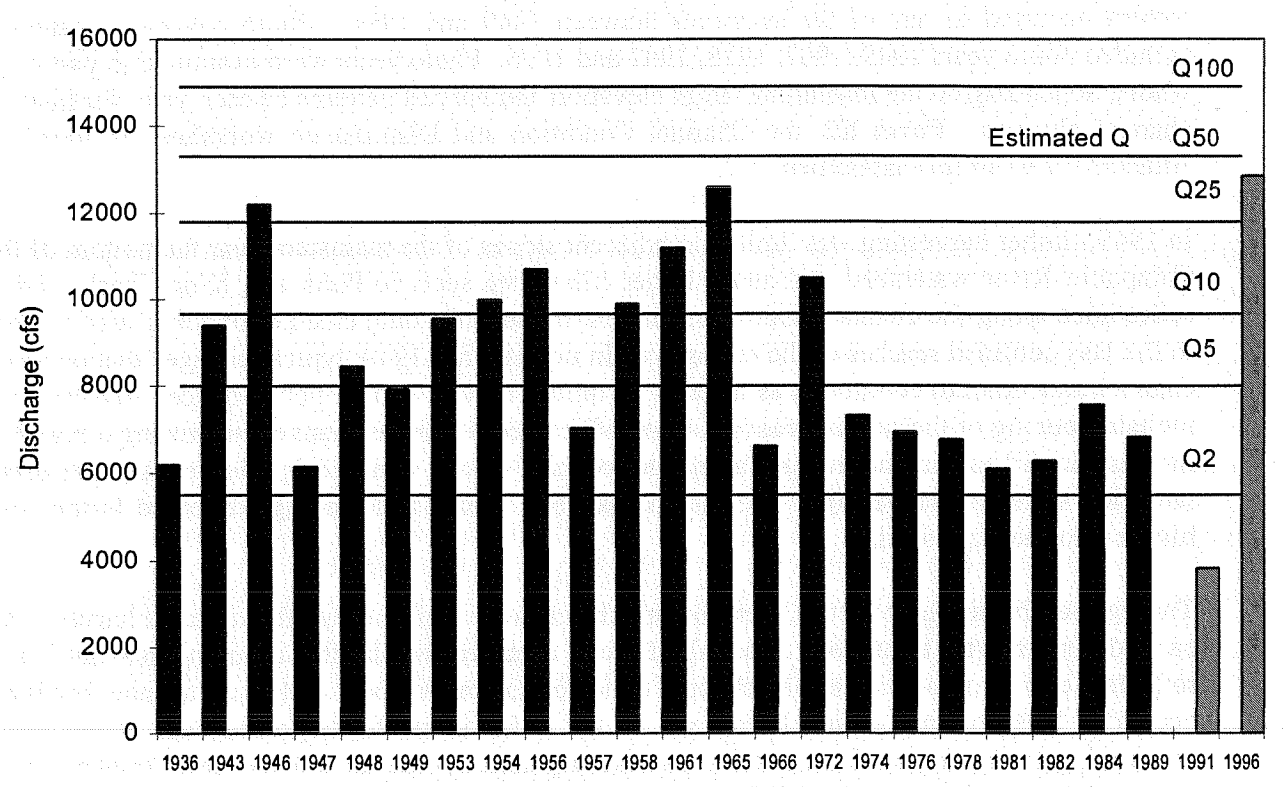


Figure E2 The instantaneous annual discharge for the Calapooia River at Holley, selected high flow years (Hydrology Appendix C).

CURRENT STREAM CHANNEL CONDITIONS

The objective of the channel field assessment is to identify and compare relationships between current channel form and historical conditions, and to evaluate response potentials of each channel type to the following factors: the volume and size of sediment in storage, the frequency and nature of channel obstructions (e.g., woody debris and boulders), and hydrologic conditions. These relationships provide the context for extrapolating similar channel characteristics to other channel segments.

Field Site Selection Criteria

To check the validity of the initial clustering of stream segments into Geomorphic Map Units, several streams were selected for reconnaissance or surveys prior to commencement of field work. Field reconnaissance and surveys were conducted intermittently by Weyerhaeuser in September and October, 1997, under low to moderate flow conditions. ODFW surveys were taken during the summer of 1991. Twelve reaches were surveyed by Weyerhaeuser (Segments 79, 96, 98, 112, 229, 243, 308, 324, 324.1, 325, 327, 328). ODFW data was useful for general survey information, but because of a difference in data collection methodologies, the ODFW data was not meaningful for some comparisons.

Woody debris tallies and measurement of channel characteristics were made within a wide range of different channel types. Observations of a reconnaissance nature were made at many other segments. Site selection was done by choosing segments within different channel gradient classes, by accessibility and for testing initial GMU designations (see Form E1, Attachment E1). **Form E3** (Attachment E1) details site selection rationale for all segments observed. Channel Assessment Field Forms (**Form E4**) are located at the back of this assessment in Attachment E2. Physical habitat measurements made by ODFW are summarized in Appendix F (Unpublished data, 1991). Data summaries and other anecdotal information collected for this assessment can be found in the relevant Geomorphic Map Unit descriptions.

CHANNEL SENSITIVITY TO CHANGES IN INPUT FACTORS

Large Wood

Bilby and Ward (1989) showed that frequency of woody debris decreases with increasing stream size in old growth forests in western Washington. The following figure (E3) compares Bilby and Ward (1989) to the current Weyerhaeuser data collection. The figure indicates that there has been a reduction in wood in the Calapooia River as compared to a natural wood loading. Reductions in wood in the Calapooia are probably related to past land-use activities (i.e., log drives, stream cleaning and mining).

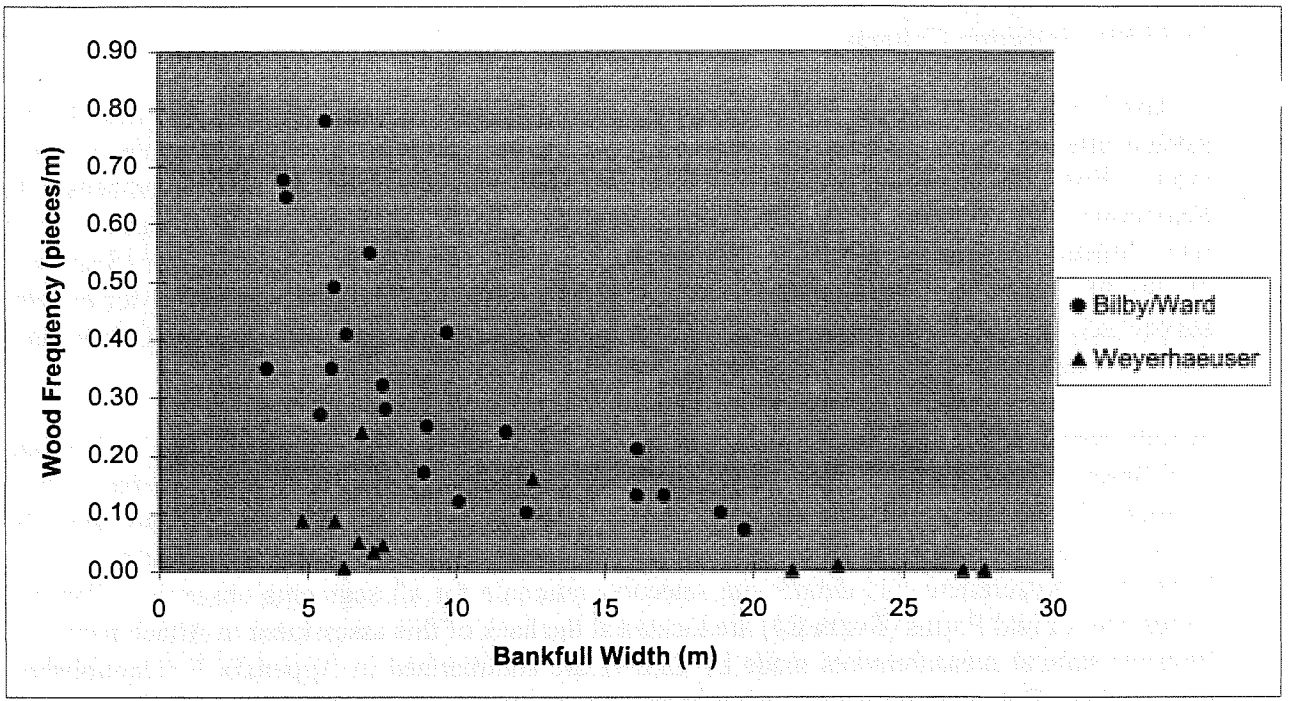


Figure E3 Bilby and Ward (1989) wood frequency (pieces/m) versus bankfull channel width (m) found in old growth forests of western Washington and wood frequency (pieces/m) in relation to bankfull channel width (m) from current Weyerhaeuser wood count surveys in the Calapooia River watershed.

Pool spacing related to wood loading in the South Fork Coos WAU, according to comparisons with Montgomery et. al., 1995, is much greater than found in old growth systems. Montgomery et. al., 1995, indicates that old growth systems show a decrease in pool spacing with increasing large wood frequency in old growth forests (Figure E4). The Calapooia River reaches have a lower large wood frequency and in some cases, a high pool spacing. Most pools are formed by coarse sediment in this system (Figure E5). This suggests that a reduction in in-stream LWD has resulted in fewer pools than might naturally exist in the surveyed reaches of the Calapooia River.

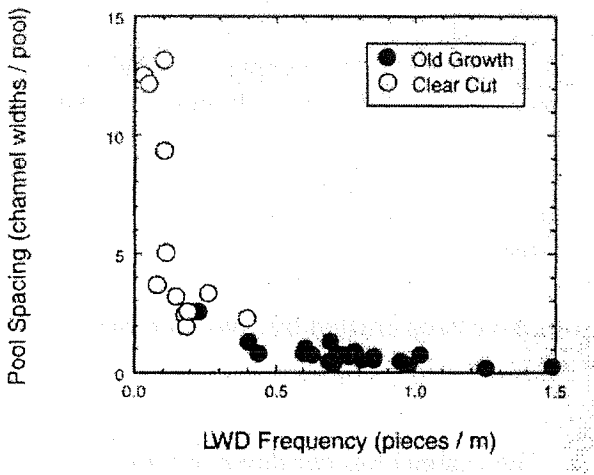


Figure E4 LWD frequency versus pool spacing for channels surveyed in previously clear-cut and old growth forests. Reproduced from Montgomery et al, 1995.

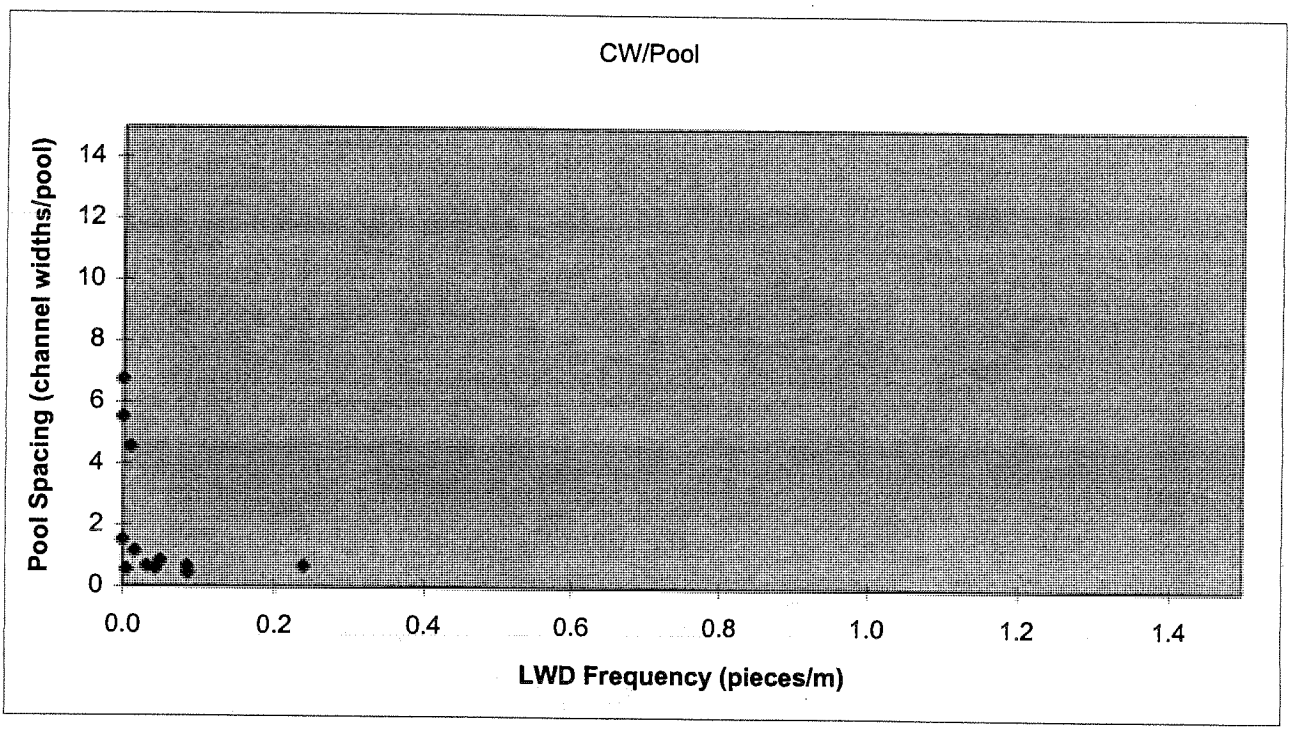


Figure E5 LWD frequency versus pool spacing for channels surveyed in the Calapooia River WAU. Boulders and or bedrock form many of the pools.

Summary

Frequency and size of large wood has decreased in stream channels as compared to old growth systems. Because of these decreases in channel roughness the following changes in channel morphology have occurred:

- pools are developed from boulders and bedrock
- pool spacing has become wider, there are fewer pools
- gravel storage and fine fraction storage has been reduced
- pool depth has decreased
- plane-bed morphologies and bedrock channels may have been created by LWD removal

Entrenchment

The mainstem of the Calapooia River is entrenched. The channel has cut down and incised into the valley bottom so that it no longer is connected to a higher terraced floodplain (Figure E6). Bankfull is evident as much as two and sometimes three meters below the floodplain at the lower end of the watershed.

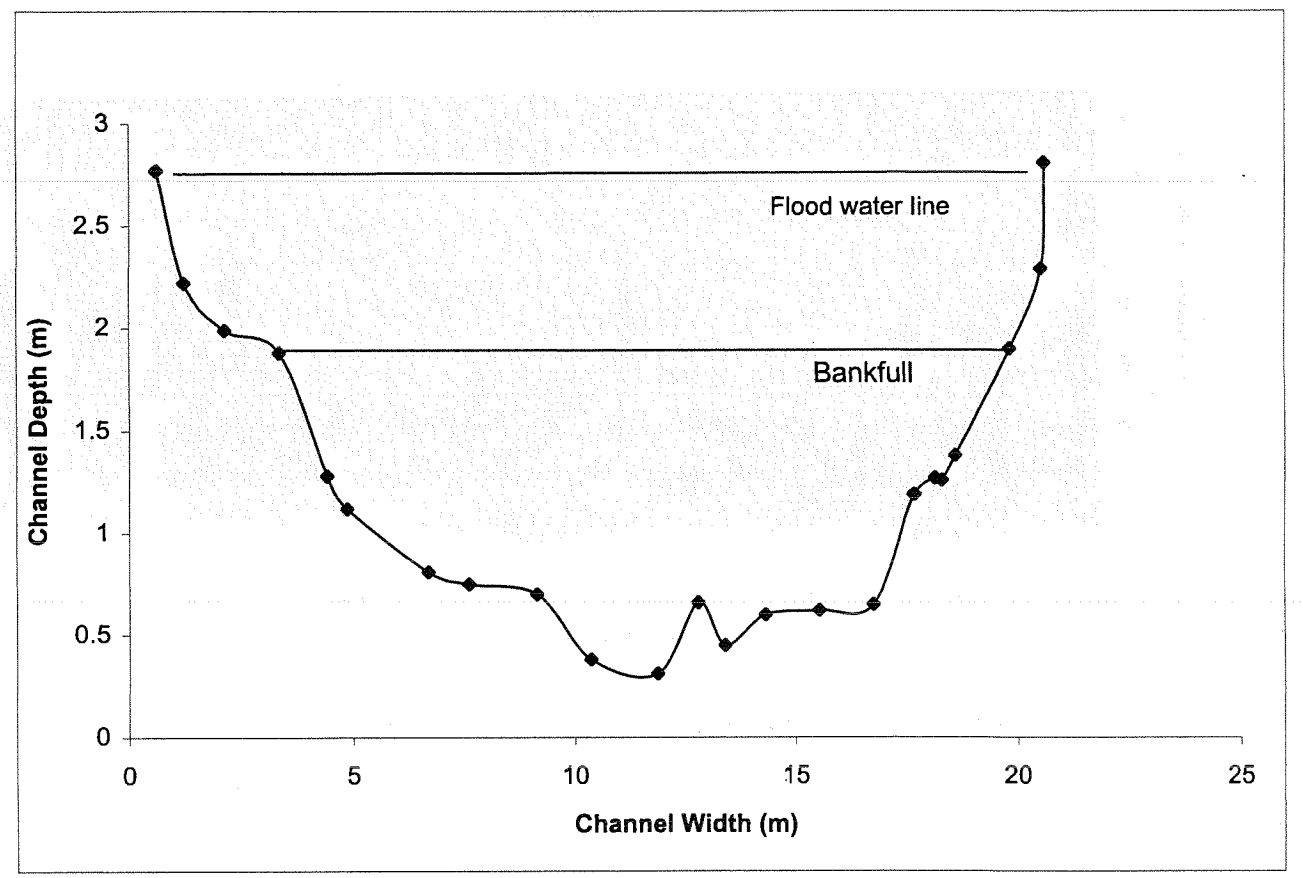


Figure E6 This cross-section was measured downstream of U.S. Creek in segment 327. The profile is typical of the confined mainstem reaches of the Calapooia River. Bankfull is entrenched within a deeper set channel, frequently incised into bedrock.

Another indication of entrenchment is that a significant drop-off occurs at the mouths of the tributaries throughout the system. One to two meter cascading drops occur in, but are not limited to, U.S. Creek, Potts Creek, Hands Creek, Blue Creek and Bigs Creek. Entrenchment may have been induced by log drives and the removal of debris jams which would have lowered base level, lowered roughness values, and increased boundary shear stresses leading to export of sediment and incision.

There are loosely confined segments along the mainstem that are not entrenched. At these reaches, alluvial deposits are evident in the channel-bank with imbricated layers of sand, gravel and cobble.

GEOMORPHIC MAP UNITS

The discussion of current stream channel conditions and sensitivities is organized by Geomorphic Map Units (GMUs). Each GMU includes the stream channel and adjacent landforms that contribute to its character. For example, hillslopes from streamside to ridgetop control, in part, the volume and rate of sediment, wood, and water inputs to the channel and are therefore considered part of the GMU. The GMUs encompass stream segments inferred to have similar:

1. channel characteristics
2. sensitivities to woody debris, peak flow, and sediment inputs
3. surrounding geomorphic terrain which can influence bedforms and valley bottom character

To aid in understanding the spatial relationship of these segment clusters, **Map E2** shows the spatial extent of each GMU and Figure E7 displays each GMU, its drainage, gradient and confinement.

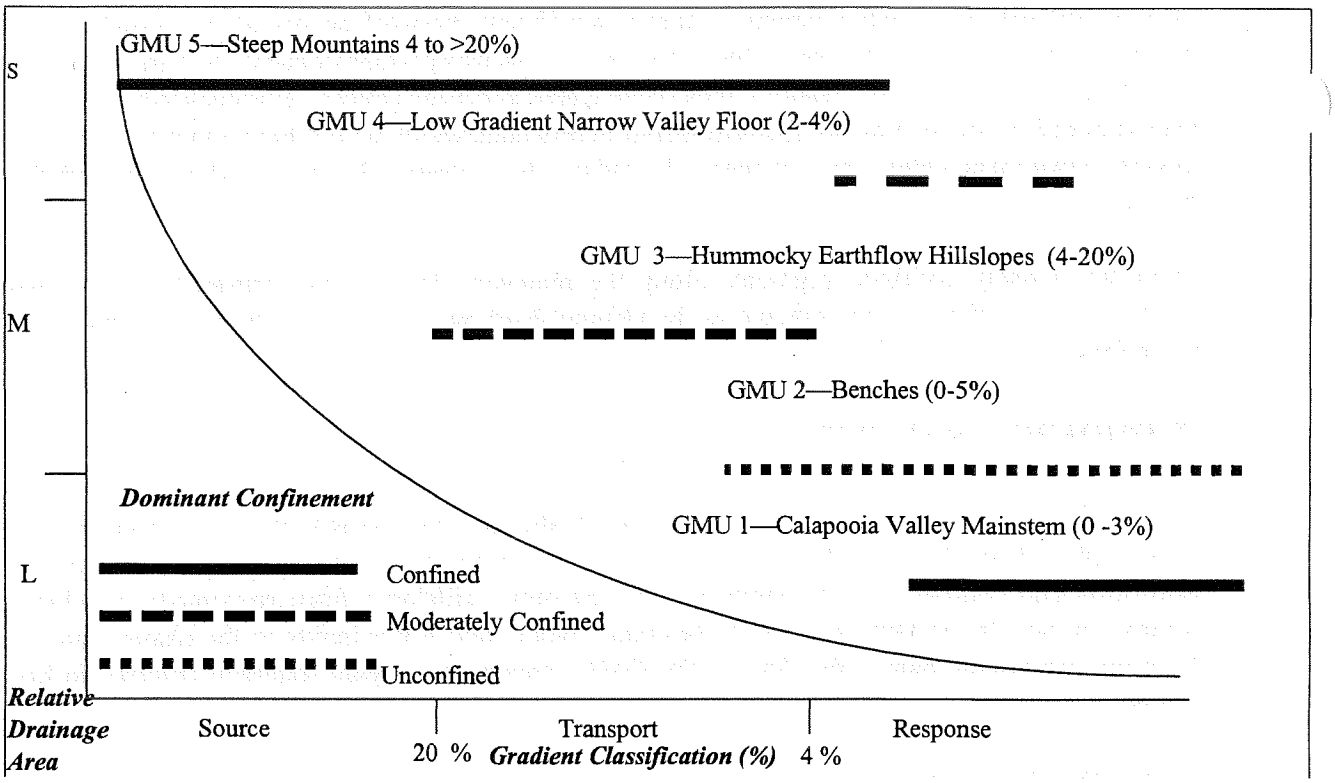
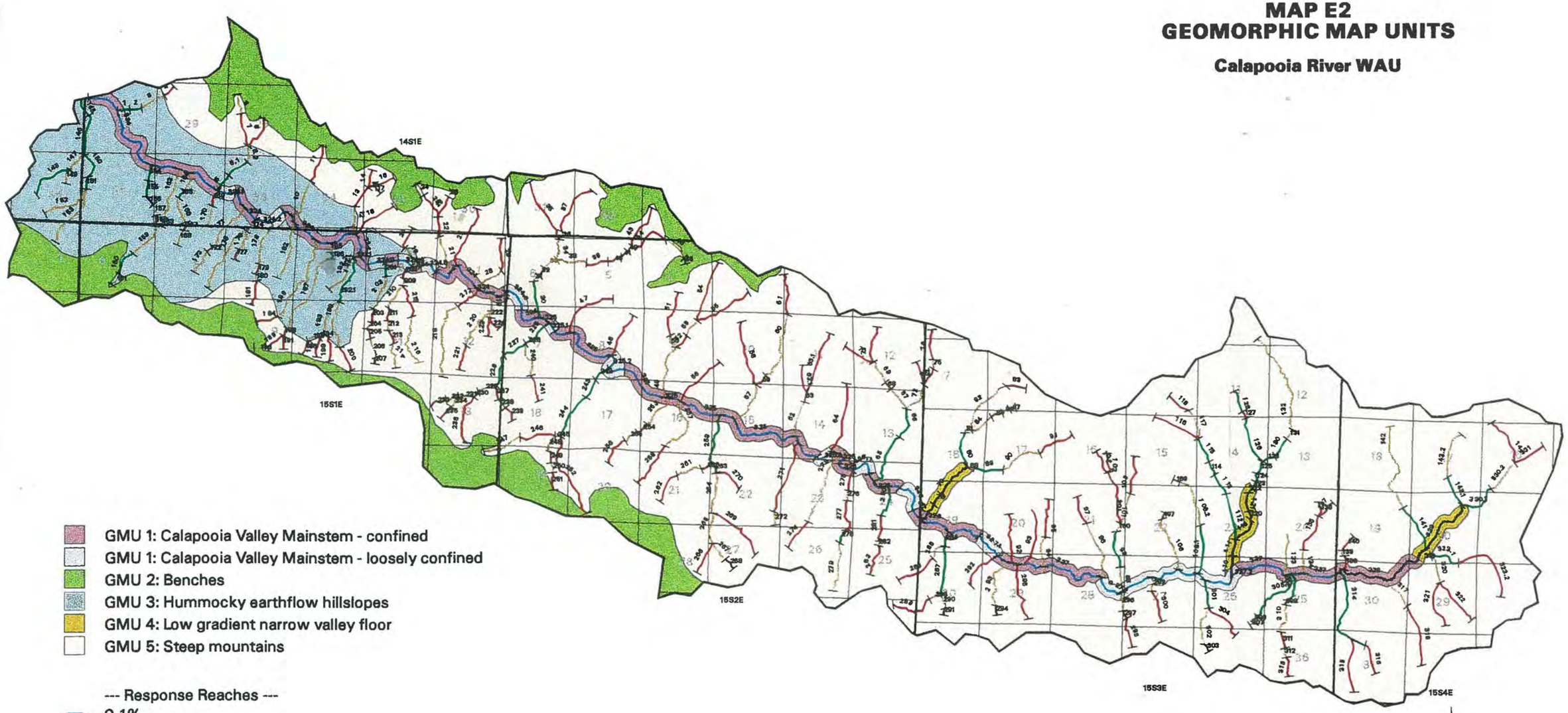


Figure E7 Illustration of five geomorphic map units found in the Calapooia WAU showing relative drainage size (small, medium, and large), gradient classification and confinement.

The five GMUs are illustrated in Figure E8 and individual tables (Tables 2,3,4,5,6; **Forms E6**) present the Geomorphic Unit description and sensitivity justifications.

MAP E2
GEOMORPHIC MAP UNITS

Calapooia River WAU



- GMU 1: Calapooia Valley Mainstem - confined
- GMU 1: Calapooia Valley Mainstem - loosely confined
- GMU 2: Benches
- GMU 3: Hummocky earthflow hillslopes
- GMU 4: Low gradient narrow valley floor
- GMU 5: Steep mountains

--- Response Reaches ---
- 0-1%
- 1-2% (none)
- 2-4%

--- Transport Reaches ---
- 4-8%
- 8-20%

--- Source Reaches ---
- > 20%

1:90000

1 inch = 7500 feet

Map E2 Geomorphic Map Units

Weyerhaeuser

DATE: 08/12/98

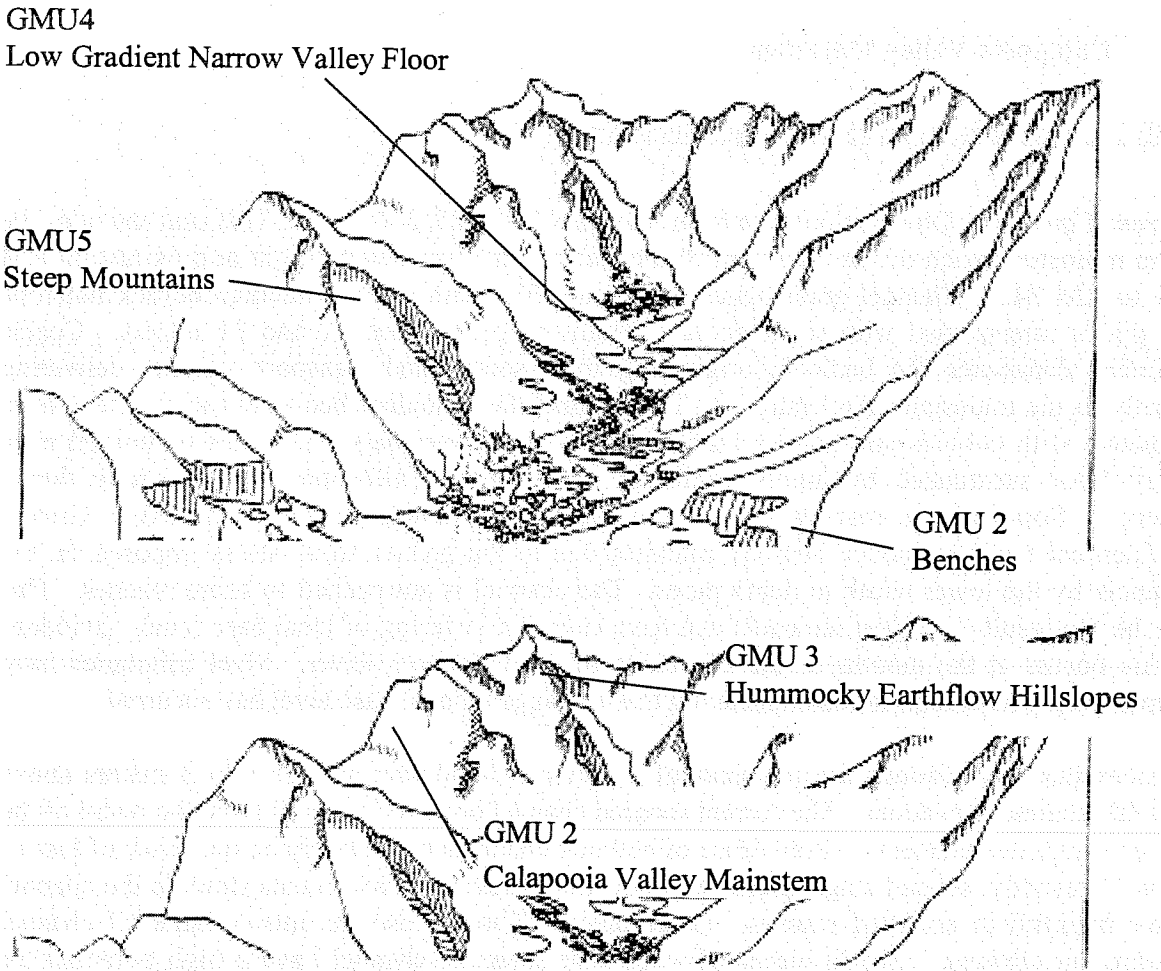


Figure E8 Illustration of the five geomorphic map units (GMUs) found in the Calapooia River watershed.

Descriptions of channel characteristics are separated into current observed conditions and expected conditions. Expected condition is dependent upon the current channel condition but reflects the potential for future change. Changes in watershed processes and channel condition occur as a result of natural or land-use effects and channels may or may not have had recent disturbances. Sensitivities are based on the potential for future change and the expected channel response given the channel characteristics and considering the magnitude, frequency, and distribution of the processes affecting each input factor.

(1) Calapooia Valley Mainstem

GMU 1 Characteristics and Sensitivities Summary

Current Condition: Observation/Data from segments 324, 325, 326, 327.2. This unit includes the entire mainstem reach of the mainstem of the Calapooia River beginning at approximately RM 48.5 to RM 74.5. Channel gradients are between 0-3%, with reaches having bedrock outcrops and glides interspersed with scour pools. Widths range between 11 and 31 meters. Coarse sediment dominates the bedload, originating from source and transport streams delivering directly to the mainstem (Appendix A). The channel has a boulder bed-load (up to 2 to 3 m in diameter) with cobbles and gravels lining margins and gravel bars. The unit is defined by a valley floor surrounded by highly confining steep forested hillslopes with a single thread channel. Some of the reaches are more moderately confined (loosely confined). Greater confinement tends to induce bedrock channels due to the greater shear stress imposed on the channels by the lower width to depth ratios. The channel is entrenched in some reaches. This may be the result of logjam removals that have caused a lowering of local base level. Evidence of this occurs at the mouths of the tributaries of the Calapooia River. Most tributaries have steeper drop-offs at their mouths indicating that a change in local base level has occurred.

Terraces that have formed are remnants of a previous floodplain and lie 1 to 3 meters above bankfull channel elevations. The current scoured channel bed is considered to be the result of the loss of roughness elements. Prevalence of bedrock channels may largely be the result of loss of wood. Presently, several single pieces of wood from previous flood events straddle the channel above bankfull in confined reaches. Large pieces of wood also lie outside bankfull channel margins on terraces. Single pieces of wood that enter the channel have a high potential for floatation and export to lower reaches during floods due to high discharge energy. Currently large wood recruitment and shade ratings are low for the mainstem Calapooia River (Appendix D).

Expected Channel Characteristics:
Sediment: The channel in this GMU is a direct depository for debris torrents that propagate from upstream source and transport reaches. Debris torrents occur episodically from upstream tributaries particularly GMU 5. Sediment retention occurs primarily in the more loosely confined reaches where shear stresses are reduced and sediment deposits in gravel bars. Boulders and meander bends also create sediment retention reservoirs in the more confined reaches. The large drainage area, meaning more stream power with the absence of roughness, may predispose this unit to having bedrock reaches. Bedrock glides are expected to occur intermittently in the GMU as geologic knickpoints. Transport capacity would exceed sediment supply in these reaches because of high shear stresses. Long term sediment storage, either as infrequently mobilized overbank deposits or, more frequently, entrained gravel and sand bars, is therefore limited to localized reaches where increases in valley width, meander bends and/or decreases in slope can encourage alluvial deposition. The stream channel is too wide for single pieces of wood to act effectively in storing sediment except locally, but debris jams could set up and provide an upstream sediment retention area.

Suspended sediment loads readily flush through GMU 1. Transport capacities are high, and most sediment inputs, excluding large boulders, are rapidly routed through unobstructed reaches. Textural patches in the sand size class exist on gravel bars and along channel margins where streamflow patterns induce deposition. Backwater areas in forced-pool reaches would be the most sensitive to fine sediment.

Water: This channel reach has a large drainage area and experiences very high peak discharges. There is little floodplain area available to dissipate energy during high flood stage. Peak flows can modify the channel by scouring pools, moving gravel bars and developing new side channels in the loosely confined areas. In 1996 the Oregon Department of Fish and Wildlife undertook an assessment resurveying 1991 reaches after a 1996 flood event. Their report indicates that a moderate impact of channel modification occurred in 15% of the 1000m reach they resurveyed and 2% of the reach had a high impact in the form of torrent scour (Jones et al, 1998).

Wood: Historically, large in-stream woody debris may have played a more significant role in GMU 1, particularly in the form of debris jams. Fallen trees wedged between boulders could create debris jams and trees falling top-down into the side of the channel could create riffles and provide shelter from fish predators. Overhanging trees and snags would provide cover and shelter for migrating fish. Fallen trees may affect local waterflow patterns and turbulence may affect the sedimentation patterns. Table E2 lists the characteristics and sensitivities to input variables.

Table E2 Characteristics and sensitivities of GMU 1 (Form E6).

GMU 1 Calapooia Valley Mainstem		
Characteristics		
Segments: 324,324.1,324.2,324.3,324.4,324.5,324.6,325,325.1,325.2,325.3,326,326.1,326.2,327,327.1,327.2,328		
Dominant Stream Morphology: 0-3%, response reach, bedrock forced pool riffle and scour pools, (removal of roughness has created plane beds and currently bedrock is evident) ***Dominant Confinement:*** Moderately (loosely) to tightly confined—frequently entrenched ***Dominant Bedload:*** Coarse, fines stored where roughness elements provide formation of sediment reservoirs ***Controlling Geology:*** Sedimentary rocks, tuffs and basalts ***Geomorphic Rationale:*** Mainstem with bedrock steps and scour pools are interspaced with boulder and cobble riffles, 11-31 m wide ***Salmonid Species:*** All species ***Habitat Use:*** Anadromous migration corridor, spawning and rearing for all species ***Land Use Influence:*** Adjacent timber harvest, roads, log driving, stream cleaning, railroad, mining		
GMU 1 Sensitivities		
Input	**Sensitivity**	**Justification**
Coarse sediment	Low in tightly confined Moderate in loosely confined	• Stream energy appears sufficient to carry sediment load • Confinement limits planform shifts from aggradation; however, temporary storage can occur in loosely confined reaches • High deliveries of coarse bedload from upstream source and transport reaches are migrating through GMU 1 • Observed reaches are scoured to bedrock • Gravels well sorted
Fine sediment	Low in tightly confined Moderate in Loosely confined	• High energy, rapid transport through tightly confined reaches, deposition in velocity shadows • Observations that system is processing fines in tightly confined reaches • Fines are evident on margins and gravel bars of loosely confined reaches and fine sediment deposition is possible in localized areas
Peak flow	High in tightly confined Moderate in loosely confined	• Limited potential for planform shift, too confined, bed and banks resistant to erosion, but less confined reaches may respond • Current conditions include pool scour; however, with bank proximal LWD and large boulder roughness, pool scour would decrease. Debris floods possible during floodstage • Bedrock channel present indicating scour • Post '96 Flood study by ODFW indicates channel modification and torrent scour occurred during flood event
LWD	Moderate	• In some places channel widths are 11 – 31 m allowing single pieces to lodge and span channel • Wood deposits are present on terrace/floodplain areas, not in channel • Bank erosion evident, wood needed for bank protection • Snags and tightly wedged debris jams are present and obstruct flow, trap sediment and create pools; pool formation by wood appears on a limited basis • Important as side complexity feature/holding cover for fish and bank protection • Low wood recruitment and low shading cited in Appendix D along the mainstem • High potential for floatation
Catastrophic	Moderate	• Debris flows do not originate in these reaches, but sediment is directly routed into this GMU from upstream transport and source reaches and adjacent tributaries (Appendix A). • Locally, inputs would cause pool filling and gravel bar formation • Dam break floods may occur locally with current debris jam loading

(2) Benches

GMU2 Characteristics and Sensitivities Summary

Current Condition: Observations/No quantative data was collected from these segments. This unit includes the streams within the benches along the lower half of the watershed. Channel gradients are between 0-5%, and widths are between 3 to 5 meters. Because of low gradients and small drainage areas, beaver populations are able to establish themselves in this GMU. The channels are mostly unconfined but moderate confinement occurs in steeper gradients with a step-pool morphology.

Expected Channel Characteristics:
Sediment: This GMU receives few to no inputs from landslides. Coarse sediment inputs are limited. Transport capacity is low, and because of small drainage areas and low slopes fine sediment deposits readily. Sediment input sources include bank erosion and road surface erosion.

Water: The drainage area within this unit is small and peak flows are small. Wider floodplains and beaver ponds aid in dissipating stream energy.

Wood: Historically, large woody debris played a large role in GMU 2. Low discharge and low coarse sediment inputs result in wood playing an important role in pool formation.

Table E3 Characteristics and sensitivities to input variables of GMU 2 (Form E6).

GMU 2 Benches		
Characteristics		
Segments: No segment numbers found in these reaches		
Dominant Stream Morphology: 0-5% pool riffle and step pool ***Dominant Confinement:*** Unconfined to moderate confinement ***Dominant Bedload:*** Gravel ***Controlling Geology:***Basaltic lava flows and andesitic rocks ***Geomorphic Rationale:*** Small sized, low gradient tributaries, with beaver ponds ***Salmonid Species:*** None ***Habitat Use:*** NA ***Land Use Influence:*** Adjacent timber harvest		
GMU 2 Sensitivities		
Input	**Sensitivity**	**Justification**
Coarse sediment	Low	• Coarse sediment could locally cause aggradation and channel braiding with excess upstream inputs, but coarse sediment is not available from upstream sources
Fine sediment	High	• Low gradients capture fines and may cause pool filling • Bank erosion noted along narrow alluvial reaches • Beaver ponds store fines • High fines are present in the geologic material
Peak flow	Low	• Effects from increased peak flows dampened by wider floodplain • Smaller drainages have lower stream power
LWD	High	• Low stream power, pools easily forced by obstructions • High fines in geologic material, wood is primary pool former • Function as bank protection • Channel widths are 3 – 5 m allowing single pieces to lodge and span channel • Currently large wood works effectively to obstruct flow, trap sediment and create pools
Catastrophic	Low	• Inputs from upstream source reaches and tributaries are not available

(3) Hummocky Earthflow Hillslopes

GMU 3 Characteristics and Sensitivities Summary

Current Condition: Observations/No quantatative data collected. GMU 3 is comprised of small tributaries of the Calapooia River that flow through ancient earth flows. They have gradients between 4-20%, which are moderately to tightly confined. The streams in this unit are defined by the undifferentiated tuffaceous sedimentary rocks, tuffs, and basalts which they flow through. The streams have a limited amount of coarse sediment available to them. The channels range from pool-riffle to step-pool and cascade morphology with cobble/boulder roughness elements within the channel, but wood is a primary pool former. Because of lower gradients, transport capacity of coarse sediment is low. Because of the geologic materials, fine sediment is abundant. Stream banks are composed of colluvial fine sediments.

Expected Channel Characteristics:
Sediment: Historically, debris torrents have not occurred in GMU 3. Although catastrophic debris flows are unlikely to propagate through GMU 3, deliveries from adjacent tributaries to this low gradient stream unit are possible. Large inputs of immobile boulders from hillslopes are limited particularly in areas of wider floodplain, which intercepts some of the sediment. Dam–break floods could route through the steeper portions of GMU 3, but none have been documented. No quantitative measurement of sediment entrainment thresholds are available; however, it is fair to assume that much of the boulder–sized material is immobile in this system. Because coarse sediment is less mobile in this reach, high inputs could result in aggradation and pool filling.

Fine sediment deposits easily in GMU 3 because of low gradient reaches and because the geology delivers a high natural background rate. GMU 3 has response reaches where deposits of fine sediment are to be expected, particularly with roughness elements. Fine sediment is readily available from bank erosion.

Water: Peak flows and or frequent high sediment transporting discharges can potentially cause bank erosion in this GMU. Noncohesive banks can widen during peak flows leading to planform changes in channel morphology.

Wood: Woody debris would readily trap bedload and force deeper pools. Large trees recruited from bank erosion and lodged in jams would sort and store storm-derived coarse bedload and create backwater areas. Despite lower gradients, peak flow energy causes hydraulic scour and pool formation. Wood also functions to protect banks and create flow conditions, that keep the gravel clean. A decrease in the supply of LWD has resulted in significant morphological changes such as: pool loss, increased effective shear stress, and conversion to plane-bed morphology. Table E4 lists the characteristics and sensitivities to input variables.

3. Hummocky Earthflow Hillslopes

GMU 3 Characteristics and Sensitivities Summary

Current Condition: Observations/No quantatative data collected. GMU 3 is comprised of small tributaries of the Calapooia River that flow through ancient earth flows. They have gradients between 4-20%, which are moderately to tightly confined. The streams in this unit are defined by the undifferentiated tuffaceous sedimentary rocks, tuffs, and basalts which they flow through. The streams have a limited amount of coarse sediment available to them. The channels range from pool-riffle to step-pool and cascade morphology with cobble/boulder roughness elements within the channel, but wood is a primary pool former. Because of lower gradients, transport capacity of coarse sediment is low. Because of the geologic materials, fine sediment is abundant. Stream banks are composed of colluvial fine sediments.

Expected Channel Characteristics:
Sediment: Historically, debris torrents have not occurred in GMU 3. Although catastrophic debris flows are unlikely to propagate through GMU 3, deliveries from adjacent tributaries to this low gradient stream unit are possible. Large inputs of immobile boulders from hillslopes are limited particularly in areas of wider floodplain, which intercepts some of the sediment. Dam–break floods could route through the steeper portions of GMU 3, but none have been documented. No quantitative measurement of sediment entrainment thresholds are available; however, it is fair to assume that much of the boulder–sized material is immobile in this system. Because coarse sediment is less mobile in this reach, high inputs could result in aggradation and pool filling.

Fine sediment deposits easily in GMU 3 because of low gradient reaches and because the geology delivers a high natural background rate. GMU 3 has response reaches where deposits of fine sediment are to be expected, particularly with roughness elements. Fine sediment is readily available from bank erosion.

Water: Peak flows and or frequent high sediment transporting discharges can potentially cause bank erosion in this GMU. Noncohesive banks can widen during peak flows leading to planform changes in channel morphology.

Wood: Woody debris would readily trap bedload and force deeper pools. Large trees recruited from bank erosion and lodged in jams would sort and store storm-derived coarse bedload and create backwater areas. Despite lower gradients, peak flow energy causes hydraulic scour and pool formation. Wood also functions to protect banks and create flow conditions, that keep the gravel clean. A decrease in the supply of LWD has resulted in significant morphological changes such as: pool loss, increased effective shear stress, and conversion to plane-bed morphology. Table E4 lists the characteristics and sensitivities to input variables.

Table E4 Characteristics and sensitivities to input variables in GMU 3 (Form E6).

GMU 3 Hummocky Earthflow Hillslopes		
Characteristics		
Segments: 1,2,3,5,6.1,6.2,10,12,19,145,146,147,148,149,150,151,152,153,154,155,156,157,158,159,160,161,162,163,164,165,166,167,168,169,170,171,172,173,174,175,176,177,178,179,180,182,183,185,186,187,192,192.1,192.2,193,194,195,199,201,202		
Dominant Stream Morphology: 4-20% step pool and cascade reaches ***Dominant Confinement:*** Moderate to tightly confined ***Dominant Bedload:*** Gravel ***Controlling Geology:*** Sedimentary rocks, tuffs and basalt; soils have a higher component of clay ***Geomorphic Rationale:*** Small-sized tributaries, alluvial terraces localized in reaches, high fine sediment source from deeply weathered parent materials ***Salmonid Species:*** Cutthroat trout. Steelhead use possible in lower ends ***Habitat Use:*** All life history phases of cutthroat trout ***Land Use Influence:*** Adjacent timber harvest		
GMU 3 Sensitivities		
Input	**Sensitivity**	**Justification**
Coarse sediment	Moderate	• Coarse sediment could locally cause aggradation and channel braiding with excess upstream inputs, but upstream inputs are limited • Low gradients, smaller drainages equal lower stream powers which do not process coarse sediments well and could result in pool filling, aggradation, gravel bar formation
Fine sediment	High	• Low gradients capture fines and may cause pool filling • Bank erosion noted along narrow alluvial reaches • Pool filling noted • Geologic influence: streams flow through earth flow materials, soils have high clay contents
Peak flow	Moderate	• Bank erosion possible in localized areas, but smaller drainages have lower stream power and therefore less power to erode banks • Wood dampens peak flow effects • Smaller substrate sizes are prone to entrainment and pool filling
LWD	High	• Low stream power, pools easily forced by obstructions • High fines in geologic material, wood is primary pool former • Function as bank protection • Channel widths are 3 – 5 m allowing single pieces to lodge and span channel • Currently large wood works effectively to obstruct flow, trap sediment and create pools
Catastrophic	Low	• Inputs from upstream source reaches and tributaries are possible, but not present historically; dam break floods might propagate through some reaches

(4) Low Gradient Narrow Valley Floor

GMU 4 Characteristics and Sensitivities Summary

*Current Condition:*Observations/Data from segments 78, 323.1. This unit includes the lower reach of Potts, North Fork Calapooia and the headwaters of the Calapooia River mainstem. Channel gradients are between 2 and 4%. Reaches have bedrock glides and plane beds interspersed with pool-riffles, some step-pools. The unit is characterized by moderate and tightly confined channels. Greater confinement tends to force bedrock beds due to the greater shear stress imposed on the channels by the lower width to depth ratios. Smaller source and transport channels in GMU 5 feed these reaches. The channels are vulnerable to debris torrents (Appendix A) and large wood recruitment from stream adjacent conifers is low in some reaches (Appendix D).

Expected Channel Characteristics:

Sediment: Catastrophic events, generally dam-break floods, can propagate through this response reach. Coarse and fine sediment is readily delivered to these streams. Bank erosion releases sediment from terraced and colluvial channel margins in confined reaches. Transport capacities are high due to larger drainage areas and most sediment inputs, excluding large boulders, are rapidly routed through unobstructed reaches. Fine sediment is rapidly flushed through the system because of a lack of roughness from large wood. Debris jams can create sediment retention reservoirs in this GMU.

Water: Because of confinement, increased discharge may result in flow width and depth expansion with bank cutting. In areas of confinement, pool scour is likely.

Wood: These streams are very sensitive to loss of large roughness elements. Large roughness elements effectively store sediment, creating backwater pools and low velocity shadows because of small channel size, high sediment supply and low gradients. Most pools are currently created by bedrock forced flow convergence (scour pools). Woody debris is important as a roughness element, and is a significant pool former when present. Large single pieces, as well as jams, can be stable and functional in this zone. Table E5 lists the characteristics and sensitivities to input variables.

Table E5 Characteristics and sensitivities to input variables of GMU 4 (Form E6).

GMU 4 Low Gradient Narrow Valley Floor		
Characteristics		
Segments: 77,78,79,110,111,119,120,121,329		
Dominant Stream Morphology: 2-4% response reach, pool riffle (plane bed) ***Dominant Confinement:*** Moderate to tightly confined ***Dominant Bedload:*** Gravel and cobbles ***Controlling Geology:*** Sedimentary rock, tuffs and basalt ***Geomorphic Rationale:*** Moderate sized response reach, 5-8 m wide, which experiences high flows and LWD routed from upstream. Debris jams are possible ***Salmonid Species:*** Steelhead/rainbow trout in tributary reaches of Lower North Fork and Potts Creek, Cutthroat trout throughout ***Habitat Use:*** Spawning and rearing habitat, all life history phases of cutthroat trout ***Land Use Influence:*** Adjacent timber harvest, roads, stream cleaning		
GMU 4 Sensitivities		
Input	**Sensitivity**	**Justification**
Coarse sediment	Moderate in moderately confined Low in tightly confined	• When tightly confined there is limited planform shift, however large inputs of coarse sediment could result in a temporarily braided channel in more loosely confined reaches • Plane bed morphology, 3% gradients, indicate stream energy is sufficient to carry sediment load • High deliveries of coarse bedload from upstream source and transport reaches are migrating through GMU • Gravels well sorted • Bedrock reaches observed in tightly confined reaches
Fine sediment	Moderate	• 2 to 4% gradients rapidly transport fines downstream but fines are present in velocity shadows and in channel margins
Peak flow	High	• Coarse alluvial banks are available for erosion, bank erosion along meander bends is evident • Pool scour is likely, however with increasing roughness (LWD) pool scour could decrease
LWD	High	• Single large pieces may form pools • Pools are forced by LWD • Function as bank protection • Channel width varies, averaging 5-8 m • Large wood was observed providing roughness and creating upstream aggradation, creating pools and changing channel planform
Catastrophic	Moderate	• Low gradient is not conducive to debris flows but can receive them and become a debris flood during floodstage • Debris floods could occur, but could be decreased under conditions when obstructions such as large conifers line the riparian area

(5) Steep Mountains

GMU5 Characteristics and Sensitivities Summary

Current Condition: Observations/Data from segments 30, 49, 56, 57, 78, 95, 96, 98, 112, 138, 225, 243, 259, and 308. Gradients in GMU 5 are generally 4 to greater than 20%. These are transport and source reaches with step-pool to cascade morphologies. Channels are confined between steep hillslopes and bedrock walls. Stable bed-forming particle sizes make cascade channels resilient to alterations in sediment supply or discharge. Channel substrate alternates between bedrock and mobile colluvial bed surfaces. Waterfalls become more numerous toward tributary headwaters. This unit incorporates source segments (>20% gradient) in tributary headwaters as well as lesser sloped transport stream segments. Fluvial form is generally weak and colluvial processes frequently dominate channel character. Debris flows and dam break floods have scoured stream channels in this GMU (Appendix A). Large wood recruitment and shade are considered low in many of GMU 5 stream reaches (Appendix D).

Expected Channel Characteristics:
Sediment: Landslide delivery and remobilization of colluvium and alluvium in storage along the streams occurs episodically. Debris torrents originate in this GMU and route through lower gradient reaches, typically as dam-break floods. Sediment of mixed sizes is delivered directly to the mainstem (GMU 1) from these transport reaches. Colluvial rockfall and erosion from steep stream adjacent hillslopes is common in this steep mountainous zone and provides important boulder roughness to the channels. Transport capacities are high and most sediment inputs, excluding large boulders, are rapidly routed through unobstructed reaches. Burial of cascade channels by debris flow deposition is generally short-lived, as these high-energy channels excavate rapidly. With decreases in discharge, a decrease in the average grain size is likely to occur, but bed-forming cobbles and boulders remain essentially static. Fine sediment is rapidly routed through this GMU.

Water: Because of tight confinement, the width and depth of the channels respond rapidly to high flows by overflowing their resilient banks. Peak flows generally do not make significant bed roughness changes.

Wood: Debris jams are present at constrictions but because of tight confinement, wood does not play an important role in channel morphology except where the jams have created large sediment deposition areas in lower gradients (<8%). Steep gradients and tight confinement lead to dam-break floods and scour of the bed channel. Single pieces of wood wedged between boulders create stairsteps, but boulders are more likely to provide this function. Table E6 lists the characteristics and sensitivities to input variables.

Table E6 Characteristics and sensitivities to input variables in GMU 5 (Form E6).

GMU 5 Steep Mountains

Characteristics

Segments:
4,7,8,9,11,13,14,15,16,17,18,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100,101,102,103,104,105,106,107,108.1,108.2,109,112,113,114,115,116,117,188,122,123,124,125,126,127,128,129,130,131,132,133,134,135,136,137,138,139,140,141,142,143,143.1,143.2,144,181,184,188,189,190,191,196,197,198,200,203,204,205,206,207,208,209,210,211,212,213,214,215,216,217,218,219,220,221,222,223,224,225,226,227,228,229,230,231,232,233,234,235,236,237,238,239,240,241,242,243,244,245,246,247,248,249,250,251,252,253,254,255,256,257,258,259,260,261,262,263,264,265,266,267,268,269,270,271,272,273,274,275,276,277,278,279,280,281,282,283,284,285,286,287,288,289,290,291,292,293,294,295,296,297,298,300,301,302,303,304,305,306,307,308,309,310,311,312,313,314,315,316,317,318,319,320,321,322,323.1,323.2,330.1,330.2,331

Dominant Stream Morphology: 4 to >20%, transport reaches, coarse bedded step-pool and cascade morphology
Dominant Confinement: Tightly confined
Dominant Bedload: Gravel, cobble
Controlling Geology: Sedimentary rock, tuffs and basalt
Geomorphic Rationale: Moderately sized tributary channels with boulder forced-pools interspaced with bedrock, recorded widths range between 4.2 – 8.5 m. Debris flows are frequently routed as dam break floods into lower reaches. Debris jams currently create lower gradient reaches
Salmonid Species: Cutthroat trout, steelhead in lower U.S. Creek and maybe other tributaries
Habitat Use: All life history phases of cutthroat trout, some steelhead spawning and rearing
Land Use Influence: Adjacent timber harvest, roads

GMU 5 Sensitivities

Input	Sensitivity	Justification
Coarse sediment	Low	• Moderate confined areas experience planform shifts from aggradation; temporary storage can occur, filling pools • Boulders line margins of channel and stream energy appears to be sufficient to carry sediment load • High deliveries of coarse bedload from upstream source and transport reaches are migrating through GMU 5
Fine sediment	Low	• High energy, rapid transport to lower reaches, deposition in velocity shadows is expected • Inputs include erosion from stream adjacent hillslopes
Peak flow	Low	• Limited potential for planform shift, mostly too confined and bed and banks resistant to erosion • Little evidence of damage from peak flow • Low drainage areas • Stream flows expand and contract over resilient channel bed
LWD	High in lower gradients Moderate in gradients >8%	• Can span channel and wedge debris jams, working effectively to obstruct flow, trap sediment and create pools in lower gradient channels (<8%) • Debris jams effectively create pools and trap sediment • Boulders are primary pool former in all gradients, but in lower gradients wood could force larger pools
Catastrophic	High	• Dam break flood could affect channel; confined, moderately steep in deposition zone of debris torrents • With the return of large diameter riparian conifers, dam break flood potential would be reduced by large trees holding back debris

CHANNEL RESPONSE TO LAND USE

High confinements, relatively high gradients and downstream increases in channel size translate to relatively high sediment transport capacities in this system. Changes in runoff from roads and a reduction of root strength on harvest units influence sediment storage on hillslopes which may contribute to an increase in landslides. Stream surveys, anecdotal evidence, and air photo analysis show a large channel response to debris flows (natural and management related). This indicates a high sensitivity to catastrophic effects in GMU 5. Although coarse sediment is delivered to the stream system, and it temporarily sets up, the high energy in the streams readily reworks and routes coarse sediment.

Surface erosion from roads provides a chronic source of fine sediment to the streams but is flushed through the system quickly. Geologically, GMU 3 is naturally high in fine sediment and streams exhibit sensitivity to fines in this unit. Despite the management–induced fine sediment inputs imposed on the channels (>50% of background in some sub-basins – see Appendix B, Surface Erosion Assessment), observed pool tail–outs and riffle substrates in these large response reaches did not contain unusually high volumes of fine sediment. Storage of fine sediment in backwater areas and at channel margins occurs throughout the watershed as expected. Road erosion was found to contribute to fine sediment loads as turbidity and may form a component of stored alluvium in very localized reaches.

GMUs 1 and 4 are sensitive to peak flows. These are lower gradient response reach units, which have relatively large drainage areas and frequently have confined reaches within them. Given the high energy and rapid transport through tightly confined reaches, it is expected that pool scour may occur. Stream banks are also prone to bank erosion given the high shear stresses imposed on them during bankfull flows.

Most channels are sensitive to the gain or loss of roughness elements, whether that roughness is provided by the bed, the banks, or particles like woody debris and boulders. Form roughness was found to contribute to pool formation in GMUs 1, 2, 3, and 4, but additional woody debris is particularly important as a roughness element in aiding and inducing sediment storage and pool formation. Some degree of bedrock exposure may be expected in these channels. However, it is assumed that large wood removal during the log drives in the early 1900s, fish barrier removals in 1959 and more recent events (e.g., debris torrents and localized stream cleaning) have increased the frequency of bedrock exposure. The loss of in-channel LWD is therefore inferred to have decreased pool/riffle ratios, residual pool depths, and alluvial sorting and storage volumes. Currently, large wood recruitment and shading is considered relatively low for GMUs 1, 4 and 5.

HABITAT FORMING PROCESSES

Some important physical factors that affect fish survival are water temperature, water velocity, availability of escape cover, annual discharge of the stream (flow regime) and pool volume (both the number of pools, and size). Following is a description by GMU of the geomorphic processes controlling channel morphology relevant to the creation of fish habitat.

GMU 1—Upstream and downstream migration, fall Chinook spawning and rearing require deep pools, cover and gravels. High discharge velocities have formed bedrock pools good for juvenile rearing, although refuge cover within these pools is low. Side channels are relatively rare primarily because the mainstem channel has long stretches of entrenched reaches. Scoured bedrock is visible along the margins. Stream cleaning and log drives have removed wood and have contributed to the development of a scoured channel. Logging adjacent to the stream has reduced recruitment potential into the stream. Few overhanging banks and little overhanging vegetation is available for cover and refuge habitat for fish. Loss of roughness has occurred through confined reaches because of high shear stresses reducing available spawning gravels. Less obstruction to high flows also increases the potential for redd scour. Coarse and fine sediment is delivered directly from source and transport reaches through debris torrents and in the more loosely confined areas that are not entrenched, sediment stays around for longer periods of time supplying good spawning gravels on pool tailouts.

GMU 2—No fish.

GMU 3--Cutthroat trout live in pools and spawn in gravel patches and steelhead use is possible on the lower ends of these streams. Channel simplification through the removal of LWD has reduced the size and number of pools and reduced the number of good gravel bar tailouts suitable for spawning. Coarse sediment is limited in this GMU and wood is the primary pool former. There is a high natural background rate of fine sediment production in this GMU from the geologic substrate. Fine sediment may fill pools locally and turbidity, particularly during the winter rearing season, may be higher in GMU 3 than in other GMUs found in the WAU, although it does not appear to be a significant problem.

GMU 4—Steelhead and rainbow trout in Lower North Fork and Potts Creek and Cutthroat trout throughout, use this GMU for all life history phases. Spawning and juvenile rearing requires pools, cover and gravels. Channel simplification through the removal of LWD has reduced the size and number of pools and reduced the number of good gravel bar tailouts suitable for spawning. Historically, stream adjacent timber was cut and large wood recruitment potential has been reduced. A loss of roughness has increased stream velocities which increases redd scour potential. Frequently, bedrock glides exist where roughness (wood) has been removed. A general reduction in vegetation along banks has reduced bank stability and the number of undercut banks useful for fish protection from predation. The channels have received and routed debris torrents which have left large volumes of coarse sediment within and outside the channel margin. Finer sediments and gravels needed for spawning are limited despite lower gradients found in GMU 4 because of large drainages and high stream power. Pieces of large wood routed from upstream source areas during the debris torrents are frequently outside the channel margin on terraces or hillslopes and are not available to induce morphologic changes to the stream channel to increase fish habitat complexity.

GMU 5—Cutthroat trout and steelhead in the lower portions of U.S. Creek, require habitat for all life history phases. Spawning and juvenile rearing habitat requires pools, cover and gravels. Channel simplification with the removal of LWD has reduced the percent of cover available for protection of fish, reduced pool size and number. Logging has removed stream adjacent timber and recruitment of large wood potential is drastically reduced. Catastrophic flows transported through many of these reaches may scour the channel bed, reducing pool numbers and volumes and available spawning area. Large wood recruitment has been reduced by historic streamside harvests. Waterfalls, cascades and debris jams are natural barriers to fish passage and several fish populations are isolated in this GMU. Large accumulations of sediment from debris torrents create low flow barriers during the summer. No fish are present in the steeper stream reaches of this GMU.

The relationship of Geomorphic Map Units to fish distribution, and discussion of current habitat issues and concerns is presented in Appendix F, Fish Habitat Module.

CONFIDENCE IN WORK PRODUCTS

Stream Channel Partitioning

Measuring reach average gradients from topo maps (using DEMs) is generally acceptable and is given a moderate call in confidence for reliability. However, differences in resistance in the geologic materials creates much gradient variability as the streams erode through short sections of parent material with different resistance to erosion. Also, intermittent changes in long profile character are usually not resolved on the 1:24,000 scale topographic maps and only a broad profile is captured. Organic steps (wood jams) found in the channels also significantly reduces unit–level gradients from those derived from the topographic maps.

Field Assessment of Current Channel Condition

Weyerhaeuser and ODFW channel segment surveys were utilized during GMU determination, though many more segments were visited and field observations noted. For those segments where data was collected, surveys covered a small fraction of total segment length, and issues such as accessibility, which was influenced by road crossings, occasionally drove selection of survey sites. Field survey data was not used exclusively to create the Geomorphic Map Units, but was utilized as an aid in defining unit boundaries and sensitivity descriptions. Data supplied by ODFW was consistent with observations and added to overall confidence. There is a high confidence call in assessing current channel condition.

Historic Conditions

Data on channel condition in the WAU prior to forest management activities consist of air photo interpretation, General Land Surveys, documents and interviews. Reconstruction of channel conditions, as well as the pre–management style and function of woody debris, is based loosely on inferred stand conditions and morphologic attributes that can affect wood function and routing, such as channel size. Observations from aerial photos are good on the larger mainstem, where changes in channel storage of sediment is visible. Identifying features in confined channels is not possible due to the scale of the air photos. Vertical adjustments of channel beds are difficult to identify and impossible to quantify using photos. Old photographs aided in identifying early harvest patterns and potential affects to the stream channel. Interviews validated air photo interpretation. The 1800s General Land Surveys gave indications of channel condition before harvest. There is high confidence in identifying the historic trends of the watershed.

Geomorphic Map Units

Confidence in the level of extrapolation, the scale of each GMU, and the inferred sensitivities assigned is moderate to high. Numerous observations were made in most GMUs. The moderate confidence call occurs because delineating the location of gradient boundaries and overlying this with geologic influence within GMU 5 is a little uncertain. Boundaries between different gradients was problematic since the current condition of the channels pushed channel types into gradient ranges outside their typical designation. This created a GMU which had gradients from 4% to >20%.

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