SWANSON HYDROLOGY + GEOMORPHOLOGY

FINAL REPORT

South Scappoose Creek Restoration Plan

prepared for Scappoose Bay Watershed Council

MARCH 2009

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Executive Summary

In 2000, the Scappoose Bay Watershed Council (SBWC) completed a watershed assessment for the streams and catchments that enter Scappoose Bay (DEA, 2000). The watershed assessment identified several areas of concern affecting watershed and ecosystem health. Concerns include sediment delivery into Scappoose Bay, loss of high quality spawning and rearing habitat for salmonids, and incision within many of the primary channels. Of particular concern was the potential impact that channel incision has on channel and floodplain interaction and the ability of the stream to support and maintain the physical habitat features that provide for good aquatic habitat.

A five mile stretch of South Scappoose Creek that flows through the City of Scappoose was determined to have high priority for further assessment. This segment is characterized by an incised channel, severe bank erosion, lack of a continuous riparian corridor, a half dozen road crossing that have constricted the channel and floodplain, and urban encroachment into the historic floodplain. It was identified as a priority for further assessment due to local concerns about erosion and flooding and the opportunities to enhance conditions for salmon and other organisms that rely on high quality aquatic habitat.

Clear evidence of continuing changes in creek conditions makes it likely that the channel is still in the process of responding to changes in the hydrology, and to the impacts of local and regional land use. This prompted the Council to commission a focused study to evaluate historic and current hydrologic and geomorphic conditions, and identify a comprehensive strategy to address habitat loss, bank erosion, and chronic flooding.

This study required several stages of analysis with the ultimate goal of developing a comprehensive approach to actions that will restore and enhance morphologic function on lower South Scappoose Creek within the context of current and future land uses. The tasks outlined by Swanson Hydrology and Geomorphology (SH+G) to evaluate historic impacts and develop an enhancement strategy include the following:

- Historic Geomorphic Analysis
- Existing Conditions Analysis
- Identification of Enhancement Actions
- Project Prioritization and Conceptual Design

The study area encompasses approximately five miles of South Scappoose Creek from the Raymond Creek confluence in Dutch Canyon on the upstream end, to West Lane Rd crossing on the downstream end (Figure ES-1). The study area is located at the lower end of the watershed and is characterized by a low gradient meandering channel that is severely incised from the Dutch Canyon Road crossing to the Columbia River Highway crossing. A total of eight reaches were delineated for the project area. Reach delineations were based on specific changes in channel and valley morphology, site specific geomorphic conditions, and other variables such as a tributary input, bridge location, or changes in bed substrate.

Channel morphology through the five mile study reach is much different today than it was when Europeans arrived in the 19th Century. Historically, reaches such as this would have consisted of a primary channel more closely at grade with the adjacent valley floor. The reach would have contained a more sinuous primary channel, with remnant channels, backwaters and other wetlands occurring across the valley floor. The vegetation on the valley floor most likely consisted of a mix of hardwood and coniferous species that formed a dense understory and canopy. The understory would have contained downed logs that created a rough channel and floodplain surface which obstructed flow, encouraged formation of new flow paths, and resulted in deposition of sediment delivered from large landslides and debris flows in the upper watershed and adjacent tributaries.

Remnants of past channel patterns, including old meander scars and terraces can be seen on the modern valley floor. In most cases these channels have been modified in some way or are cut off from the main channel by levees or filled areas of the floodplain, creating discontinuous overbank channels. These channels, though not functioning biologically or morphologically as they did in the past, still provide some function by collecting and filtering runoff from adjacent land, thereby reducing pollutant loads to South Scappoose Creek.

The mid-19th century to the early 20th century was most likely a period of rapid change in land use and stream morphology on the lower Scappoose Creek valley floor. Following removal of much of the marketable timber, agriculture and grazing took hold on the fertile soil. This required clearing land, building levees, and controlling local and tributary drainage. Over time, this process affected most of the valley floor, confining South Scappoose Creek to a narrow riparian corridor. It is also likely that the creek was forced into a single channel at the margins of the valley floor to maximize usable farmland, a process which likely resulted in early channel incision.

Constricting the channel and reducing total floodplain area has created a more homogeneous, less dynamic environment, thereby reducing the range of physical habitats necessary to support all salmonids life stages. Flood flows in most of this reach are now focused into an entrenched primary channel which is isolated from much of the historic floodplain. This has resulted in higher flow velocities and more energy focused on the bed and banks of the channel. Consequently, the channel has incised, exposing steep banks that are prone to erosion.

The most significant area of concern for the project reach – in terms of impacts to existing infrastructure, loss of property, and introduction of excessive fine sediment loads to the channel – is associated with long-term and systemic channel incision and the resulting risk of excessive bank erosion and failure. Simon and Hupp (1986) present a six stage model describing the long-term evolution of incised channels. The model hypothesizes that channels go through a series of stages, whereby the incised condition eventually is remedied, resulting in a more natural channel with functional floodplain inset into the historic floodplain (Figure ES-2). Based on our observations, South Scappoose Creek is in Stage 4 (degradation and widening), and in some areas is transitioning into Stage 5 (aggrading and widening). Stage 5 consists of continued bank erosion, combined with an aggradation phase resulting from deposition of material eroded from the banks in Stage 4, and constitutes the "floodplain building" phase of the channel evolution model. The widening phases (Phases 4 and 5) are often the most destructive in that they affect adjacent properties and infrastructure and can completely remove narrow riparian corridors that provide shade and large woody debris to the creek, essential to healthy salmon habitat.

To evaluate bank conditions locally, a comprehensive bank and channel stability analysis was conducted for the project. The results show that a majority of the banks within the study area are classified as a moderate risk of erosion (Figure ES-3). Within the critical portion of the channel between Highway 30 and the Dutch Canyon crossing, most of the banks are characterized as having a moderate to high risk of erosion. Within this segment, 11 large active erosion sites were identified out of the 13 total identified in the project area.

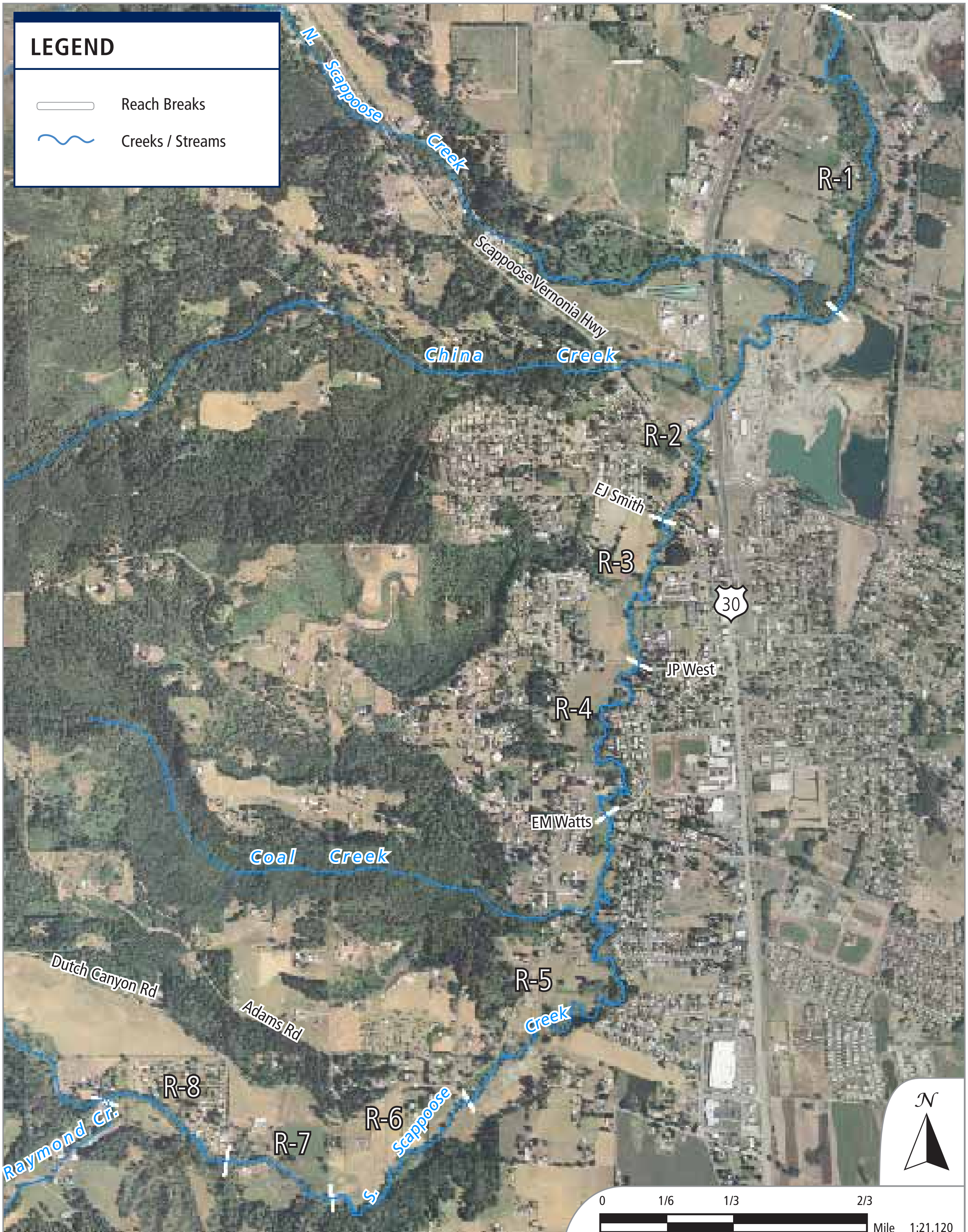
To comprehensively evaluate the frequency of overbank flooding, channel hydraulic conditions, and the potential affect that future enhancement scenarios have on channel conditions, a hydraulic model was prepared for a portion of the South Scappoose project area (based on available data). The hydraulic model was developed using HEC-RAS, the U.S. Army Corps of Engineers one-dimensional hydraulic modeling software. The hydrology data were used to evaluate water surface elevations at each cross-section for the 2-year, 5-year, 10-year, 25-year, and 100-year events. The results suggest that frequent flooding (e.g. – 5-year and greater) inundates the adjacent valley floor at the lower end of the project area and at the upstream end of each of the main bridges. In most cases, the bridges are inundated and overtopped in the 25-year, 50-year, and 100-year events. Flow velocities are relatively low upstream of the bridges, where backwaters are created, but flow velocities are high immediately downstream of the bridges. High flow velocities at the downstream side of bridges can exacerbate bank erosion, as was observed downstream of the Raymond Creek Bridge.

In addition to their role in constricting flow during high magnitude, infrequent events, the bridges also protect the creek from incising further. Historic head cut migration up South Scappoose Creek likely resulted in exposure of bridge abutment foundations and piers, which most likely prompted the owners of the bridges to take remedial action and place large rock in and around the abutments and piers to protect them from further erosion. Those actions have prevented further head cut migration. Long-term management of the South Scappoose Creek will require some careful consideration of the channel, bank, and floodplain conditions around the bridges to ensure that an attempt to fix one problem does not exacerbate another. Consequently, a more detailed study will be required to evaluate enhancement opportunities in and adjacent to the existing bridges.

For this project, the overarching desired future condition for South Scappoose Creek would be to move toward a more stable channel with functional floodplain and a continuous and diverse riparian corridor. Based on our geomorphic analysis, the existing functional value of South Scappoose Creek, especially the portion that flows through the City of Scappoose, is limited because of the severe incision, narrow riparian corridors, and lack of a connected floodplain. According to the Simon and Hupp model, the current incised condition of the channel will likely lead to accelerated bank erosion in the future. Although in the long-term this process will lead to a more stable channel with functional floodplains and healthy riparian corridor inset into the existing valley floor, this "vision" of the creek is at conflict with the interests of adjacent properties and infrastructure. In addition, excessive erosion of banks that consist primarily of fine sediment would have negative consequences to aquatic communities that are already stressed and in decline. Consequently, enhancement opportunities that address the existing and future instability of stream banks should receive priority given what is desired by the community. Within the Simon and Hupp model framework achieving a quasi equilibrium defined under Stage 6 (quasi equilibrium) would be the desired future condition and would be achieved by active expansion of the floodplain and lowering the bank angle to reflect a more stable condition. The approach selected at a particular location will depend on site specific opportunities and constraints that will be identified at the project design phase.

To achieve the desired future condition for South Scappoose Creek, our enhancement approach recognized the fact that the goals and objectives of a successful management strategy should consider regional issues that integrate the concerns of multiple landowners and address the larger issue of channel stability and floodplain function. Consequently, SBWC and SH+G devised a project prioritization strategy that focuses on enhancement activities using a Management Zone approach, the boundaries of which are roughly defined by parcel boundaries and ownerships along the channel, similarities in proposed project types, and the degree to which landowners have participated in the process. A total of 18 Management Zones were defined in the project area, from A to R. The boundaries of each of the Management Zones are shown in Figure ES-4, along with the proposed project types occurring within each of the Zones and their approximate locations.

To achieve consensus on a prioritization strategy while also taking advantage of the research information generated as part of this study, results from a stakeholder prioritization workshop were combined with the results of a Project Team prioritization effort. Project opportunities outlined within each Management Zone were identified through discussions and site visit with property owners, with the exception of the riparian planting projects, which were identified via an aerial photo analysis. Scores from each of these efforts were summed and averaged to generate a Management Zone prioritization that identifies, in five-year increments, the management strategy for the next fifteen years. The results of this analysis are presented in ES-5. Using this approach, six Management Zones fell into the first five years of implementation (MZ's: A, C, G, H, J, O), five in the second five years (MZ's: E, I, K, L, Q), and seven in the last five years (MZ's: B, D, F, M, N, P, R). The prioritization provides a framework for restoration and enhancement of the project area, but it will be up to the Watershed Council, the City of Scappoose, local residents, and other project partners to determine how this plan is implemented.



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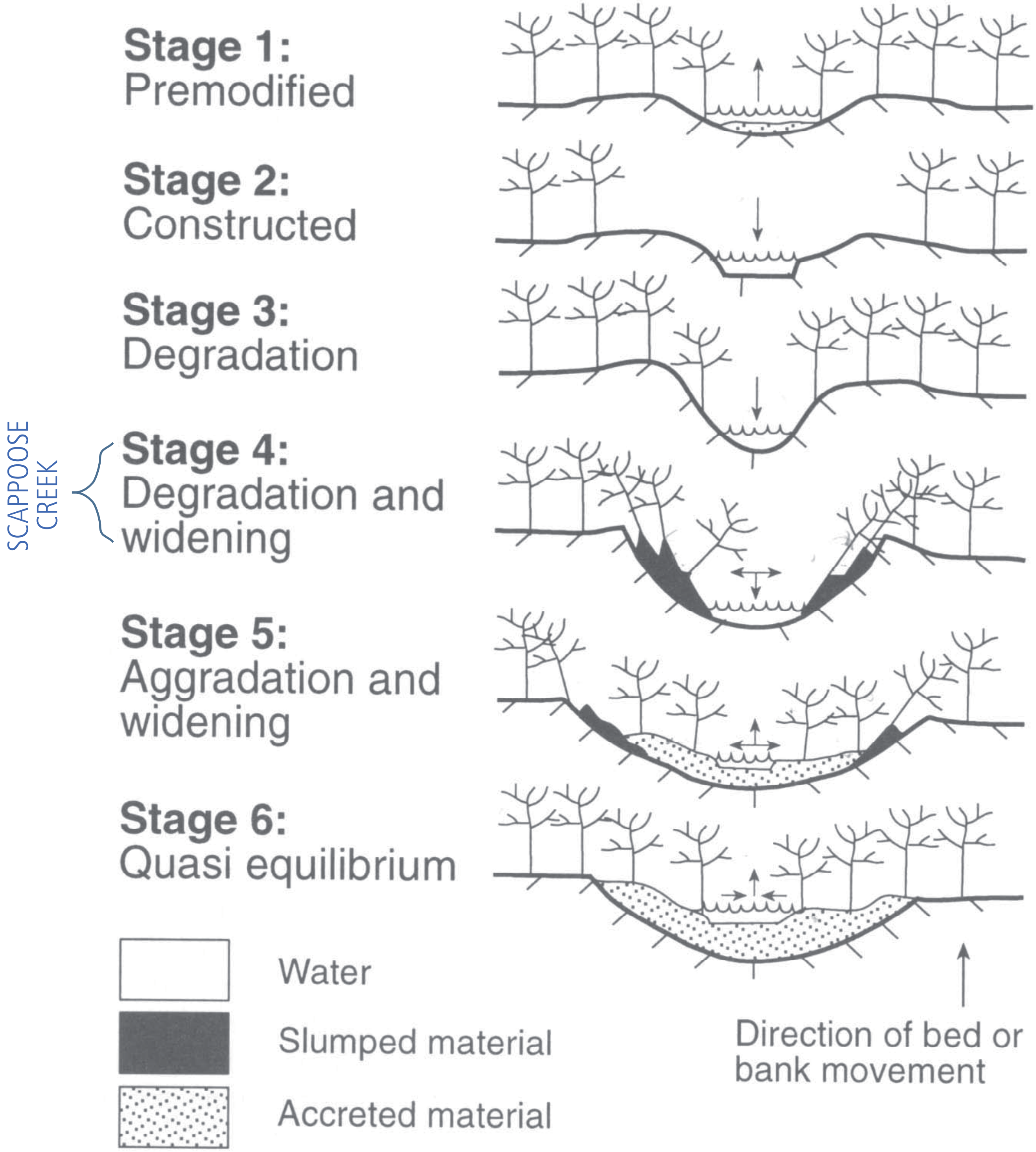
ES-1: Map of reaches delineated for the project area. The project focused on the mainstem of South Scappoose Creek from the confluence of Raymond Creek at the upstream end to the West Lane Bridge at the downstream end and encompasses eight distinct reaches.



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ES-2: Channel evolution model for incised creeks. (Simon and Hupp, 1986)

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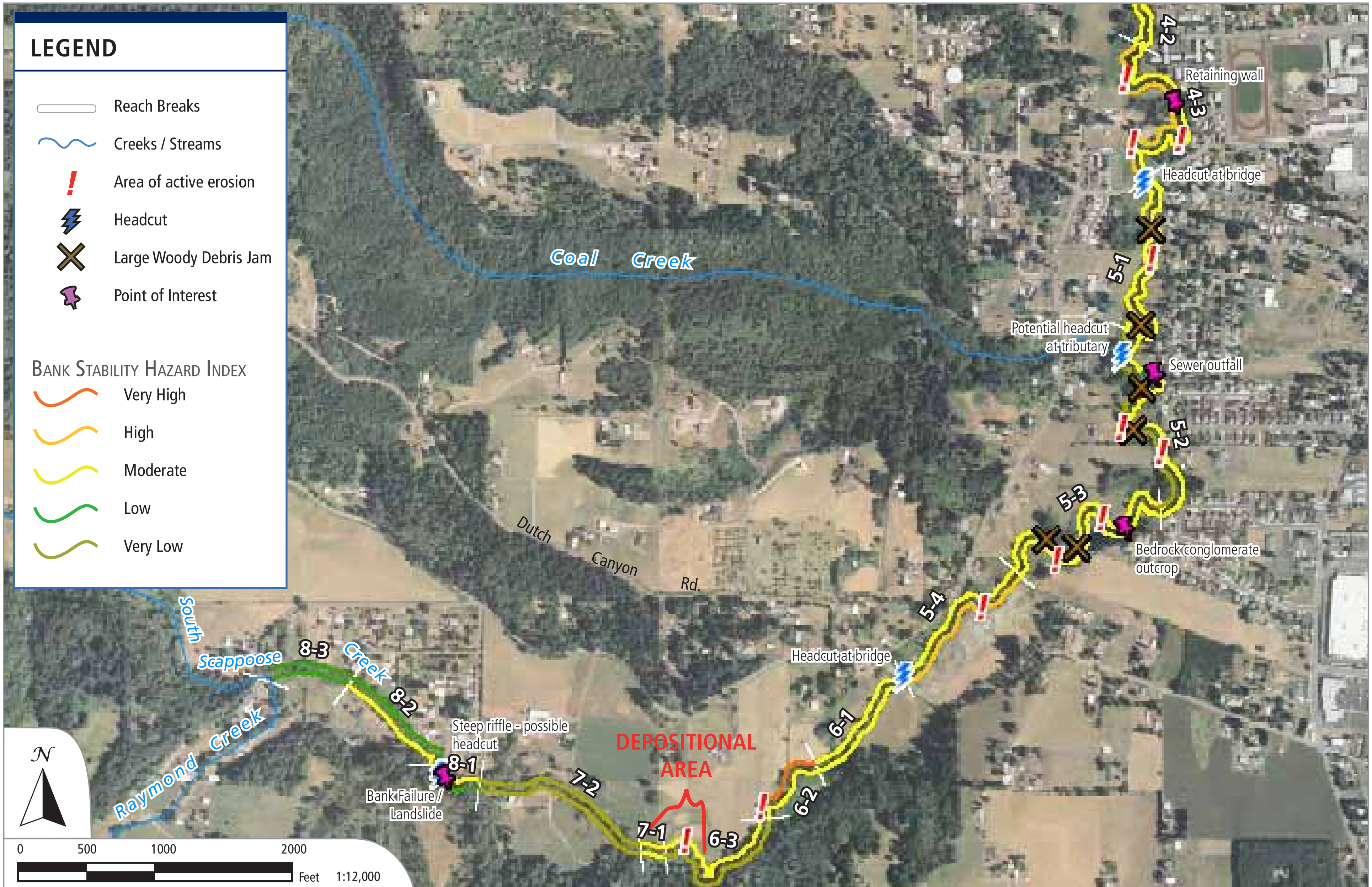
ES-3: A bank and channel stability survey was conducted on South Scappoose Creek through the project area. The selected study approach, based on Rosgen (1996), produced a Bank Erosion Hazard Index (BEHI) for each bank along with site specific bank and bed stability observations.



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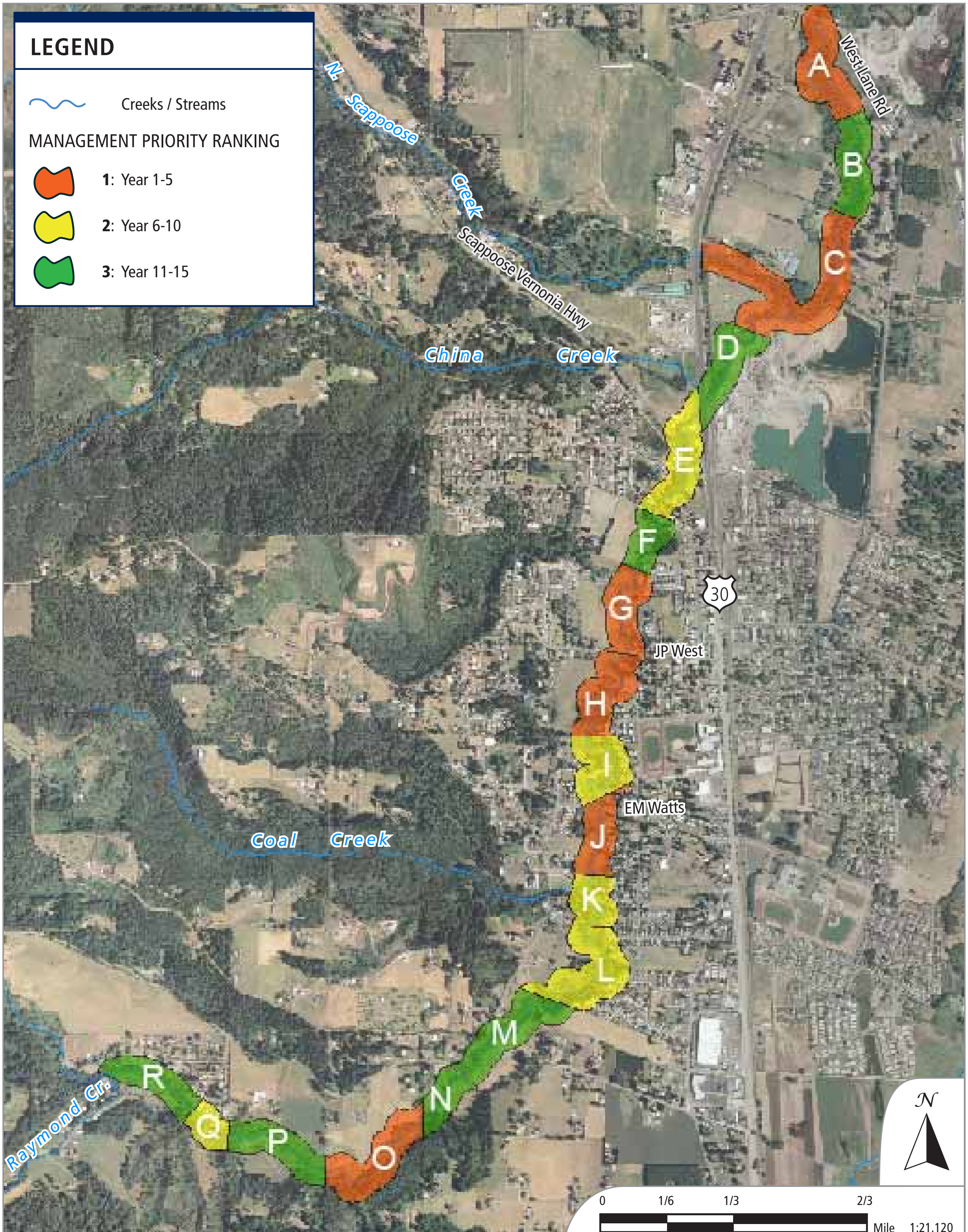
ES-3 continued...



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ES-4: Overview of the proposed final prioritizations for Management Zones A through R in the South Scappoose study area. The final prioritizations were derived by integrating a Project Team analysis of project evaluation criteria with results derived from a prioritization workshop with stakeholders.

Management Area	Project Team Prioritization		Technical Advisory Committee Prioritization		Final Proritization	
	Score	Ranking 1 = Year 1-5 2 = Year 6-10 3 = Year 11-15	Score	Ranking	Average Score	Ranking 1 = Year 1-5 2 = Year 6-10 3 = Year 11-15
A	15	1	16	1	15.5	1
B	9	3	0	3	4.5	3
C	11	2	21	1	16	1
D	9	3	0	3	4.5	3
E	11	2	3	3	7	2
F	9	3	1	3	5	3
G	13	1	31	1	22	1
H	15	1	24	1	19.5	1
I	11	2	8	2	9.5	2
J	13	1	18	1	15.5	1
K	12	2	10	2	11	2
L	12	2	13	2	12.5	2
M	10	3	1	3	5.5	3
N	10	3	0	3	5	3
O	13	1	16	1	14.5	1
P	10	3	0	3	5	3
Q	13	1	14	2	13.5	2
R	9	3	0	3	4.5	3

ES-5: Summary of the proposed final prioritization of Management Zones in the South Scappoose project area. Prioritizations are lumped into a timeline of 1-5 years, 6-10 years, and 11-15 years.

1. Introduction

1.1 Problem Statement

In 2000, the Scappoose Bay Watershed Council (SBWC) completed a watershed assessment for the streams and catchments that enter Scappoose Bay (DEA, 2000). Several concerns identified in the watershed assessment that affect watershed and ecosystem health included sediment delivery into Scappoose Bay, loss of high quality spawning and rearing habitat for salmonids, and incision within many of the primary channels. Of particular concern, noted in the watershed assessment, was the potential impact the incision has on channel and floodplain interaction, morphologic variability, and the ability of the stream to support and maintain the physical habitat features that provide for good aquatic habitat.

One particular section of stream channel within the Scappoose Bay Watersheds that was determined to be high priority for further assessment is a five mile stretch of South Scappoose Creek that flows through the City of Scappoose. This segment of channel is characterized by an incised channel, severe bank erosion, lack of a continuous riparian corridor, a half dozen road crossing that have constricted the channel and floodplain, urban encroachment into the historic floodplain, and profound changes in the condition of the creek. It was identified as a priority for further assessment due to local concerns about erosion and flooding and the opportunities to enhance conditions for salmon and other organisms that rely on high quality aquatic habitat.

Clear evidence of continued planform instability makes it likely that the channel is still in the process of responding to changes in the hydrology and the impacts of local and regional land use practices. These geomorphic changes, along with concerns from the community about protecting important salmon habitat, prompted the need for a focused study to evaluate historic and current hydrologic and geomorphic conditions and identify a comprehensive strategy to address habitat loss, bank erosion, and chronic flooding.

1.2 Study Objectives

Addressing the issues outlined in the problem statement requires several stages of analysis with the ultimate goal of developing a comprehensive approach to actions that will restore and enhance morphologic function on lower South Scappoose Creek within the context of current and future land uses. The first step in the process of identifying specific enhancement actions is to evaluate historic, existing, and future trends in channel morphology and identify causative factors related to excessive fine sediment delivery into Scappoose Bay, loss of high quality spawning and rearing habitat for salmonids, and incision within many of the primary channels. Once these causative factors are identified, general prescriptive measures can be outlined that address each of the factors, followed by site specific remedies that take into account the local land use setting and other site opportunities and constraints.

Within this framework, the SBWC commissioned Swanson Hydrology and Geomorphology (SH+G) to address the following key questions:

- How is the South Scappoose project area functioning geomorphically as compared to historic conditions?
- What is the expected long term stability of the channel, both vertically and laterally?
- Are there opportunities to implement projects that will enhance channel form and function within the existing hydrology, morphology and sediment transport regime?
- What effects/improvement would the proposed projects have on planform and profile stability and sediment transport conditions?
- Are there external factors, such as land-use change or changes in downstream base level that would affect the future success of the proposed enhancement activities?
- Are the expected habitat benefits of the proposed projects measureable and on what time scale?

The tasks outlined by SH+G to meet the study objectives and prepare a technical document describing the results are as follows:

- ***Historic Geomorphic Analysis:*** An evaluation and description of geomorphic conditions and functions that were present prior to intensive land uses of the 19th and 20th centuries,
- ***Existing Conditions Analysis:*** An evaluation of current channel morphology and function and probable expected future conditions,
- ***Enhancement Actions:*** Identify reach scale prescriptions to mitigate for the identified impacts; and identify site specific opportunities and constraints to apply the proposed prescriptions in a way that enhances South Scappoose Creek.
- ***Project Prioritization and Conceptual Design:*** Assign project cost and work with stakeholders to identify priorities within the list of potential actions. Actions identified as the highest priority are carried through a preliminary design phase.

2. Setting

2.1 Watershed Setting

Scappoose Creek, located in Columbia County, Oregon, is the largest watershed draining into Scappoose Bay (Figure 1). The watershed encompasses approximately 63 square miles of primarily private forest land draining the northeast slopes of the Tualatin Hills. The primary subwatersheds are South Scappoose and North Scappoose Creeks. The lower watershed, which encompasses the five mile study area, consists of a broad alluvial valley, the lower portion of which was historically influenced by flooding from the adjacent Columbia River and Willamette River lowlands. Land uses in the lower valley consist of a mix of rangeland, rural residential and low density residential within the City of Scappoose. Within the project area there are a total of ten bridges consisting of nine public and one private road.

The climate of the Scappoose Creek watershed is characterized by a prolonged wet season and a short dry season. The wet season typically runs from October to May with the dry season running from June to September. Rainfall totals in the upper watershed average approximately 50 inches per year, whereas lower elevation areas in the Scappoose Bay lowlands receive an average of 45 inches of rainfall each year. Most precipitation in the watershed falls as rain, though snowfall can occur.

Rock types within the Scappoose Creek watershed consist primarily of young geologic material. The lowlands and valley bottoms are composed of Quaternary and Miocene deposits from the Missoula Floods along with more recent deposits from the modern Columbia River and Willamette River lowlands. The upper watershed and hillslopes are dominated by Miocene deposits from the Columbia River Basalt Group. Erosion of the Basalt Group has exposed Paleogene marine sedimentary rocks and older, more erosive volcanics (Figure 2). The study reach, located along a low gradient, wide valley bottom, consists primarily of Missoula flood deposits and recent alluvial deposits from Columbia River flooding (Figure 3).

Soils in the project area are composed primarily of loams and silty loams (Figure 4). Highly erodible soils, combined with steep slopes (Figure 5) are limited to escarpments along the river valleys and steep slopes in the headwaters. Hillslopes in South Scappoose are generally at a higher risk of erosion as defined by slopes greater than 30% and a soil erodibility factor (k value) greater than 0.25 (Figure 6).

2.2 Reach Setting

The study area encompasses approximately five miles of South Scappoose Creek, from the Raymond Creek confluence in Dutch Canyon on the upstream end, to West Lane on the downstream end (Figure 7). One large tributary, North Scappoose Creek, and several smaller tributaries, including Coal Creek and China Creek, enter the project area from the north. The project study area is located at the lower end of the watershed and is characterized by a low gradient meandering channel that is severely incised from the Dutch Canyon Road crossing to the Columbia River Highway crossing. A longitudinal profile of South Scappoose and North Scappoose Creeks show the graded form (gradually decreasing slope with distance downstream) of South Scappoose Creek compared with the stepped form of North Scappoose Creek (Figure 8). The steeper gradient of lower North Scappoose Creek is the result of a basaltic plug in the lower channel, which presumably limits rates of valley incision as compared to South Scappoose Creek.

A total of eight reaches were delineated for the project area (Figure 7). Reach delineations were based on specific changes in channel and valley morphology, site specific geomorphic conditions, and other variables such as a tributary input, location of a bridge, or changes in bed substrate. Although eight distinct reaches were delineated for the project area, generally there was little morphologic variability throughout the project area in comparisonto morphologic conditions across the larger watershed.

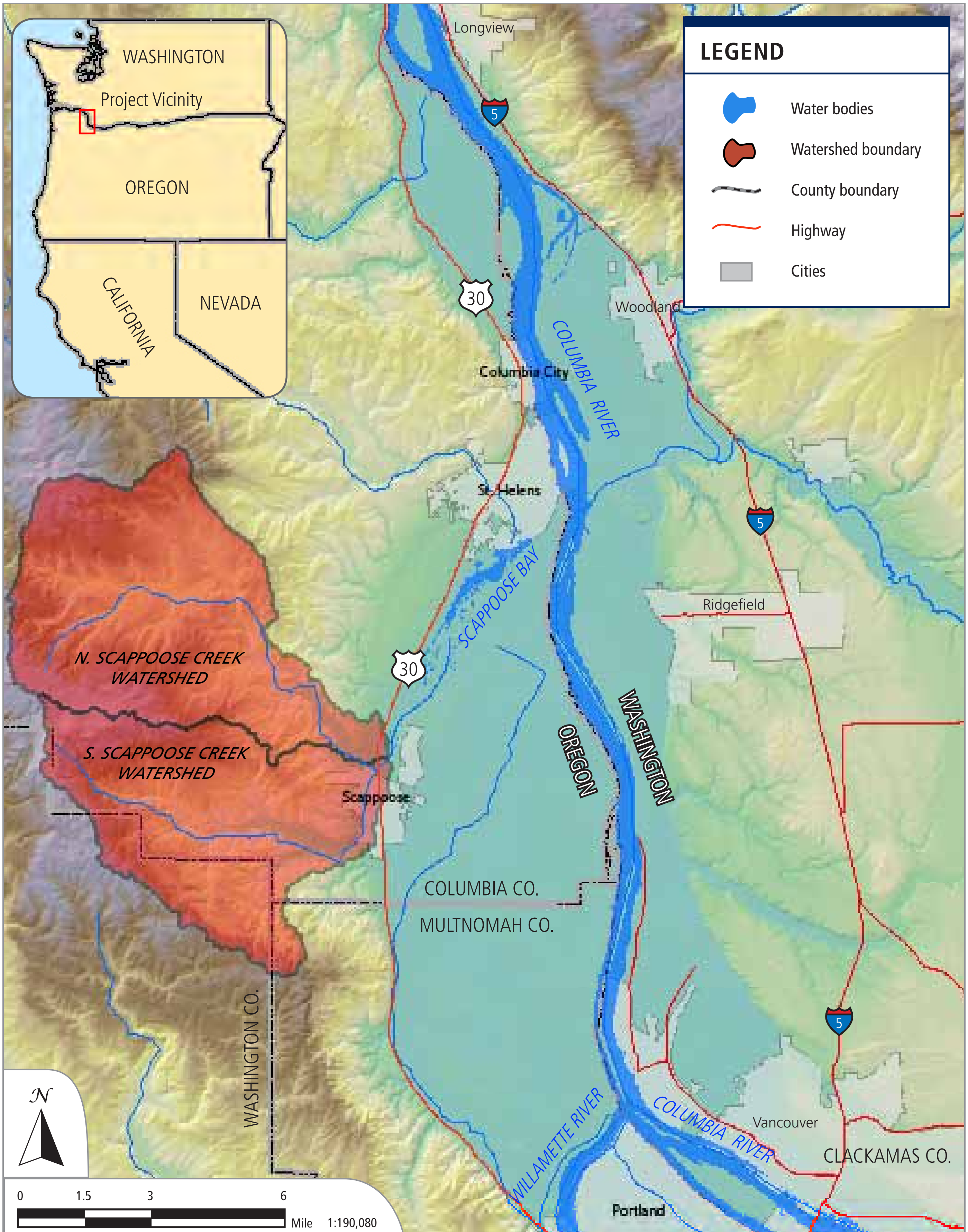

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FIGURE 1: The project is located on South Scappoose Creek in the Scappoose Bay Watershed in northwest Oregon. Scappoose Creek drains the northeast side of the Tualatin Hills and enters Scappoose Bay, located just downstream of the confluence of the Columbia and Willamette Rivers.

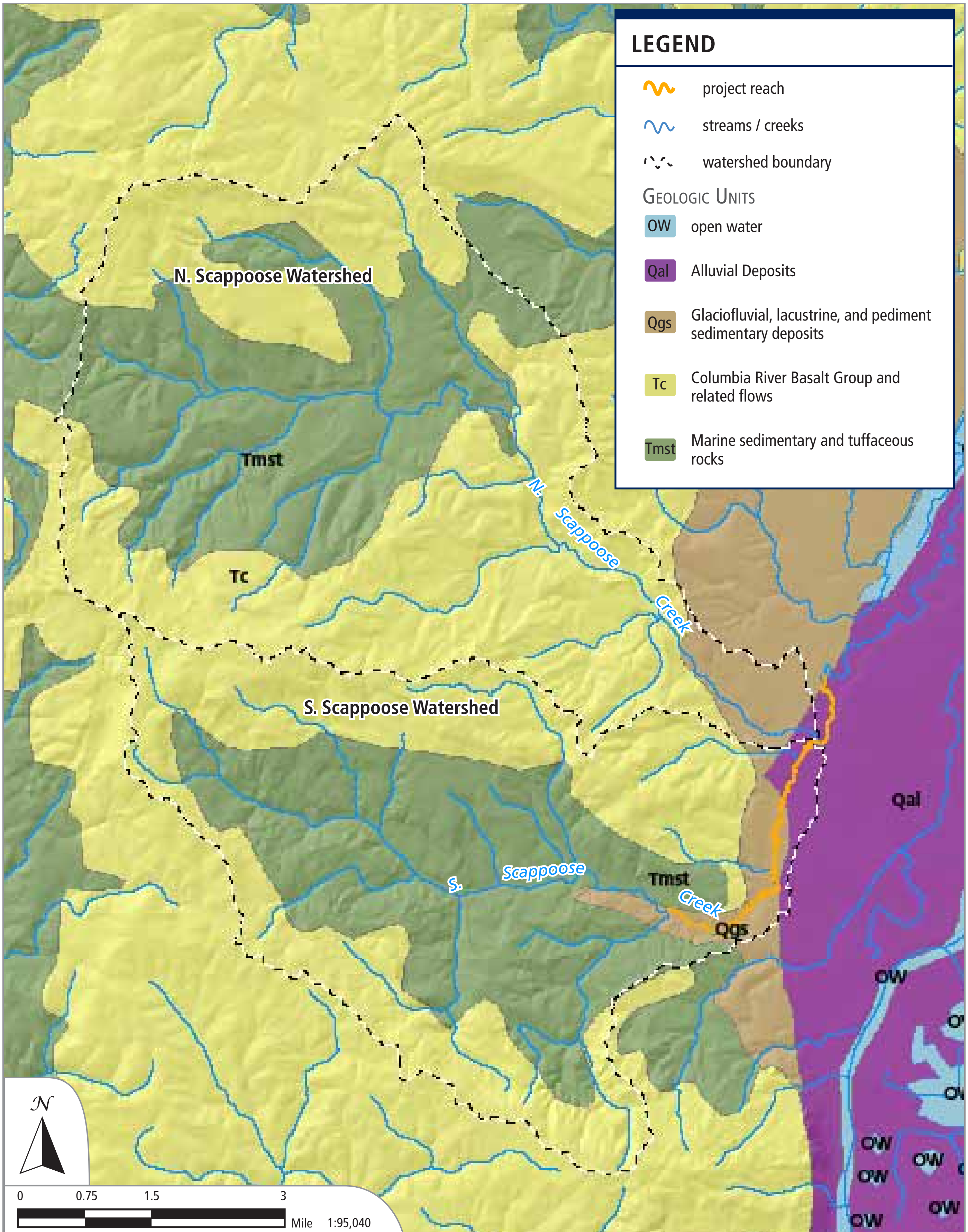

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FIGURE 2: Surficial geology of the project and surrounding area. Much of the valley floor within the project area is underlain by fluvial backwater deposits from the Missoula floods with the exception of the lower project area which consists of more recent Columbia River flood deposits.

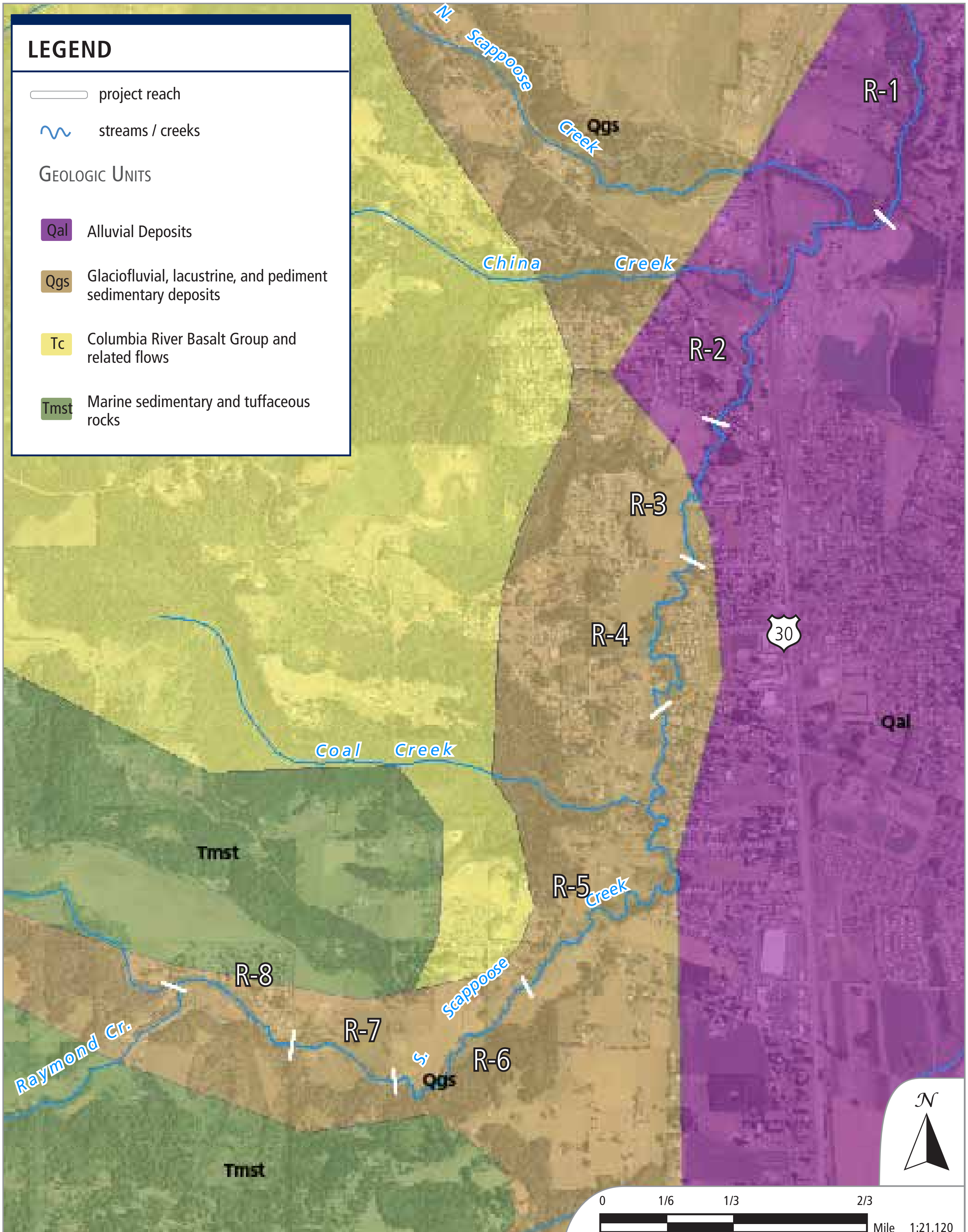

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FIGURE 3: Surficial geology of the project study area. Note the change from Missoula Flood deposits to more recent Columbia River flood deposits in Reach 3.

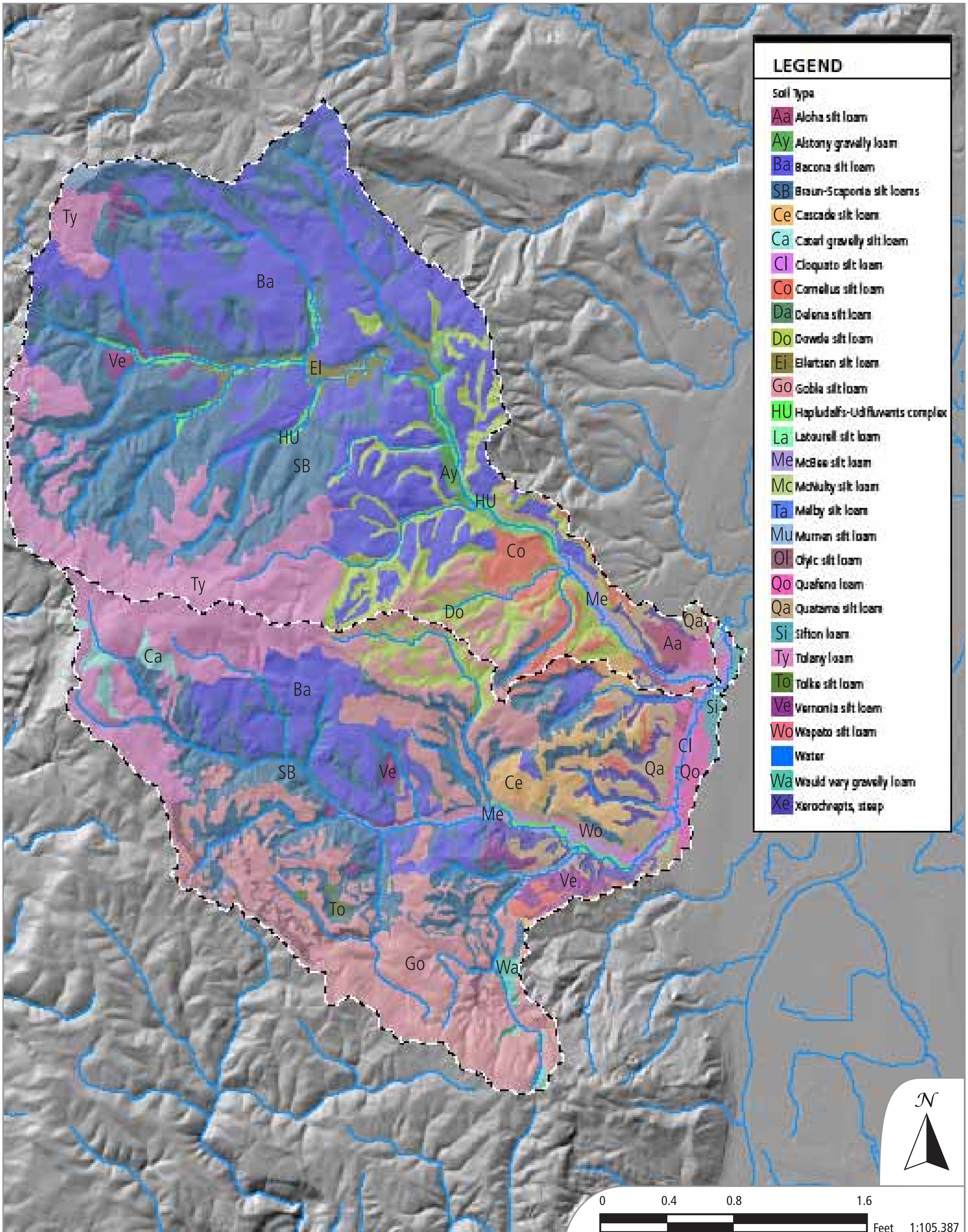

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FIGURE 4: Mapped soils of the South and North Scappoose Creek watersheds. Soils in the valley bottoms of South Scappoose Creek are dominated by loam and silty loams.

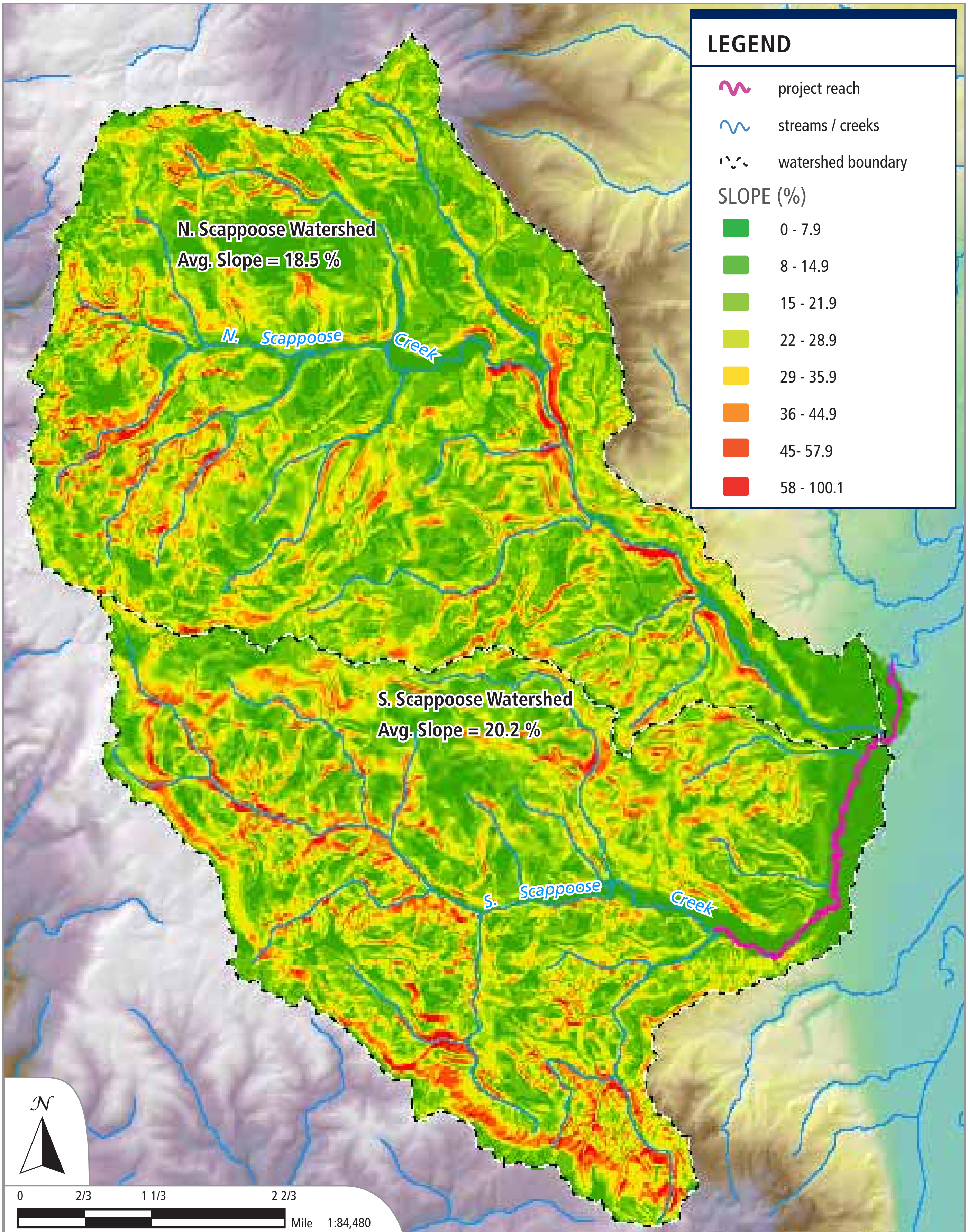

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FIGURE 5: Percent slope for the South Scappoose and North Scappoose Creek watersheds. Average slope for the South Scappoose watershed is 20.2% which is slightly higher than the average slope of 18.5% for the North Scappoose watershed.

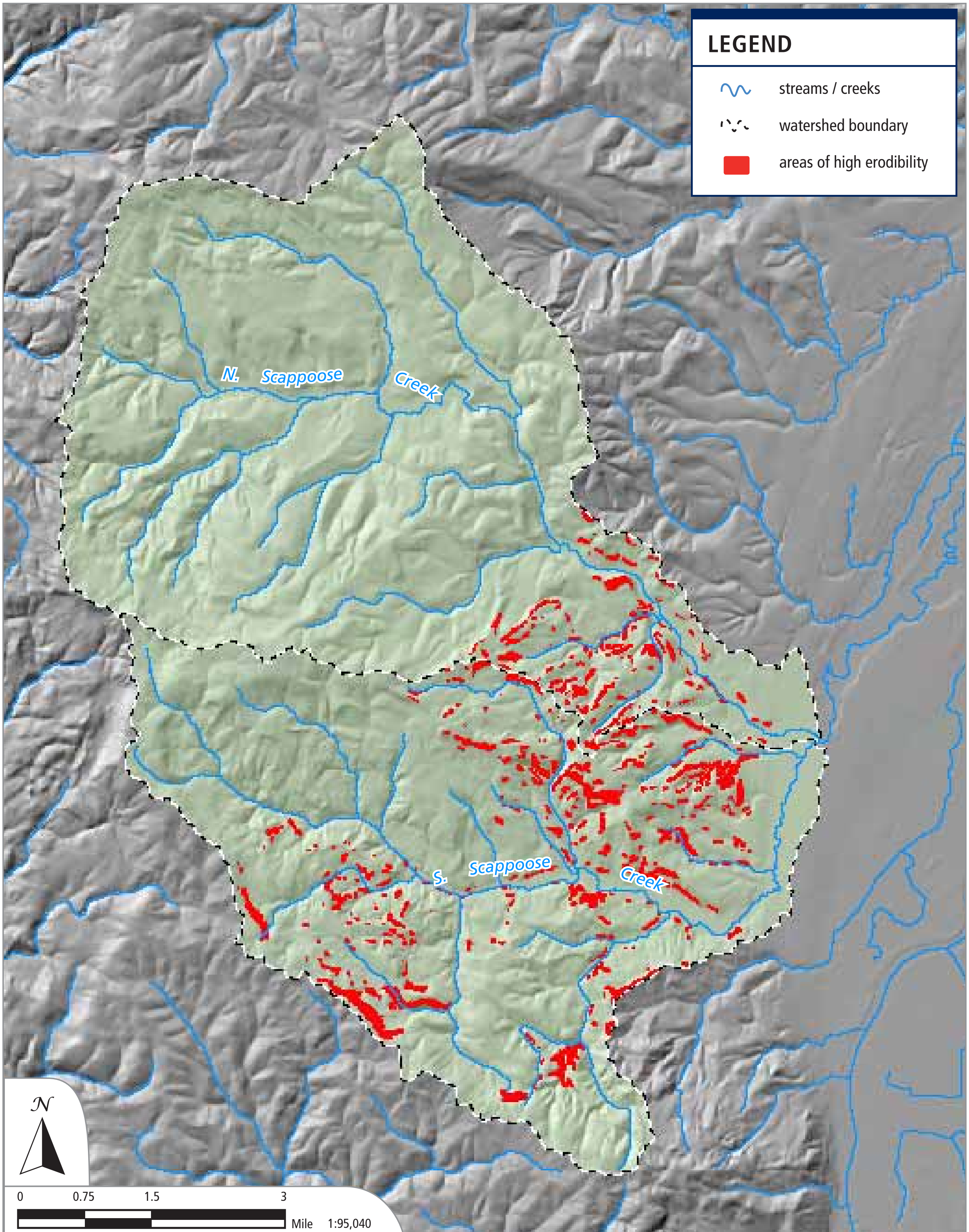

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FIGURE 6: Map depicting areas classified as a high risk of erosion associated with landslides and debris flows. The criteria used to depict high erosion risk are slopes greater than 30% and soils with a k-factor of erodibility classified as High (k-factor > 0.25).

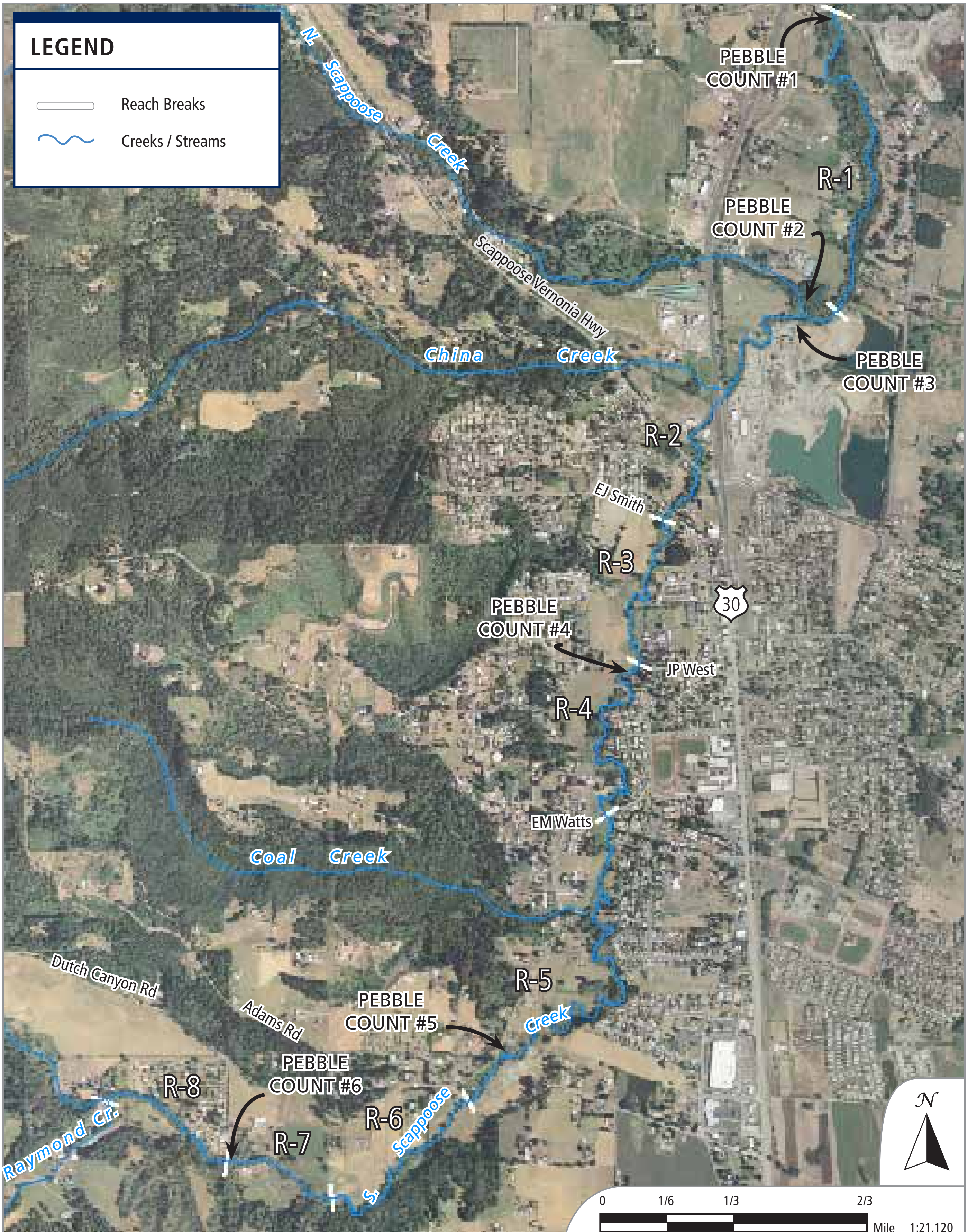

FIGURE 7: Map of reaches delineated for the project area. The project focused on the mainstem of South Scappoose Creek from the confluence of Raymond Creek at the upstream end to the West Lane Bridge at the downstream end and encompasses eight distinct reaches.

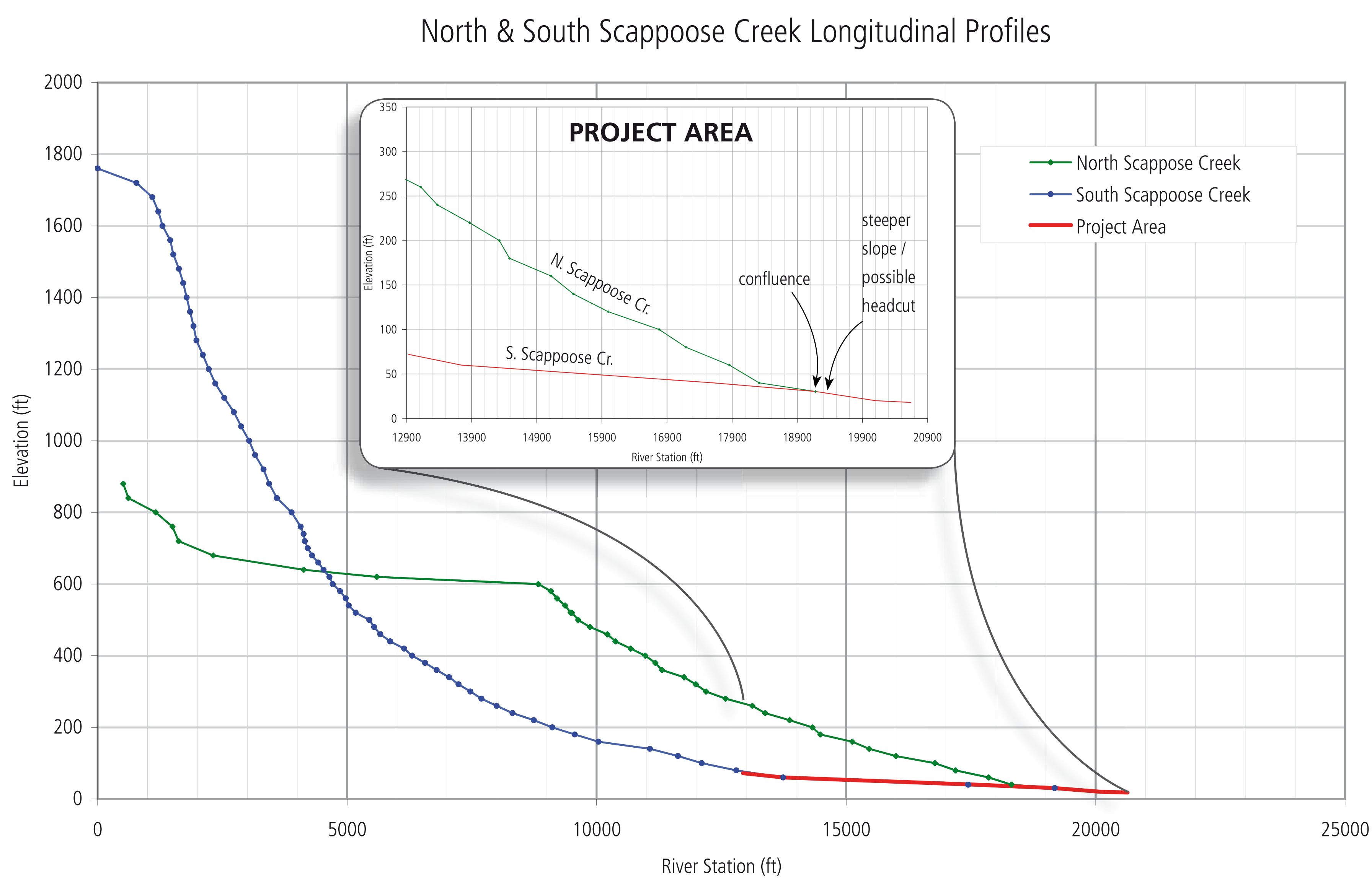

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FIGURE 8: Longitudinal profiles for South Scappoose and North Scappoose Creeks derived from USGS 1:24,000 scale Digital Line Graphs (DLG's). Note the graded form of South Scappoose compared to North Scappoose which reflects the differences in the surficial geology along the primary channel.

3. Historic Conditions

3.1 Background

Stream channels function in a physical sense to transport watershed products, including water, sediment, woody debris, and nutrients, to the lower end of the catchment. All of the fundamental characteristics of the channel, such as planform, capacity, and width-depth ratio, are reflective of the quantity and characteristics of watershed products supplied to the channel, and eventually transported through it. Changes in the quantity or characteristics of watershed products supplied to the channel are likely to result in changes in fundamental channel characteristics, although the link between the watershed and the channel is complex and specific channel response to watershed changes may be difficult to predict (Lisle 1999).

The supply of watershed products to the stream channel is to a great extent determined by geology and climate. Often termed independent variables in models of channel response, geology and climate do not respond to other factors governing channel behavior, and are not influenced by human management. The influence of these independent variables on channel behavior is felt across the entire watershed. Topography and watershed gradients, which control the rate of erosion, are dictated by tectonic activity and subsequent hillslope and fluvial erosion. The quantity and size of bedload and suspended load sediments available for transport by the channel are a function of the erodibility of rocks in the watershed and their mode of transport from hillslope to stream channel. Climate-driven precipitation determines the amount and timing of water and sediment supplied to the channel. Geologic and climatic histories are also important influences on the delivery of watershed products; for example, the effects of higher past erosion rates, driven by a wetter or colder climate, still influence how erosion occurs today.

The transport of watershed products through the stream system is also highly influenced by climate and geology. Large-scale geologic features such as faults, landslides or bedrock constrictions influence the stream profile gradient, the continuity of sediment transport down-valley during floods, and the storage of sediment and wood in the channel and on the floodplain (Grant and Swanson, 1995; Benda, 1990; Miller, 1994), . The magnitude, timing and duration of floods have significant influence over rates of sediment transport.

Dunne and Leopold (1978) define the floodplain as the "flat area adjoining a river channel constructed by the river in the present climate and overflowed at times of high discharge". Again, although this appears to be a simple definition, on closer examination the reality is more complex. For example, the flat area in this definition is a landform constructed primarily by slow lateral migration and overbank deposition. In developing a technique for channel classification, Rosgen (1994), working from the Dunne and Leopold concepts of bankfull discharge and floodplain formation, notes that the active floodplain is the area of the valley flat above bankfull discharge and below a flood prone stage, or twice the maximum bankfull flow depth. He notes that this may include both active flood plain and low terrace (a former floodplain abandoned due to climatic or other changes).

During floods, localized erosion and deposition occurs on the floodplain, resulting in a highly varied microtopography. Sediment deposition on the floodplain is a key element in establishing new riparian vegetation, as is localized erosion, which provides growing areas in proximity to the water table. Also, log jams and woody debris act as hydraulic controls in the channel, and influence groundwater elevation throughout the floodplain, increasing the amount of time that soil moisture is available during the growing season, and increasing the overall density of vegetation. Woody debris also plays a key role in stabilizing the floodplain by providing resistance to erosion in flood channels, storing and sorting sediment in localized areas, and preventing widespread erosion by resisting the tendency of flood flows to concentrate. Individual trees or downed logs break up floodplain flow paths.

The heterogeneous nature of the floodplain, due to these processes, contributes to the future recruitment of large trees and woody debris. Recent deposits of sediment during floods deliver nutrient rich deposits to the floodplain and thus provide suitable establishment areas for riparian vegetation. Nutrient rich soils in areas of high roughness become favorable locations for the regeneration of large trees, providing for the next generation of large woody debris. This, then, perpetuates the long-term supply of woody debris and provides for greater resiliency within the system.

3.2 Historic Channel and Floodplain Conditions

Channel morphology through the five mile study reach, bounded by West Lane and Raymond Creek, is much different today than it was when Europeans arrived in the 19th Century. Historically, the channel likely consisted of a primary channel that was more closely at grade with the adjacent valley floor. The primary channel occupied a more sinuous channel pattern with remnant channels, backwaters and other wetlands occurring across the valley floor. The vegetation on the valley floor likely consisted of a mix of hardwood and coniferous species that formed a dense understory and canopy. The dense understory was thick with downed logs that created a rough channel and floodplain surface that obstructed flow, encouraged formation of new flow paths, and resulted in deposition of sediment delivered from large landslides and debris flows in the upper watershed and adjacent tributaries.

Remnants of past channel patterns, including old meander scars and terraces can be seen on the modern valley floor. In most cases these channels have been modified in some way or are cutoff from the main channel by levees or filled areas of the floodplain, creating discontinuous overbank channels. These channels, though not functioning biologically or morphologically as they did in the past, still provide some function by collecting and filtering runoff from adjacent land, thereby reducing pollutant loads to South Scappoose Creek. Several backwater channels also are well-vegetated with native riparian species and therefore may provide some wildlife benefit.

The mid-19[th] century to the early 20[th] century was likely a period of rapid change in land use and stream morphology on the lower Scappoose Creek valley floor. Any large conifers that were present on the valley floor were often the first to be removed by an early wave of settlers to the area. Trees on the valley floor were large and grew quickly due to the presence of deep, fertile soils and year-round access to moisture in the valley bottom. Following removal of much of the marketable timber, agriculture and grazing took hold on the fertile soil. Development of agriculture requires clearing land, building levees, and controlling local and tributary drainage. Over time, this process affected most of the valley floor, resulting in confinement of South Scappoose Creek into a narrow riparian corridor. It is also likely that the creek was forced into a single channel at the margins of the valley floor to maximize usable farmland, a process which likely resulted in early channel incision.

The historic South Scappoose Creek channel and floodplain supported a healthy ecosystem by building and maintaining physical habitat that supported salmonids and other aquatic organisms. Physical habitat can be defined as the structure of the channel such as deep pools, clean riffles dominated by recently deposited gravel, and undercut banks. These physical habitat elements support salmonids in all stages of their life cycle by providing good quality spawning habitat, refuges from high flow conditions in the winter, and hiding places for both migrating adults and rearing juveniles. The key element in generating and maintaining good physical habitat relates primarily to two things: the channels morphologic response to discharge, sediment, and debris (Bellamy et al, 1992; Benda, 1990; Best and Keller, 1986; Grant and Swanson, 1995; Harris, 1988; Lanka and Hubert, 1987; Miller, 1994; Pitlick and Van Steeter, 1998), and the presence of roughness elements such as large woody material, bedrock outcrops, and boulders (Keller and MacDonald, 1995; Poff and Allan, 1995; Keller and Swanson, 1979; Keller et al, 1981).

In the South Scappoose Creek study area, both of these key elements have been modified over time to maximize economic use of the valley floor. Constricting the channel and reducing total floodplain area has created a more homogeneous, less dynamic environment where the range of physical habitats necessary to support all life stages of salmonids have been greatly reduced. Flood flows are now focused into an entrenched primary channel in most places with a lack of functional floodplain. The entrenched channel and lack of frequent access to the floodplain has resulted in higher flow velocities and more energy focused on the bed and banks of the channel. Consequently, the channel has incised, exposing steep banks that are prone to erosion.

Roughness elements, such as large cedar and Douglas fir logs are no longer present to the extent they were historically and do not play as much of a role in creating physical habitat. Historically, roughness elements, especially large woody material, were abundant, creating obstructions, diversity in the velocity field, and cover habitat for fish. Large woody material played a major role in creating a dynamic channel and floodplain dominated by avulsions, point bar formation, secondary channels, and backwater channels by creating obstructions to flow. These historic channel shifts were important in cleaning old spawning beds and creating new ones, limiting bed armoring, and scouring out deep pools and undercut banks. Without such obstructions present in the channel and on the floodplain, and limited potential for future recruitment due to the lack of large conifers on the floodplain, the opportunity to create physical habitat in the future through natural processes is limited.

The quantity and distribution of roughness elements in a channel also plays a role in dissipating energy. The amount of energy a given discharge exerts can be equated to the unit stream power. Stream power is a function of the discharge and the water surface slope. Roughness elements, such as large woody debris or bedrock outcrops, can resist or deflect flow, increasing the overall flow length and causing the flow to backwater as local velocities decrease. Both of these factors can reduce the local slope, thereby reducing local stream power. By reducing local stream power the stream is less likely to incise, less likely to erode banks, and more likely to deposit gravel which is important to anadromous fish populations.

A morphology consisting of multiple channels, full of large woody material and high quality spawning and rearing areas for salmon, subsequently converted to a system with a relatively narrow riparian corridor that was efficient at moving both water and the watershed products that were delivered to it (e.g. – sediment, large woody material, etc). Consequently, the watershed products that historically created habitat complexity are now transported through the system, or have greatly reduced residence times, which results in simplified morphology and habitat. To evaluate the degree to which the planform of the channel and the extent of riparian vegetation has changed or been modified over the last 60+ years, historic aerial photos were obtained for 1940, 1963, and 1995, and 2005. Each of the aerial photo sets were digitized and rectified using common points that exist in each photo, such as roads and other landmarks. Registration of the photos using GIS software allows for mapping and comparison of results at a consistent scale, independent of the scale or resolution of the aerial photos.

For each of the photo sets, riparian vegetation occurring within a distance of 100 feet from the centerline of the primary channel was digitized into GIS, producing a riparian vegetation layer for each photo set. In addition to riparian extent, the location of the thalweg, which represents the center of the active channel, was mapped for each photo set. Figure 10 shows the mapped extent of riparian vegetation for 1940, 1963, and 1995, and 2005 and Figure 11 shows the historic channel planform. A tabular summary of the results for riparian extent and channel planform is presented in Table 1.

The results for the riparian vegetation analysis vary considerably by reach. Reaches 1, 6, and 8 show an increase in riparian extent from 1940 to 2005, whereas Reaches 2, 3, 4, 5, and 7 show a decline. Where reductions in riparian extent are observed, most of the loss occurs between 1940 and 1963, with a slight recovery in riparian extent between 1963 and 2005. The increase in riparian extent since the 1960's is most likely due to conversion of streamside properties from agriculture or rangeland to residential properties. The most significant losses in riparian vegetation most likely occurred in the mid to late 1800's when the Scappoose region was initially settled and land was cleared for farming. Unfortunately, aerial photos are only available back to 1940.

The channel planform results show little to no appreciable change in the overall length of the channel or channel sinuosity, despite several locations where new meanders have formed or meanders have been cut off, leaving old meander scars. Our field analysis suggests that many of the meander cutoffs observed in the aerial photo analysis occurred prior to the recent channel incision, as evidenced by the perched condition of the abandoned channels. Recent changes in channel planform are primarily limited to localized bank erosion and channel widening that in some cases has threatened adjacent properties.

3.3 Bank and Channel Stability

Erosional Processes

There are a variety of erosional processes that contribute sediment to stream channels, including landsliding, slumping, rilling, debris flows, and bank failures. Each process differs by the quantity, timing and grain size of sediment delivered to stream channels. Each process can also be classified into sources that are natural and those that are a result of human land use impacts. Erosion sources can also be classified into those that are episodic and those that are chronic.

Landsliding results from weak geologic formations, steep topography caused by tectonic uplift, and occurrence of intense periods of rainfall and seismic forces. Landslides often terminate at and impinge upon stream channels, sometimes feeding a seemingly endless supply of fine material directly into the channels. In the worst cases, chronic sediment loading from landslides can eliminate pools, riffles and coarse substrate for hundreds of feet below the point of delivery. An important mechanism to store delivered sediment and attenuate sediment delivery downstream relates to the presence of large woody material and debris jams (Keller and Talley, 1979; Keller et al., 1981).

Steep slopes are an important factor in erosion in general and for landslides in particular. Weathered bedrock, soils and colluvium are subject to saturation by rainfall. Saturated conditions can produce a nearly instantaneous and deadly failure of a rapidly moving landslide called a *debris flow*. Debris flows occur during intense periods of rainfall after hundreds of years of persistent slope wash and colluvium accumulation in swales. The swales are often underlain by bedrock, which has a lower permeability than the overlying colluvium. When the rate of rainfall exceeds the rate that the colluvium and soil can drain water off, the saturated zone or water table above the less permeable bedrock deepens. When the saturated mass overcomes the resistance holding it on the hillslope, the mass liquefies instantly and moves down the hillslope carrying trees, soil, and whatever else is in its path. In some cases, water separates from the debris flow mass as it reaches lower gradients and a debris torrent is unleashed - a wall of mud and debris that moves very fast and is extremely destructive.

Road building is a common and often dominant theme in land use disturbance. From farm road development to driveways and public thoroughfares, roads are required for access to nearly every land use. Roads are also by far the most destructive element in the landscape as far as excessive fine sediment generation per unit area. Roads constructed along canyon floors and steep inner gorge slopes cause channel realignment resulting in direct delivery of sediment to streams. Erosion from road surfaces, ditches, shoulders and other human-induced land clearing contribute mostly fine-grained sediment. Paved and unpaved roads modify local hillslope drainage patterns, concentrate flow and increase runoff rates. Runoff on roads concentrates over soils exposed on the roadbed and shoulder, drainage ditches, road cuts, sidecasts and fills. In terms of managing sediment loads to reduce aquatic habitat impairment, fine sediment source reduction from roads will often be the most effective treatment. Road crossings can also impact the channel erosion by constricting access to the floodplain and increasing velocities around bridges.

Urbanized or urbanizing stream channels, such as South Scappoose Creek, contain other hydraulic controls, including bridges, pipeline, flood plain fill areas, bank protection structures and road crossings that affect sediment transport continuity and hydraulic forces during floods. These infrastructure features often cause local channel adjustments in streambed profile, that are susceptible to erosional damage due to long term channel bed lowering, or degradation, and to scour damage, or the short term lowering of the bed during a flood event.

Bank erosion, reworking of old floodplain deposits, and drainage network expansion associated with gullying also contributes significantly to the amount of fine sediment in the channel. These sources contribute fine sediment directly to the channel and have a significant impact on aquatic habitat conditions. Reworking of old floodplain deposits that might have been delivered to the stream channel due to historic land uses may be especially important in the Scappoose Creek watershed due to a history of logging and splash damming.

Bank Erosion Processes

Stream bank erosion is a natural process in alluvial streams, which flow within the unconsolidated and recently deposited sediments underlying a valley floor. Research on alluvial streams indicates that the natural tendency of channels is to meander in an attempt to minimize the variation in energy expenditure in the downstream direction. In other words, the stream would prefer to take a longer path if the rate of energy loss to heat and kinetic energy was more evenly distributed along the entire reach. Meandering streams move across their valley floors through erosion of the outer bank and aggradation on the inner bank (point bar), as sediment is transported down valley. Areas contained within the zone of meandering, or meander belt, are susceptible to erosion. As will be discussed below, there are many factors that affect the resistance of banks to erosion (the effect of vegetation being a primary one) and the opposing hydraulic force driving erosion, including the tendency of the stream to create a channel geometry (width and depth) and pattern that reflects the balance of flow and sediment transport.

At a basic level, bank erosion occurs when the hydraulic force of flow undermines the lower portion of the bank, leading to upper bank failure by mass wasting (slump, block fall, or debris slide) (Figure 9). Many erosion failures occur on the recession of large floods when the upper bank is saturated and long duration flows impinge and erode the lower bank. Sometimes erosion occurs during moderate or small floods, indicating that the progression of undermining the bank toe has been ongoing or that erosion of the channel bed has occurred through migration of a headcut or knickpoint along the bed. In any case, the factors affecting lower bank erosion are a primary concern in designing bank protection, because it is the location of maximum hydraulic force and the lower bank stability will dictate upper bank stability.

The lower stream bank area generally encompasses the lower third of the overall bank height. From the lowest point in the streambed (thalweg or flow line), the lower third of the bank is saturated and exposed to flow in most years. The resistance of the lower bank to erosion is dictated by the nature of its geologic materials and the degree to which they are cohesive or lithified. Clay rich sediments tend to be more cohesive than sandy sediments or coarse gravels and cobbles. In some cases circulation of groundwater can cement sediments with calcium carbonate or silica precipitates and increase their resistance. Stratification can be very important as lenses of erodible sand may be wedged between layers of cohesive silts and lead to block failures of the lower bank once the sand is eroded out.

Floodplain reclamation practices often involve deepening and straightening stream channels, which increases bank height above natural height. The height of the bank is an important factor as it dictates the upper bank mass and the degree to which hydraulic force exerted on the channel bank will increase as discharge in the stream increases. Steep, high banks are generally less stable than low, flat banks, regardless of the resistance of bank materials. This results in an entrenched or incised channel that limits overbank flow onto the floodplain during a flood. If storm flow is able to access its floodplain it will decrease flow depth, both within the channel and on the floodplain, and dissipate the hydraulic force in the channel. In urbanized areas, efforts are often made to contain the flood flows within the channel, thus exponentially increasing the hydraulic force to erode and transport sediment from the stream channel itself.

Shear stress is the critical force necessary to mobilize sediment and erode the streambed; the greater the shear stress, the larger the particle size the flow is capable of entraining. Since shear stress is a function of the depth of flow and the slope of the water surface, a steeper channel will exert greater erosive force on the streambed given the same discharge. In addition, hydraulic radius is also directly proportional to the erosive capability of the water. The compounded impacts of both channel confinement and incision exacerbate channel erosion of the lower bank and oversteepening of the upper banks, eventually leading to upper bank failure.

A very important factor in lower bank stability is the topographic stability of the streambed. Incised streams can experience bed degradation as the channel profile adjusts to restore a flatter gradient. The rate of erosion depends upon the frequency of erosive flood events and the erosional resistance of the bed material. Often, the bed is lowered through a process of "headcutting", or upstream migration of a local drop in the streambed profile. Headcuts or knickpoints migrate upstream as flow spills over the steepened section, creating a peak in the local shear stress or erosional force. Knickpoints can immediately lower the bed profile by several feet during a flood, leading to immediate lower bank erosion and loss of upper bank stability.

Vegetation plays an important role in lower bank stability. Vegetation cover is often variable in an incised channel. In some cases, the lower banks are too steep or unstable to be suitable for vegetation establishment. Woody riparian plants species such as willow (*salix spp*) and alder are naturally adapted to the lower banks and scour zone of streams. These plants and other woody riparian species rely on fresh mineral soils deposits for germination and usually move into recently disturbed areas of the stream or flood plain. Riparian species develop substantial root structures, and once established, significantly increase the stability of a bank. In addition to providing soil cohesion and bank stability, vegetation provides shelter for insects and animals, decreases water temperatures by creating shade, and is a necessary component for streamside ecological function. The natural and physical benefit of bank vegetation is significant, and any future restoration efforts should include riparian vegetation enhancements, wherever possible.

Upper bank stability is primarily dependent upon the buttressing effect of the lower bank, the geotechnical properties of the bank materials and the rooting strength provided by riparian trees. In cases where the lower bank has been eroded, the ability of the upper bank to stay intact is a function of the internal angle of friction and the degree of cohesiveness. These factors depend upon the origin of materials, but in general a clay loam will have greater strength than well-sorted sand. In the stream environment the resistance of the upper bank can be decreased by saturation, which will increase mass and can reduce the internal angle of friction.

As in the lower bank, vegetation can play an important role in upper bank stability. Root systems of large trees and smaller plants increase the cohesive strength of soils. A key factor in overall bank stability is the rooting depth of vegetation and the percentage of vegetation cover. When erosional forces on the lower bank are able to work below the rooting zone, the rate of erosion can be greatly accelerated. This can lead to rapid change in channel location and morphology, sometimes referred to as a threshold change. This rapid change is often characteristic of incised channels where channel bed degradation and headcut migration is active; the lower bank is rapidly eroded under the root zone and the upper bank fails in blocks of root-bounded soils.

Conditions on South Scappoose Creek

The most significant concern in the project area, in terms of impacts to existing infrastructure, loss of property, and introduction of excessive fine sediment loads to the channel, is associated with long-term and system channel incision and the resulting risk of excessive bank erosion and retreat. Simon and Hupp (1986) present a six stage model describing the long-term evolution of incised channels. The model hypothesizes that channels go through a series of stages, whereby the incised condition eventually is remedied, resulting in a more natural channel with functional floodplain inset into the historic floodplain (Figure 12). Based on our observations, South Scappoose Creek is in Stage 4 (degradation and widening), and in some areas is transitioning into Stage 5 (aggrading and widening). Stage 5 consists of continued bank erosion, combined with an aggradation phase resulting from deposition of material eroded from the banks in Stage 4, and constitutes the "floodplain building" phase of the channel evolution model. The widening phases (Phases 4 and 5) are often the most destructive in that they affect adjacent properties and infrastructure and can completely remove narrow riparian corridors that provide shade and large woody debris to the creek, essential to healthy salmon habitat.

Stream banks within the South Scappoose study area, especially those between the Dutch Canyon and Columbia River Highway crossings, were observed to be heavily incised and in many cases, near vertical (Figure 13). The steep banks are due to of a range of past land uses, both locally and regionally, that have caused channel incision and reduced access to functional floodplain. In addition to local land use impacts that have encouraged incision, it is possible that regional impacts, such as flood control and construction of levees on the Columbia and Willamette Rivers, created additional profile instability along South and North Scappoose Creek. Based on historic and current stage data at a USGS gage on the Columbia River, located at Vancouver, construction of dams and levees on the Columbia may have reduced the elevation of historic flooding in Scappoose Bay, thereby affecting flooding and sedimentation patterns in the lower Scappoose Creek watershed. According to the gage data, frequent flooding in the Scappoose Bay watershed prior to 1940 reached approximately elevation 30 NGVD (Figure 14). After 1940, gauge data records show that large flood events typically only reach elevation 25 feet NGVD. Although a difference of five feet in the depth of flooding may not appear to be significant, a five foot difference in elevation in the lower watershed would significantly reduce the base level of lower Scappoose Creek, resulting in the potential for headcut migration upstream, well beyond the 30 foot contour.

Evidence of historic headcutting was observed during the field assessments and through an analysis of the longitudinal profile of the channel (Figure 8). Regionally, an apparent zone of channel instability was identified in the longitudinal profile in the area just downstream of the confluence of South and North Scappoose Creeks. On North Scappoose Creek, the last 500 feet of channel, before it conflues with South Scappoose Creek, is oversteeped, creating a grade difference of approximately six feet over several coarse riffles. The mouth of North Scappoose Creek can be characterized as depositional. Coarse bed load from the higher gradient lower reaches of North Scappoose Creek are delivered into a "fan-like" feature at the confluence with South Scappoose. This coarse fan, consisting primarily of rounded cobble, creates resistance to the incision that is evident on South Scappoose Creek. The result has been local incision and steepening of the North Scappoose fan, abandonment of several secondary floodplain channels, and an inability of the observed headcut to migrate further upstream on North Scappoose Creek. Below the confluence, a series of steep riffle may represent an area of future planform instability, whereby the riffles, or distributed headcuts, would migrate upstream, lowering the bed and steepening banks. This area should be monitored in the future to determine if headcutting is occurring, although the coarseness of the bed material through this reach may provide resistance to future headcutting.

Evidence of a coarse bed at the confluence of North and South Scappoose Creek is shown in Figure 15. Pebble count data was collected at four locations along South Scappoose Creek and at one location on North Scappoose Creek, as shown in Figure 7. Pebble counts consist of direct measurement of at least 100 particles, randomly selected within a specified geomorphic feature such as a bar, riffle, or channel bed. From these data, statistics are produced to determine a grain size threshold at which a certain percent of the sample is less than, referred to as the D_{16}, D_{50}, or D_{84}. Samples 2 and 3 were collected on North Scappoose at the confluence and on South Scappoose at the confluence, respectively. The results suggest a cobble dominated bed with D_{50}'s of 60mm and 47mm for North and South Scappoose, respectively. These results contrast with the samples collected upstream, through the City of Scappoose, where D_{50}'s range between 1mm and 21mm, suggesting a bed dominated by fine material and gravel, which is significantly more mobile during a peak discharge event.

Localized evidence of past headcutting can be observed at the existing stream crossings. All of the bridges between the railroad bridge and the Dutch Canyon crossing exhibit an observed grade break of between 6 inches and 2 feet. At each bridge, rock has been placed along the entire bed to protect the bridge pilings and steep riffles are present at the downstream sides of the crossings. In some cases, the riffles at the bridges are the only significant grade drops along the reach. Other evidence of historic headcutting occurs on tributaries entering South Scappoose, including Coal Creek and North Scappoose. The Coal Creek tributary is perched approximately 4 feet above the bed of South Scappoose Creek and the lower end of the tributary is actively incising and widening.

To evaluate bank erosion potential through the project area and identify specific areas of severe erosion, SH+G conducted a bank and channel stability assessment in the summer of 2008. The assessment area included the entire project reach from the Raymond Creek confluence downstream to the West Lane Bridge. Erosion potential was evaluated for both the right and left banks separately and each bank was assigned a hazard rating from very low to extreme, referred to as the Bank Erosion Hazard Index (BEHI). Erosion potential was determined using an assessment approach adopted from Rosgen (1994). The Rosgen method is based on the assumption that the ability of a stream bank to resist erosion is primarily determined by seven components:

- The ratio of streambank height to bankfull stage,
- The ratio of riparian vegetation rooting depth to streambank height,
- The degree of rooting density,
- The composition of streambank materials,
- Streambank angle,
- Bank material stratigraphy and presence of soil lenses, and
- Bank surface protection afforded by debris, vegetation, or resistant material such as boulders or bedrock.

These seven components are evaluated in the field by measuring reach length, flow distribution, erodibility, bankfull width, bankfull width at two times the bankfull depth (i.e. – channel entrenchment), bank height, bankfull depth, sinuosity, bank angle, percent bank face protected, percent root density, rooting depth from top of bank, bank material particle size, bank material sorting, bank soil stratification, streambed material, and stream gradient. Each field parameter was determined for relatively homogeneous stream and bank segments by averaging each parameter along the segment length. Bank parameters were determined for left and right banks (looking downstream) separately to determine the final index values for each stream segment. The bank erosion potential for each field segment is then determined based on the rating table developed by Rosgen and summarized in Table 2. Adjustments are made to the final score based on bank material and bank stratification to produce a final score for each segment. The final score is then assigned a bank erosion hazard index (BEHI) rating of very low, low, moderate, high, very high, and extreme.

Results for each survey segment were tied to a GIS layer using field-based GPS data. The results are presented in Figure 16. Table 3 provides a statistical summary of the BEHI results. In addition to the BEHI, channel and bank stability data, including locations of active bank erosion, headcuts, the condition of tributaries entering the mainstem, the location of large debris jams (consisting of large woody debris), and other points of interest were noted and are shown in Figure 16.

A majority of the banks within the study area were classified as a moderate risk of erosion. Within the critical portion of the channel between Highway 30 and the Dutch Canyon crossing, most of the banks are either characterized as having a moderate to high risk of erosion. Additionally, within this segment, 11 large active erosion sites were identified out of the 13 total identified in the project area. Although the banks are steep and there is considerable concern about bank erosion through the City of Scappoose, the channel planform analysis suggests that the location of the channel has not changed dramatically over the last half century, except in a few notable locations. Similarly, the erosion potential analysis suggests that future rates of bank erosion are likely to be moderate to low through most of the project area, as opposed to being classified in the high to extreme range.

The primary reason that the bank erosion risk has a moderate rating, as opposed to high or extreme, is the presence of vegetation on the banks, the depth of the rooting zone relative to the height of the bank, and the cohesion of the soils. In addition, the results describe average bank conditions along a relatively homogeneous length of bank. For example, if a 1,000 foot section of bank exhibits very similar characteristics, parameters for that bank are lumped into a single risk type, despite the fact that there may be a short 50 foot section that exhibits other characteristics. To account for this disparity, locations of active bank erosion were identified and mapped and are shown on Figure 16.

RIPARIAN VEGETATION COVERAGE WITHIN 100 FT OF THE MAINSTEM CHANNEL (ACRES)					
		1940	1963	1995	2005
Reach	Length (mi)				
1	0.88	*	8.5	12.7	12.3
2	0.86	5.6*	4.1	3.5	4.4
3	0.47	3.6	1.4	1.1	1.9
4	0.66	4.4	3.0	2.6	3.6
5	1.30	12.6	8.6	8.4	7.6
6	0.55	3.6	5.1	4.9	5.1
7	0.29	4.3	1.6	3.8	2.4
8	0.37	1.8	2.0	5.0	4.9

CHANNEL PLANFORM									
Reach	Contemporary Length (mi)	1940		1963		1995		2005	
		Length (ft)	Sinuosity	Length (ft)	Sinuosity	Length (ft)	Sinuosity	Length (ft)	Sinuosity
1	0.88	*		4661	1.2	4449	1.2	4647	1.2
2	0.86	4066*	1.0	4606	1.2	4563	1.1	4539	1.1
3	0.47	2330	1.2	2412	1.3	2415	1.3	2497	1.3
4	0.66	3525	1.7	3621	1.7	3562	1.7	3507	1.7
5	1.30	7198	1.6	6981	1.5	6790	1.5	6865	1.5
6	0.55	2627	1.2	2720	1.3	2678	1.2	2894	1.3
7	0.29	1966	1.4	1670	1.2	1564	1.1	1544	1.1
8	0.37	2046	1.1	2027	1.1	2087	1.1	1935	1.1

TABLE 1: Summary table of results from the channel form and riparian extent analysis.

*Incomplete aerial photo coverage

Table 2: Bank erosion hazard index values for measured field parameters. A total score and rating is assigned to each field segment based on the following index values.

Bank Erosion Hazard Index												
Criteria	**Very Low**		**Low**		**Moderate**		**High**		**Very High**		**Extreme**	
	Value	Index	Value	Index	Value	Index	Value	Index	Value	Index	Value	Index
Bank Height / Bankfull Height	1-1.1	1-1.9	1.1-1.19	2-3.9	1.2-1.5	4-5.9	1.6-2	6-7.9	2.1-2.8	8-9	> 2.8	10
Root Depth / Bank Height	1-0.9	1-1.9	0.89-0.5	2-3.9	0.49-0.3	4-5.9	0.29-0.15	6-7.9	0.14-.05	8-9	< 0.05	10
Root Density (%)	80-100	1-1.9	55-79	2-3.9	30-54	4-5.9	15-29	6-7.9	5-14	8-9	< 5	10
Bank Angle (Degrees)	0-20	1-1.9	21-60	2-3.9	61-80	4-5.9	81-90	6-7.9	91-119	8-9	> 119	10
Surface Protection (%)	80-100	1-1.9	55-79	2-3.9	30-54	4-5.9	15-29	6-7.9	10-15	8-9	< 10	10
Totals		5-9.5		10-19.5		20-29.5		30-39.5		40–45		46-50

Additional Adjustments and Considerations

Bank Materials:

Bedrock - Bank erosion potential always very low
Boulder - Bank erosion potential low

Cobble - Decrease by one category unless mixture of gravel/sand is over 50%, then no adjustment

Gravel - Adjust values up by 5-10 points depending on composition of sand

Sand - Adjust values up by 5-10 points

Silt/Clay - No adjustment

Stratification:

Adjustment of 5-10 points (upward) depending on position of unstable layers in relation to bankfull stage

Bank Stability Assessment

LEFT BANK

Reach	Distance (ft)	Bank Height / Bankfull Height		Root Depth / Bank Height		Root Density (%)		Bank Angle		% Surface Protected		Bank Erosion Hazard Index
		Ratio	Rating	Ratio	Rating	Percent	Rating	Degrees	Rating	Percent	Rating	
8-3	601	1.5	Moderate	1.0	Very Low	60.0	Low	45.0	Low	80.0	Low	Low
8-2	934	2.0	High	1.0	Very Low	70.0	Low	30.0	Low	80.0	Low	Low
8-1	399	1.7	High	1.0	Very Low	70.0	Low	30.0	Low	80.0	Low	Moderate
7-2	1365	1.7	High	1.0	Very Low	60.0	Low	30.0	Low	80.0	Low	Very Low
7-1	179	1.7	High	1.0	Very Low	70.0	Low	45.0	Low	90.0	Very Low	Moderate
6-3	1263	1.3	Moderate	0.8	Low	40.0	Moderate	50.0	Low	40.0	Moderate	Moderate
6-2	668	3.3	Extreme	0.2	Very High	10.0	Very High	80.0	High	20.0	High	Very High
6-1	963	3.3	Extreme	1.0	Very Low	50.0	Moderate	40.0	Low	70.0	Low	Moderate
5-4	1270	3.3	Extreme	0.5	Moderate	40.0	Moderate	70.0	Moderate	60.0	Low	Moderate
5-3	1920	4.0	Extreme	0.5	Moderate	40.0	Moderate	70.0	Moderate	60.0	Low	Moderate
5-2	2127	3.8	Extreme	0.5	Low	30.0	High	70.0	Moderate	50.0	Moderate	Very Low
5-1	1549	3.0	Extreme	0.5	Moderate	40.0	Moderate	70.0	Moderate	60.0	Low	Moderate
4-3	1923	3.0	Extreme	0.5	Low	30.0	High	80.0	High	40.0	Moderate	High
4-2	1120	3.0	Extreme	1.0	Very Low	50.0	Moderate	70.0	Moderate	60.0	Low	Moderate
4-1	464	0.1	Very Low	0.6	Low	40.0	Moderate	70.0	Moderate	60.0	Low	Low
3-1	2497	3.0	Extreme	0.8	Low	60.0	Low	60.0	Moderate	70.0	Low	Moderate
2-2	1913	1.6	High	1.0	Very Low	60.0	Low	60.0	Moderate	70.0	Low	Low
2-1	2626	2.0	High	1.0	Very Low	50.0	Moderate	60.0	Moderate	60.0	Low	Moderate
1-2	3334	1.3	Moderate	1.0	Very Low	70.0	Low	40.0	Low	90.0	Very Low	Very Low
1-1	1313	2.7	0	0.8	Low	40.0	0.0	70.0	0.0	60.0	0.0	Moderate

RIGHT BANK

Reach	Distance (ft)	Bank Height / Bankfull Height		Root Depth / Bank Height		Root Density (%)		Bank Angle		% Surface Protected		Bank Erosion Hazard Index
		Ratio	Rating	Ratio	Rating	Percent	Rating	Degrees	Rating	Percent	Rating	
8-3	601	1.5	Moderate	1.0	Very Low	40.0	Moderate	45.0	Low	70.0	Low	Low
8-2	934	2.0	High	1.0	Very Low	70.0	Low	30.0	Low	80.0	Low	Moderate
8-1	399	6.7	Extreme	0.8	Low	40.0	Moderate	60.0	Moderate	40.0	Moderate	Low
7-2	1365	1.7	High	1.0	Very Low	60.0	Low	60.0	Moderate	60.0	Low	Very Low
7-1	179	1.7	High	1.0	Very Low	70.0	Low	45.0	Low	90.0	Very Low	Moderate
6-3	1263	5.0	Extreme	0.5	Moderate	30.0	High	70.0	Moderate	40.0	Moderate	Very Low
6-2	668	1.3	Moderate	1.0	Very Low	60.0	Low	45.0	Low	80.0	Low	Moderate
6-1	963	3.3	Extreme	1.0	Very Low	50.0	Moderate	50.0	Low	80.0	Low	Moderate
5-4	1270	3.3	Extreme	0.4	Moderate	20.0	Extreme	80.0	High	40.0	Moderate	High
5-3	1920	4.0	Extreme	0.5	Moderate	40.0	Moderate	70.0	Moderate	60.0	Low	Moderate
5-2	2127	3.8	Extreme	0.5	Low	30.0	High	70.0	Moderate	50.0	Moderate	Moderate
5-1	1549	3.0	Extreme	0.5	Moderate	40.0	Moderate	70.0	Moderate	50.0	Moderate	Moderate
4-3	1923	3.0	Extreme	0.7	Low	50.0	Moderate	80.0	High	50.0	Moderate	Moderate
4-2	1120	3.0	Extreme	1.0	Very Low	50.0	Moderate	60.0	Moderate	70.0	Low	Moderate
4-1	464	2.0	High	0.6	Low	40.0	Moderate	70.0	Moderate	60.0	Low	Moderate
3-1	2497	3.0	Extreme	0.8	Low	60.0	Low	60.0	Moderate	70.0	Low	Moderate
2-2	1913	1.6	High	1.0	Very Low	60.0	Low	60.0	Moderate	70.0	Low	Low
2-1	2626	2.0	High	1.0	Very Low	50.0	Moderate	70.0	Moderate	60.0	Low	Moderate
1-2	3334	1.3	Moderate	1.0	Very Low	60.0	Low	45.0	Low	80.0	Low	Very Low
1-1	1313	2.7	Extreme	0.8	Low	40.0	Moderate	70.0	Moderate	60.0	Low	Moderate

TABLE 3: Summary table of results of the Bank Erosion Hazard Index (BEHI) for South Scappoose Creek.

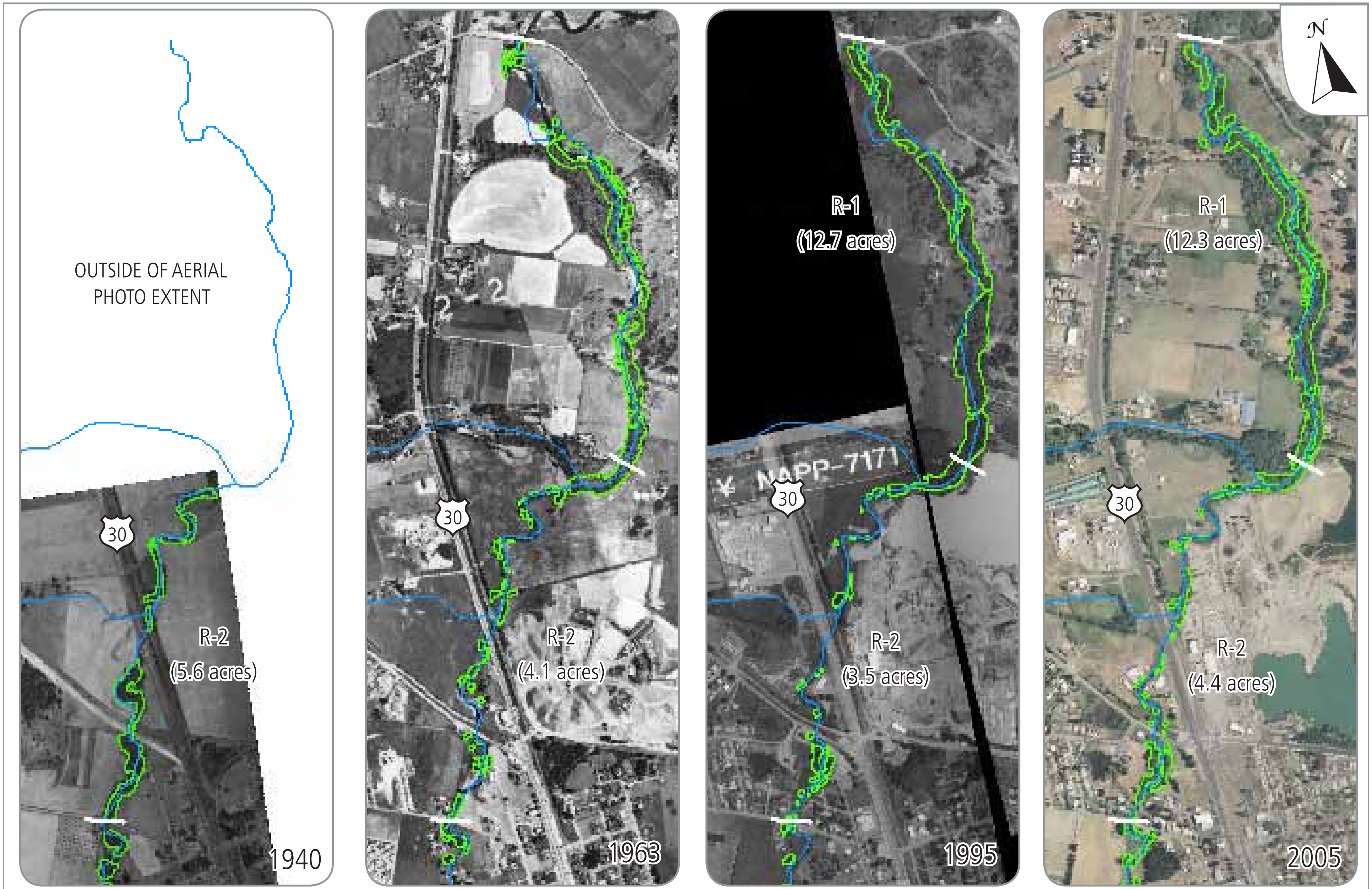

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FIGURE 9: Extent of riparian vegetation mapped from aerial photos for the project area from 1940, 1963, 1995, and 2005. Riparian vegetation was mapped if it occurred within 100 feet of the channel. Generally, results indicate an increase in riparian vegetation since 1940, most likely due to conversion from farm or grazing land uses to residential or rural residential.

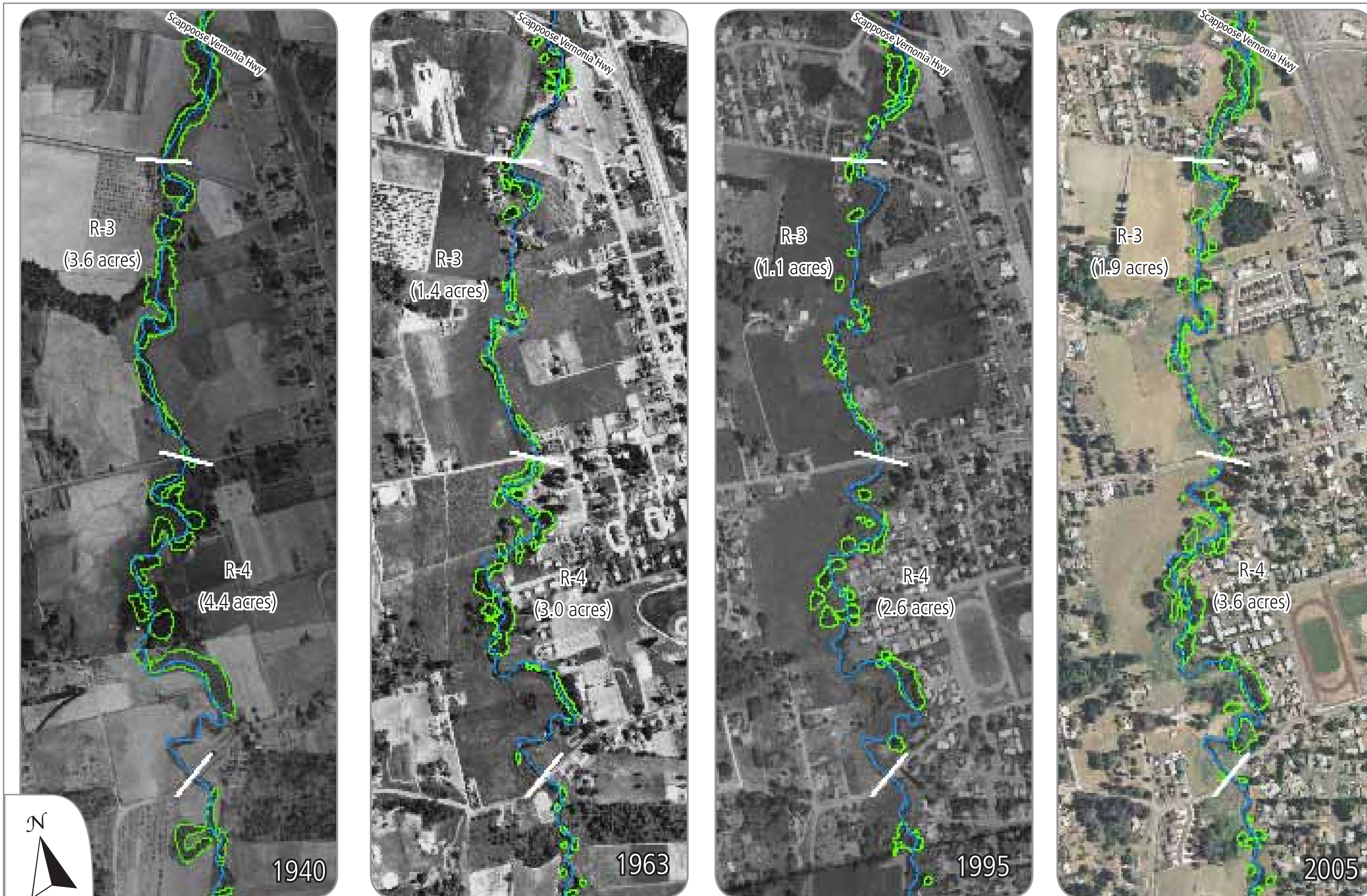

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FIGURE 9 continued...

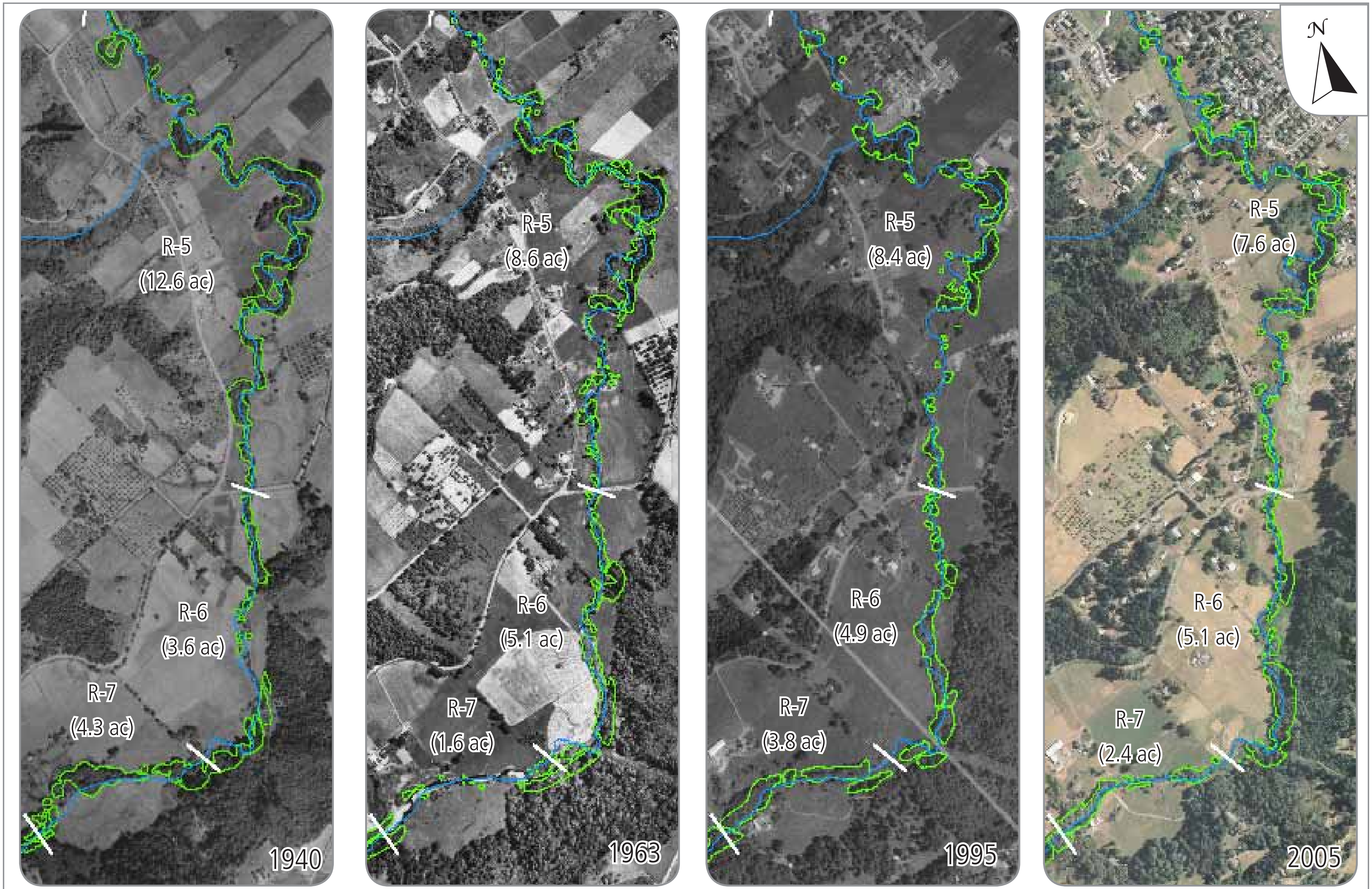

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FIGURE 9 continued...

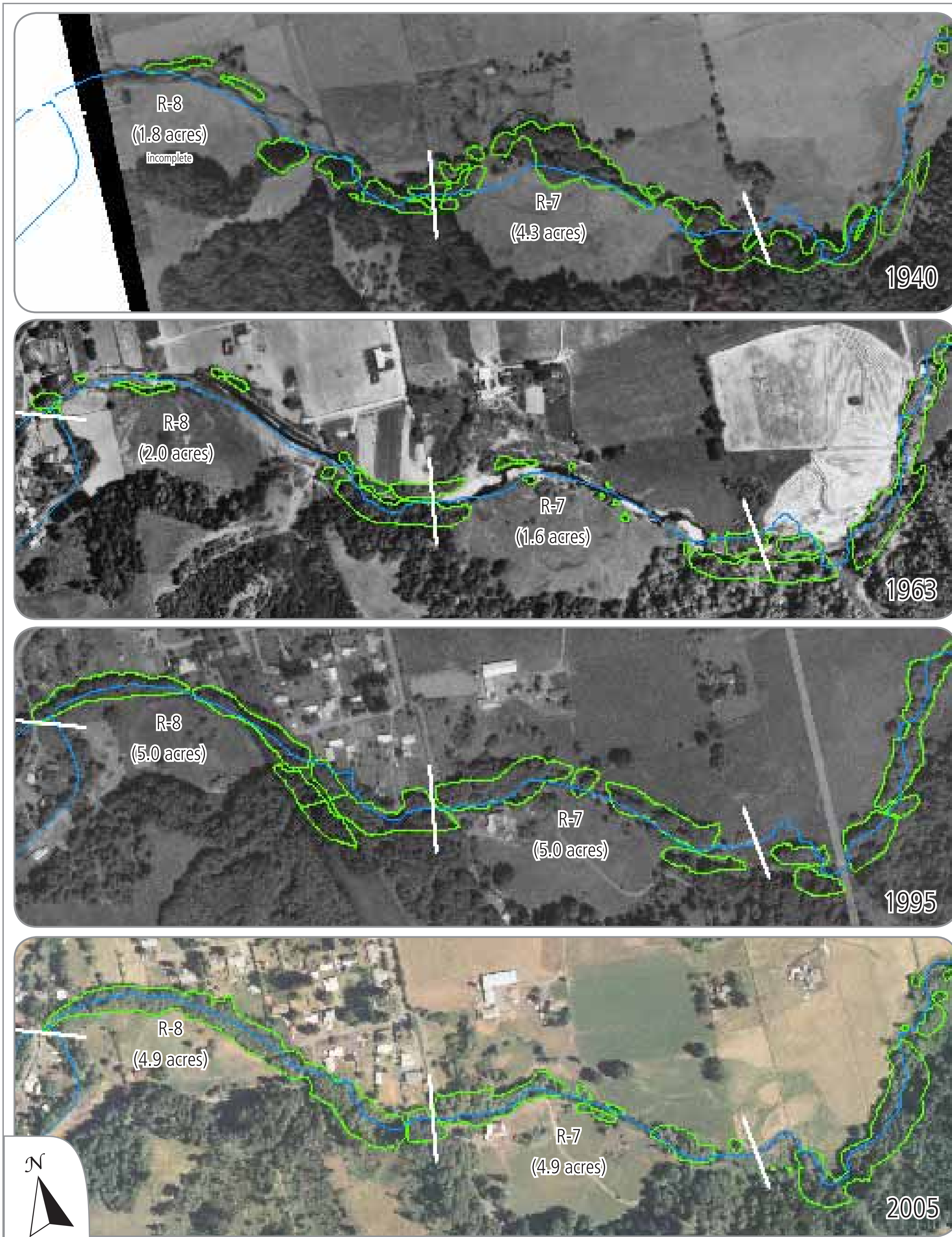

FIGURE 9 continued...

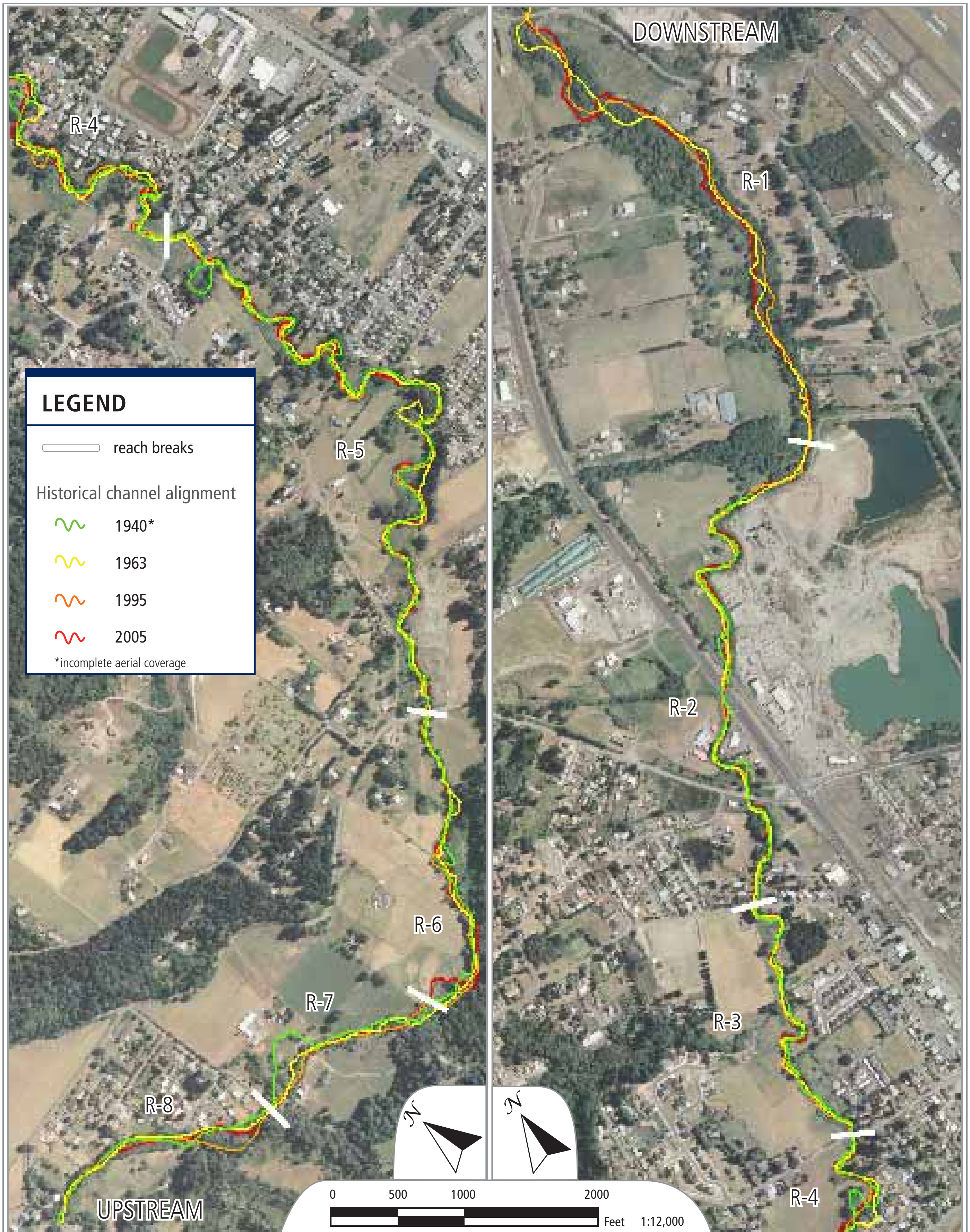

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FIGURE 10: Mapped channel planform from aerial photos of the project area for 1940, 1963, 1995, and 2005. Localized changes in the location of the primary channel were observed over the 65 year study period. The data was also used to evaluate reach-scale changes in sinuosity.

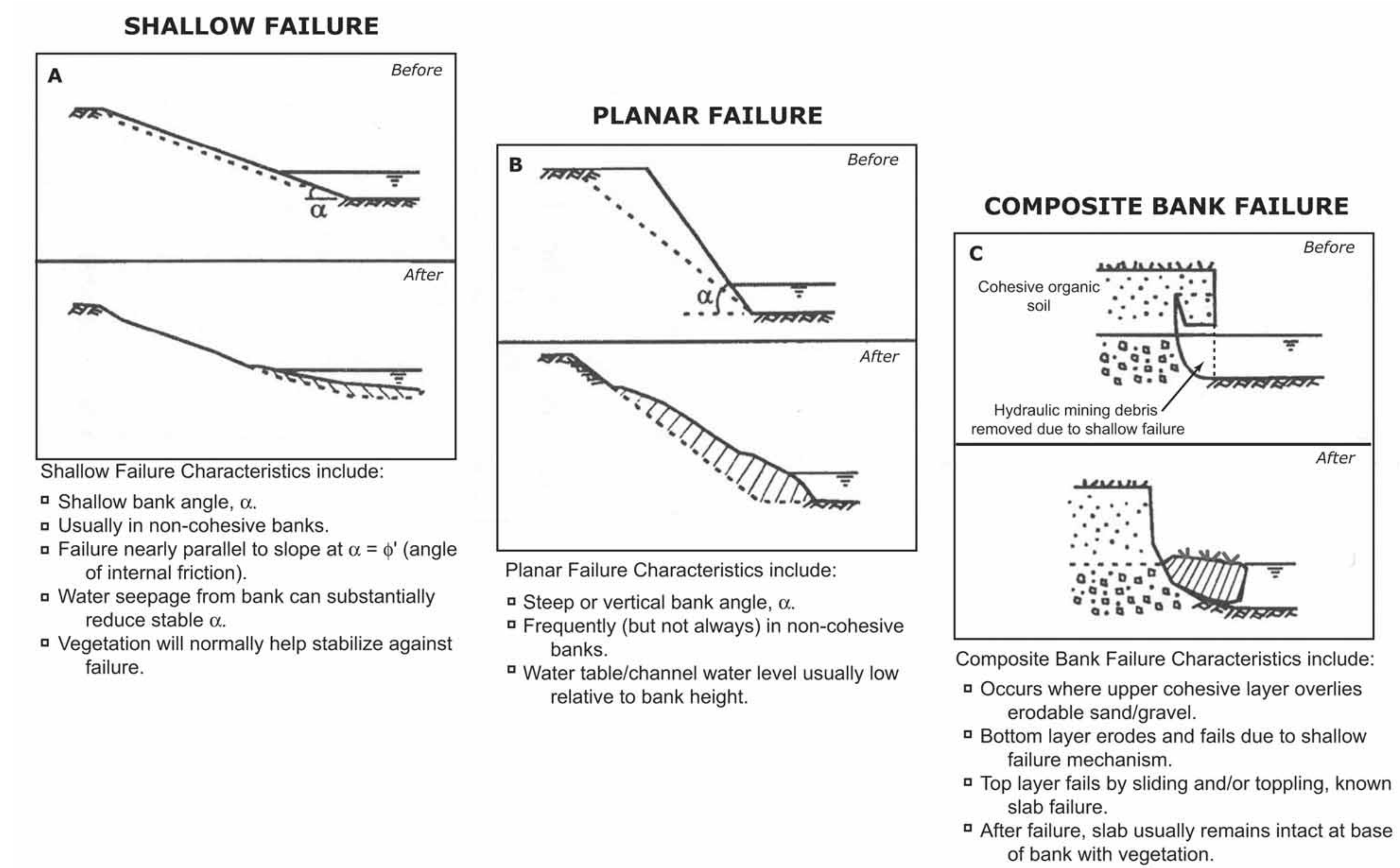

FIGURE 11: Conceptual diagram of the most common types of stream bank failure mechanisms.

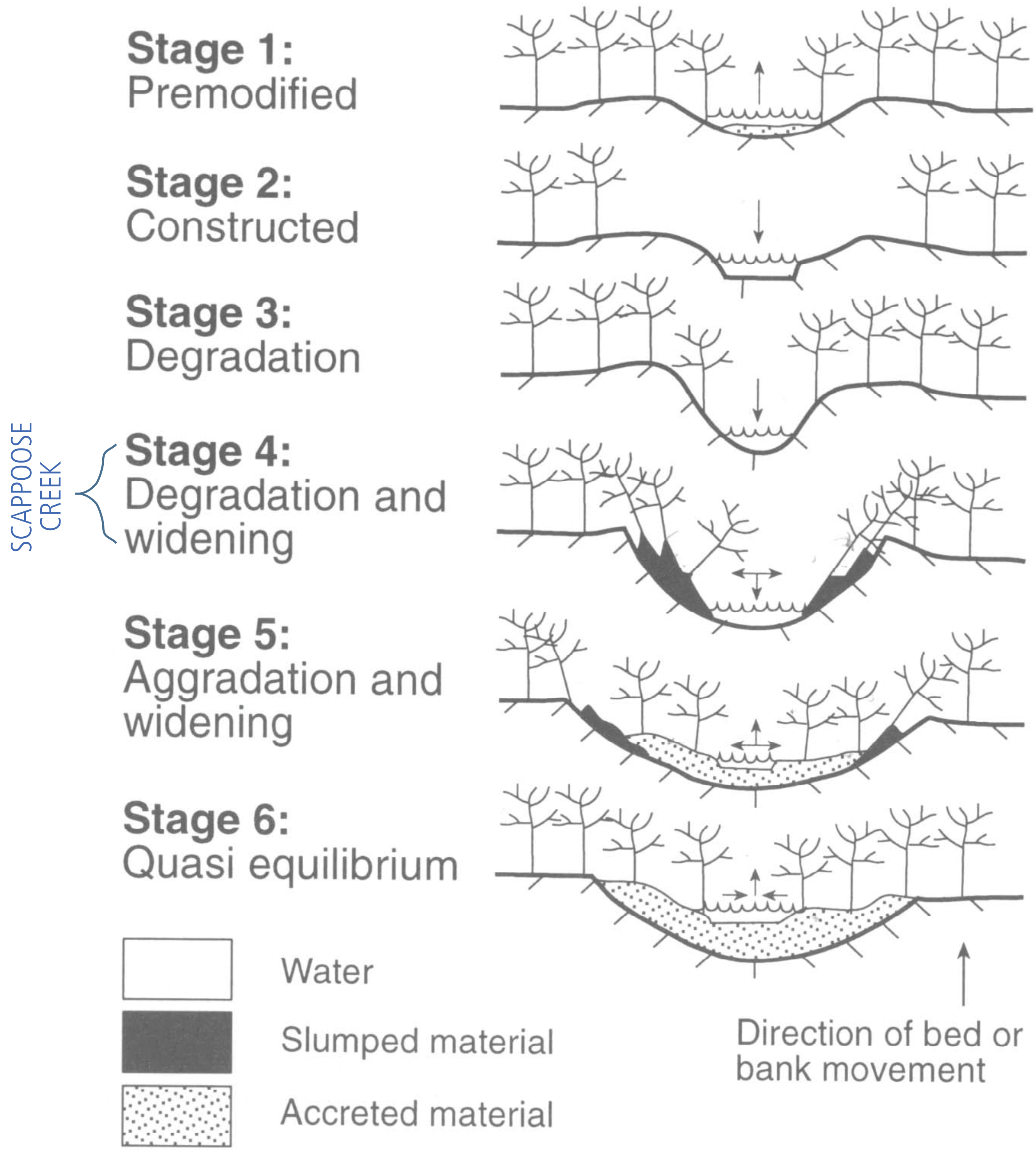

FIGURE 12: Channel evolution model for incised creeks. (Simon and Hupp, 1986)

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FIGURE 13: Examples of active bank erosion along South Scappoose Creek. Areas with the most significant bank erosion occur between Dutch Canyon Road and the Columbia Highway crossing. Note the clumps of grass at the toe of slope in several of the photos, indicating that the primary mechanism of erosion is block failure.

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FIGURE 13 continued...

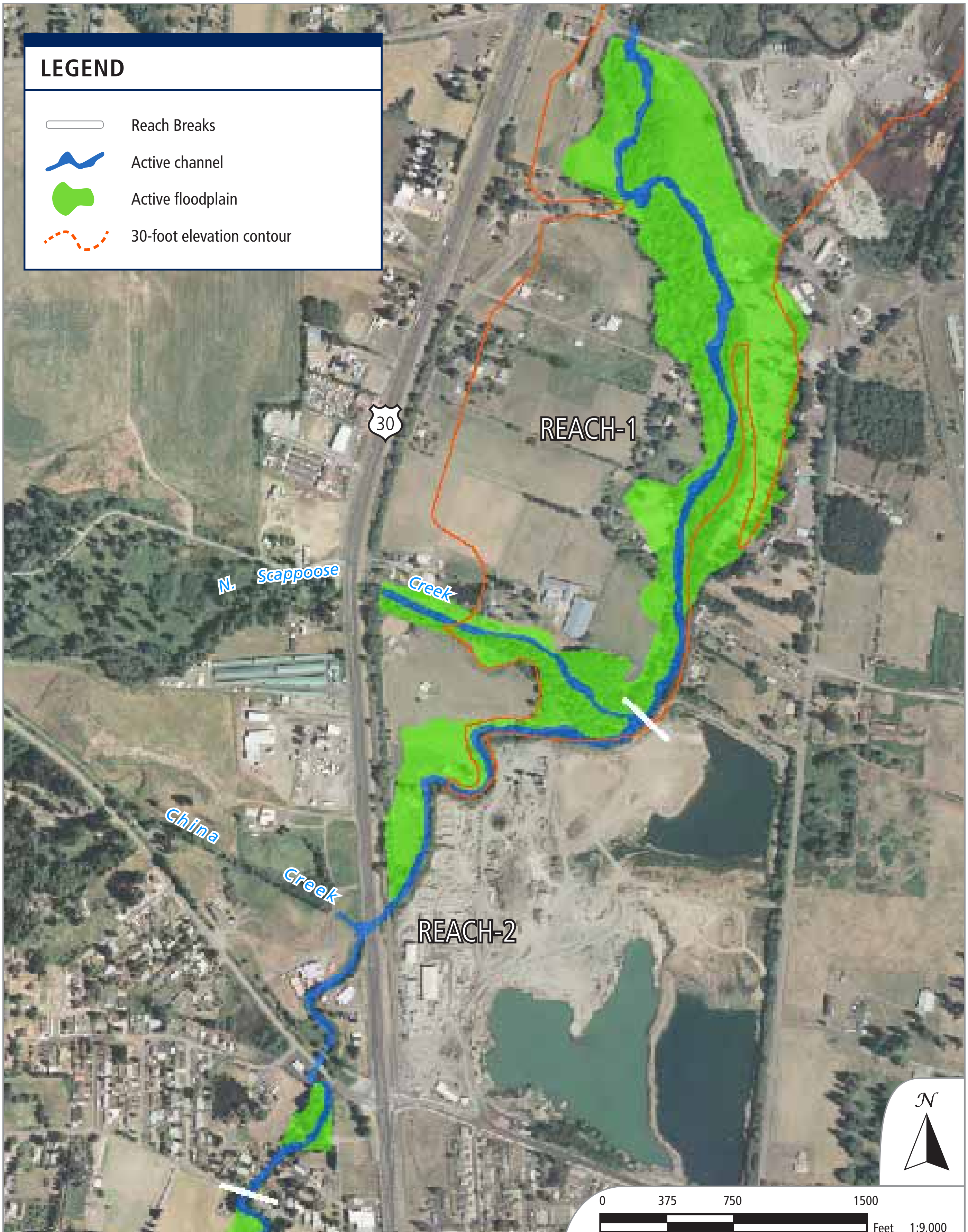

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FIGURE 14: Geomorphic map of project area covered by existing LIDAR data. Mapped features include the primary active channel and adjacent undeveloped areas that are, or have the potential to provide function floodplain and riparian habitat. Also shown is the 30-foot contour which depicts the historic extent of Columbia River flooding.

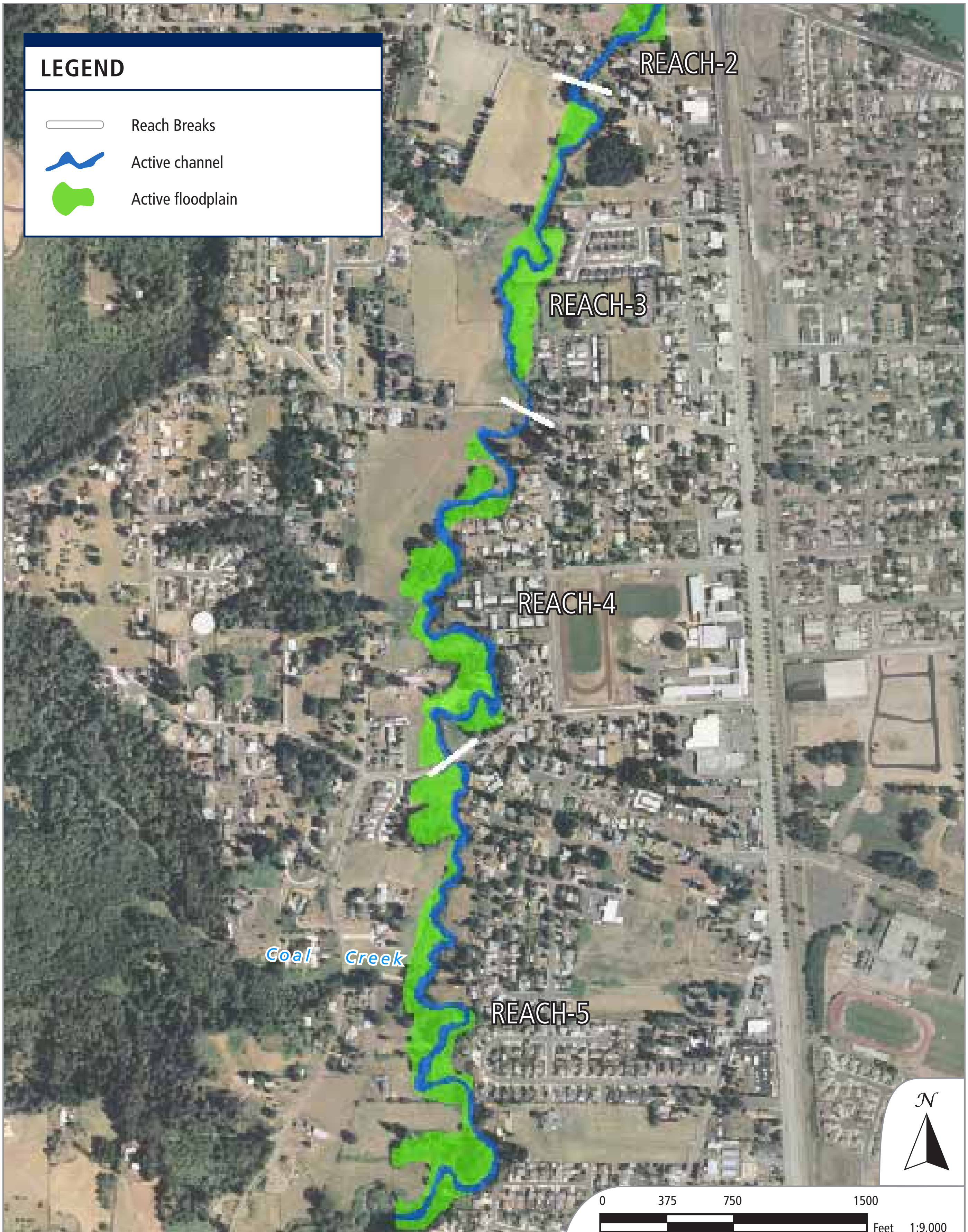

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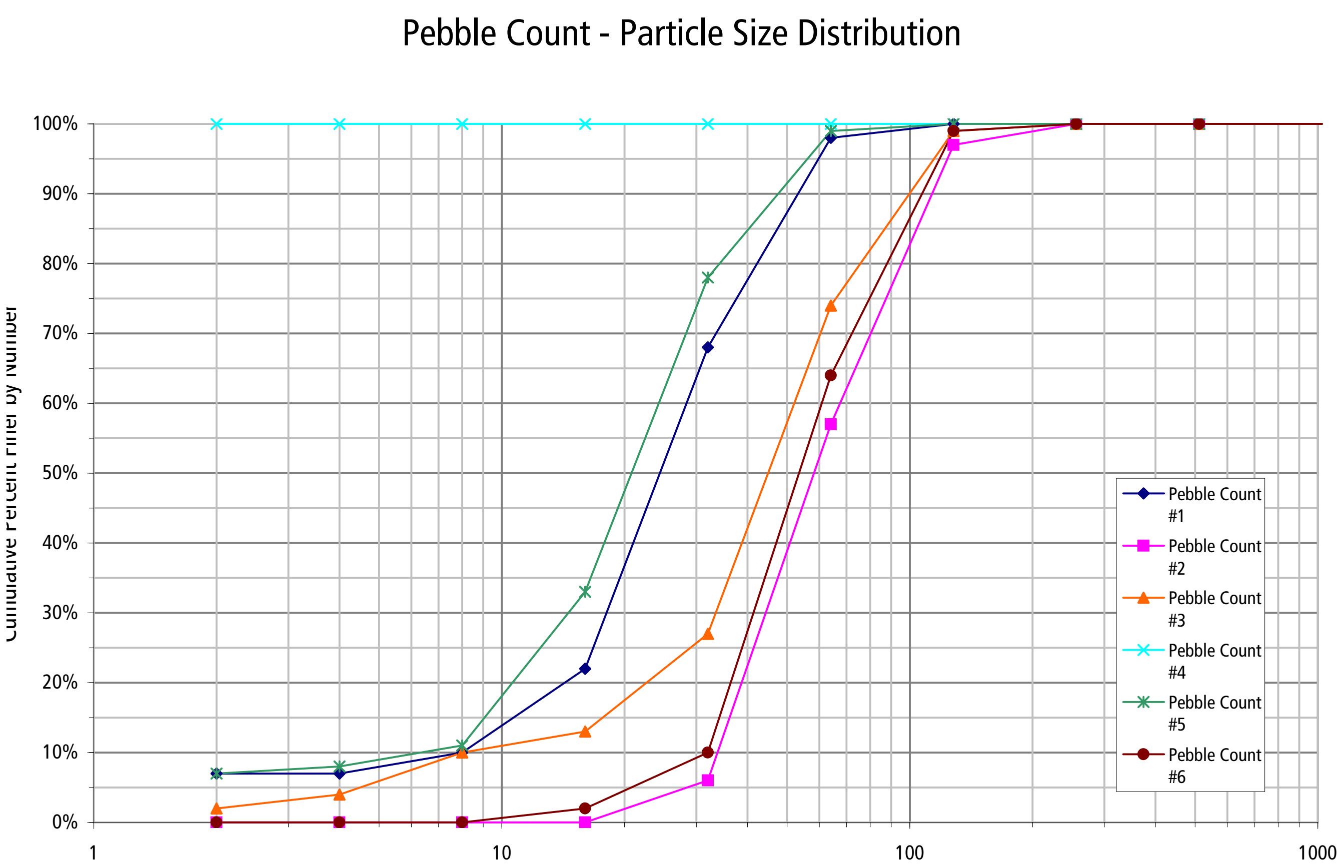
FIGURE 14 continued...



Pebble Count - Results

	Pebble Count #1	Pebble Count #2	Pebble Count #3	Pebble Count #4	Pebble Count #5	Pebble Count #6
	Grain Size (mm)					
D_{16}	13	39	22	1	12	37
D_{50}	29	60	47	1	21	57
D_{84}	38	85	80	1	40	84
mm	Percent Finer					
2	7%	0%	2%	100%	7%	0%
4	7%	0%	4%	100%	8%	0%
8	10%	0%	10%	100%	11%	0%
16	22%	0%	13%	100%	33%	2%
32	68%	6%	27%	100%	78%	10%
64	98%	57%	74%	100%	99%	64%
128	100%	97%	99%	100%	100%	99%
256	100%	100%	100%	100%	100%	100%
512	100%	100%	100%	100%	100%	100%
1024	100%	100%	100%	100%	100%	100%

FIGURE 15: Pebble count results.

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FIGURE 16: A bank and channel stability survey was conducted on South Scappoose Creek through the project area. The selected study approach, based on Rosgen (1996), produced a Bank Erosion Hazard Index (BEHI) for each bank along with site specific bank and bed stability observations.

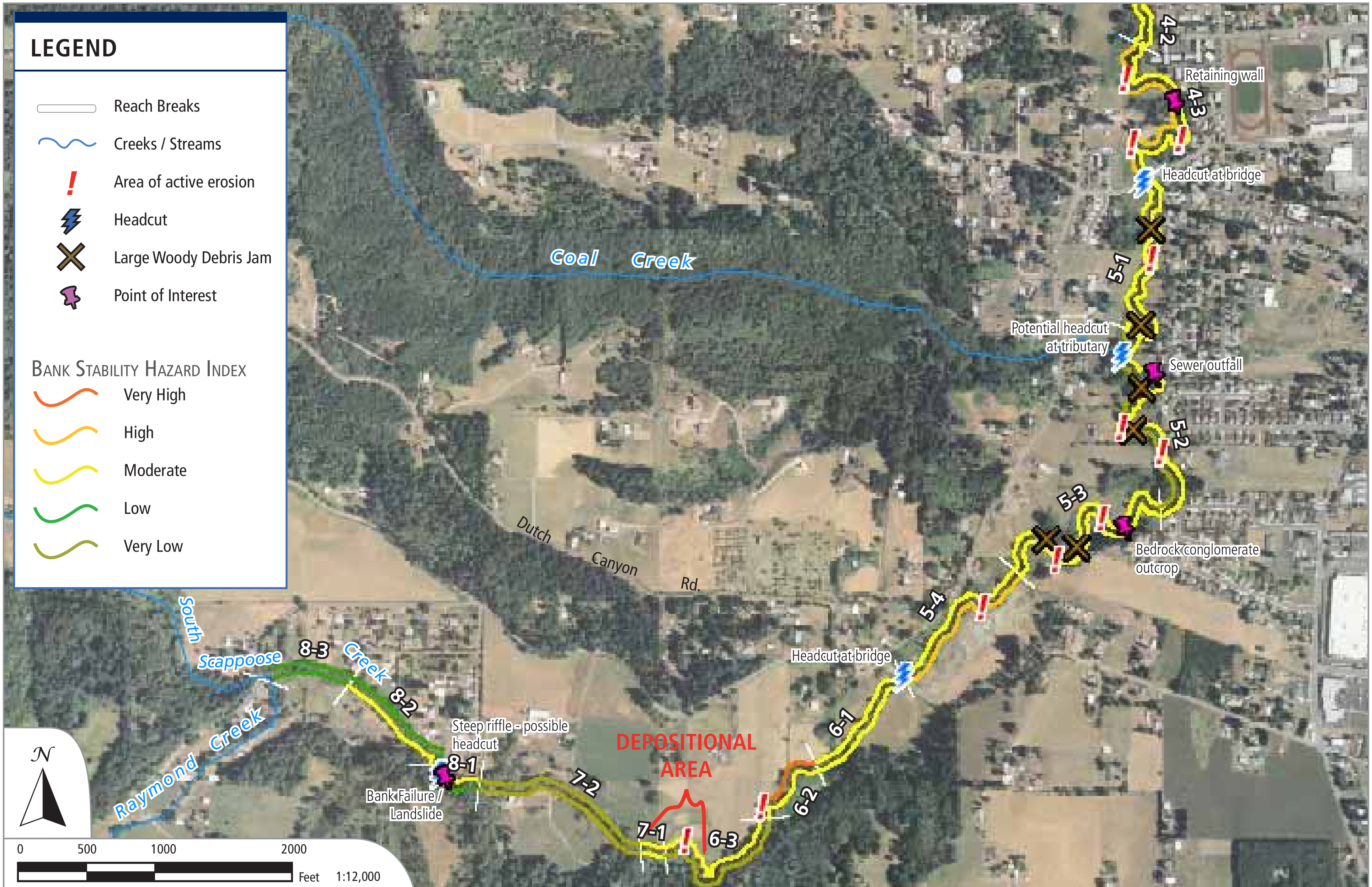

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FIGURE 16 continued...

4. Hydrology and Hydraulics

4.1 Reach Hydrology

Understanding the hydrology of a project reach is a critical when evaluating the impacts of flooding, developing modeling tools, and designing channel restoration design projects. Ideally, hydrologic information for a particular project area is assembled from a long-term streamflow record on the creek of interest, often collected by governmental agencies such as the U.S Geologic Survey or Oregon Department of Water Resources. In the absence of streamflow measurements on the creek of interest, long-term gages on nearby streams with similar morphological and geologic conditions are used. Unfortunately, none of creeks within the Scappoose Bay region have been gaged long-term. The only available streamflow records are for several large tributaries to the Columbia River, on the Washington side, and intermittent records for several tributaries to the Tualatin River such as Dairy and Rock Creek.

In the absence of long-term gage data, discharge information for flood peaks are often derived from a set of regional equations referred to as regional curves. Regional curves are often generated for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year flood events and are developed for large regions using existing long-term streamflow measurements at gaged locations. For the South Scappoose project area, we used regional curves developed by the United States Geological Survey (USGS) (Harris et al. 1979). The results for South Scappoose at the North Scappoose confluence, North Scappoose, Coal Creek, and China Creek are presented in Table 4. These data were used as input peak discharges to the hydraulic model. The advantage of using regional curves is that they provide a straightforward method to calculate peak discharged, since the relationships only require inputs of drainage area (in square miles) and the 2-year, 24-hour rainfall intensity. The drawback is that the same regional curves are used for the entire Willamette Valley which means there is likely to be significant error associated with the results. The magnitude of the error will ultimately affect the quality of the results for the hydraulic model.

Table 4: Flood frequency discharge estimates for the South Scappoose Creek project area using USGS regional curves.

Watershed	2-yr (cfs)	5-yr (cfs)	10-yr (cfs)	25-yr (cfs)	50-yr (cfs)	100-yr (cfs)
South Scappoose	838	1,308	1,638	2,098	2,468	2,857
North Scappoose	1,155	1,805	2,256	2,885	3,391	3,922
China	59	92	116	150	177	207
Coal	40	62	79	103	122	142

4.2 Hydraulic Modeling

To comprehensively evaluate the frequency of overbank flooding, channel hydraulic conditions, and the potential affect that future enhancement scenarios have on channel conditions, we prepared a hydraulic model for a portion of the South Scappoose project area. The hydraulic model was developed using HEC-RAS, the U.S. Army Corps of Engineers one-dimensional hydraulic modeling software. Cross section information was entered into the model using LIDAR data, which limited the scope of the model from the West Lane crossing at the downstream end to just downstream of the Dutch Canyon crossing on the upstream end. Each of the bridges in the project area was surveyed in the field to provide input data into the model and the channel was evaluated to determine hydraulic roughness values for the channel and overbank areas. The hydrology data developed from the regional curves was used to evaluate water surface elevations at each cross-section for the 2-year, 5-year, 10-year, 25-year, and 100-year events.

The results of the hydraulic analysis are presented in Figures 17, 18, and 19. Figure 17 presents a water surface profile for the 2-year, 5-year, 10-year 25-year, 50-year, and 100-year flood events. Frequent flooding (e.g. – 5-year and greater) inundates the adjacent valley floor at the lower end of the project area and at the upstream end of each of the main bridges. In most cases, the bridges are inundated and overtopped in the 25-year, 50-year, and 100-year events. The exception is the E.J. Smith Bridge which appears to be inundated more frequently. The velocity profiles suggest similar hydraulic dynamics (Figure 18) at the existing bridges. Prior to the bridges overtopping, water is forced through the bridges in response to an increase in head on the upstream side of the bridge. The increase in head results in higher velocities through the bridge sections which is likely exacerbated by the steeper grade at the bridge associated with the arrested headcuts. Flow velocities are relatively low upstream of the bridges, where a backwater is created, and high immediately downstream of the bridges. High flow velocities at the downstream side of bridges can exacerbate bank erosion, as was observed downstream of the Raymond Creek Bridge.

It is possible that replacement and widening of several of the bridge crossings through the City of Scappoose, or modifications to the channel cross-sections in the vicinity of the bridges could improve hydraulics and reduce flooding upstream of the bridge. To conceptually test these ideas, SH+G ran several scenarios for the E.J. Smith, E.M. Watts and J.P. West crossings. The scenarios, run for the 10-year event, included the following:

- Modify bridge openings at J.P. West and E.M. Watts (e.g. – lengthen the bridge),
- Modify channel geometry upstream of E.J. Smith,
- Modify channel geometry upstream of J.P. West,
- Modify channel geometry upstream of E.M. Watts,
- Modify channel geometry upstream of both J.P. West and E.M. Watts

Figure 20 outlines the results of the analysis for the channel geometry scenarios. Results for the bridge opening modifications are not presented due to the fact that widening of the bridges provided little in the way of additional conveyance. The results also include water surface elevation changes at the Scappoose-Vernonia Highway Bridge to evaluate the effect on downstream water surface elevations if conveyance is increased at the upstream crossings.

Generally, the results suggest that modifications at E.J. Smith provide little to no benefit to water surface elevations for the 10-year event, primarily due to the fact that the E.J. Smith Bridge is backwatered by the bridge at Scappoose-Vernonia, as evidenced by the similar water surface elevations shown in Figure 20 for the different scenarios. For the other two bridges, the benefits of modifying the channel geometry upstream of each of the bridges increases in the upstream direction, presumably due slight increases in channel gradient and less of a backwater effect from Scappoose-Vernonia. Modifications to the geometry upstream of the bridges would include recontouring and widening of existing banks to maximize conveyance through the bridges. In the case of the modeled 10-year flood, modification to the channel geometry reduces water surface elevations by approximately 0.6 feet at J.P. West and by over 2 feet at E.M. Watts.

These scenarios will require a more rigorous evaluation and assessment of their cost benefit but should be evaluated further with the hydraulic modeling tool to determine their feasibility and benefit across a range of peak discharges. If the crossings are modified, careful consideration should be made regarding the potential impact on profile stability. It will be important to maintain grade control at the bridges long-term to minimize further downcutting.

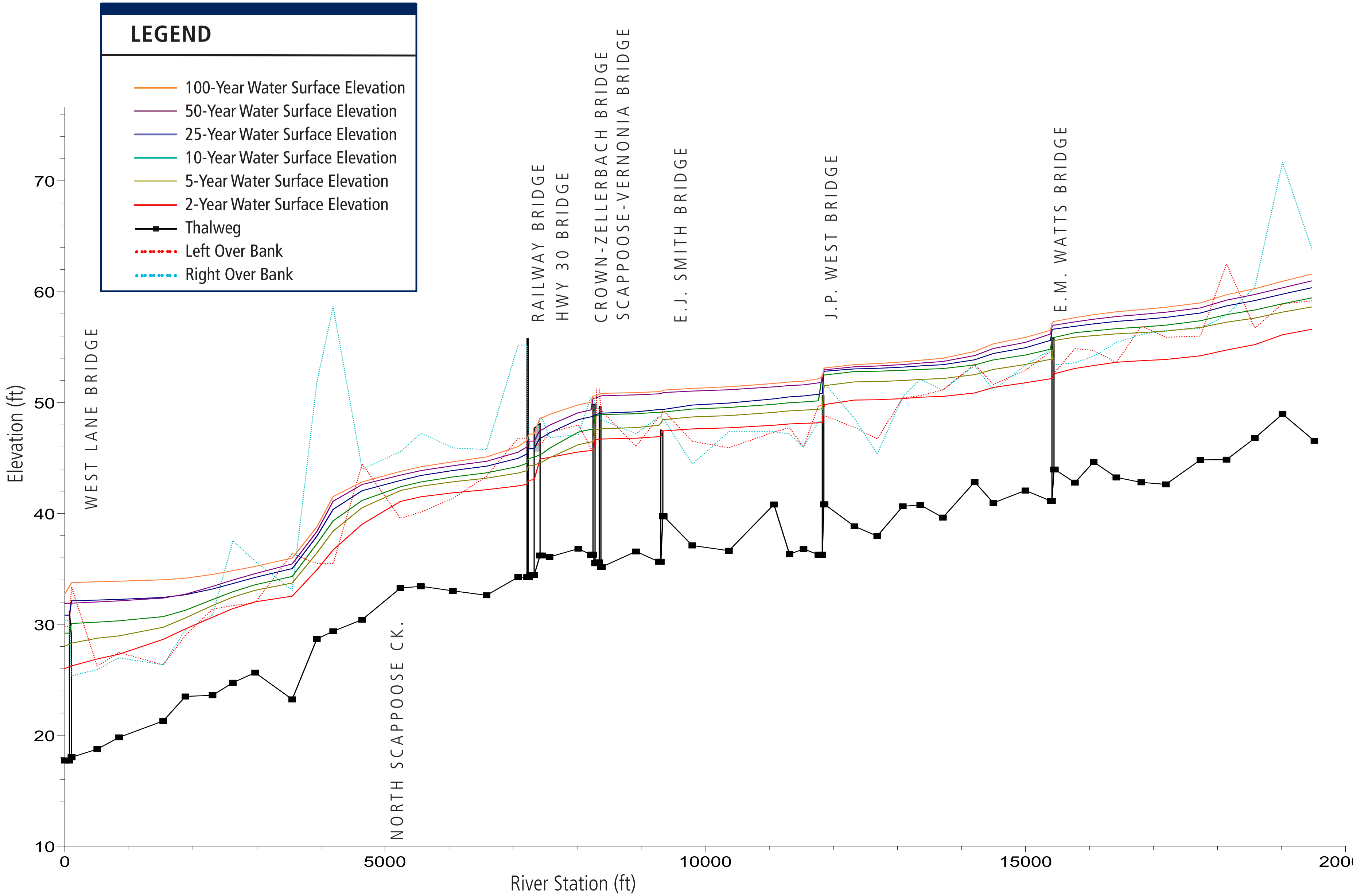

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FIGURE 17: Modeled peak discharge water surface profiles for South Scappoose Creek for the portion of the project area covered by the LIDAR data. Note the backwaternig that occurs upstream of the bridges during most modeled flows. Most of the bridges are overtopped in the 50 and 100-year events.

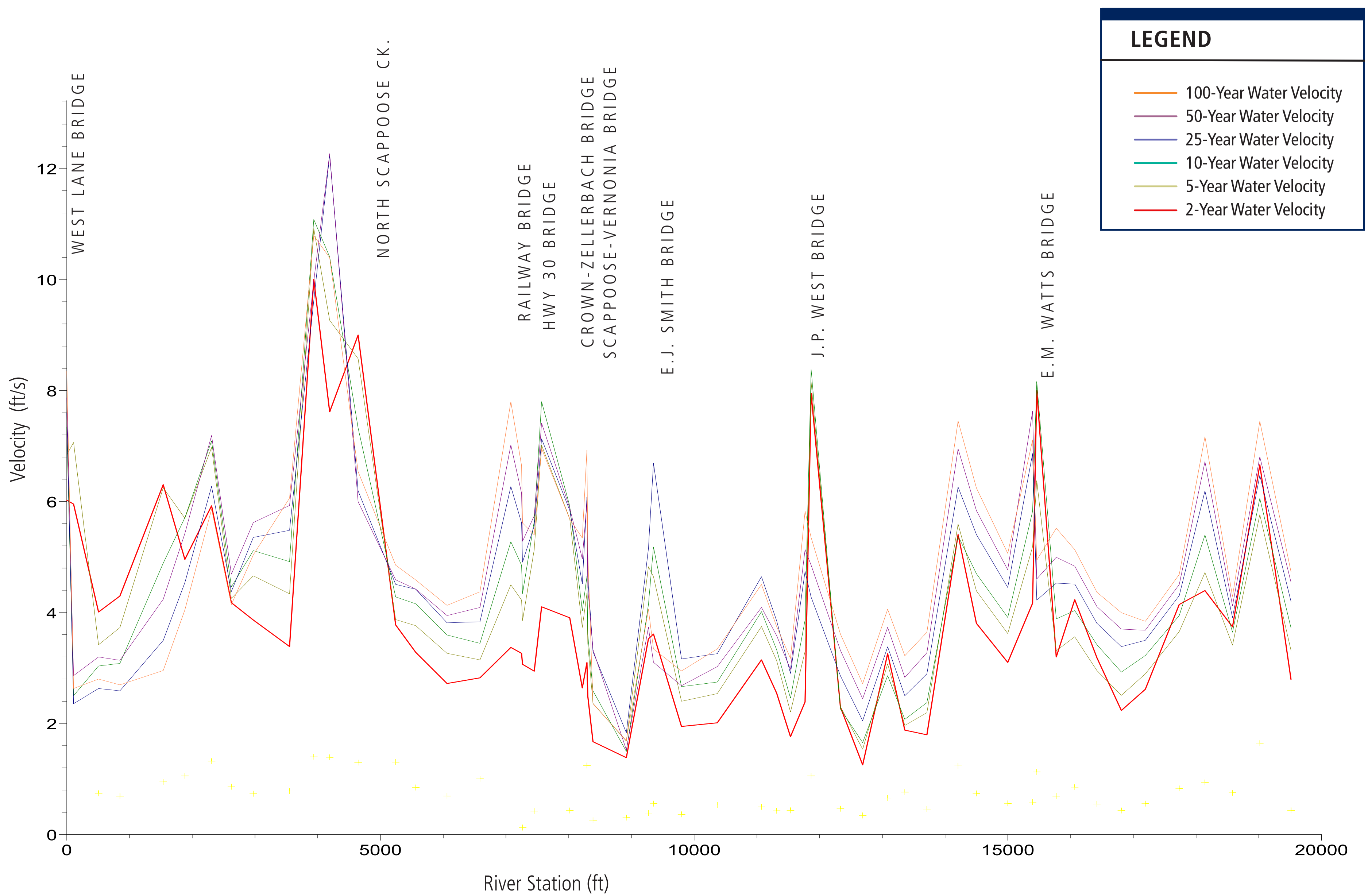

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FIGURE 18: Modeled velocity profiles for South Scappoose Creek for the portion of the project area covered by the LIDAR data. Veolcity peaks tend to occur in the vicinity of the bridges due to floodplain constriction and the grade breaks associated with headcutting which has been arrested at the bridges with placement of large rock.

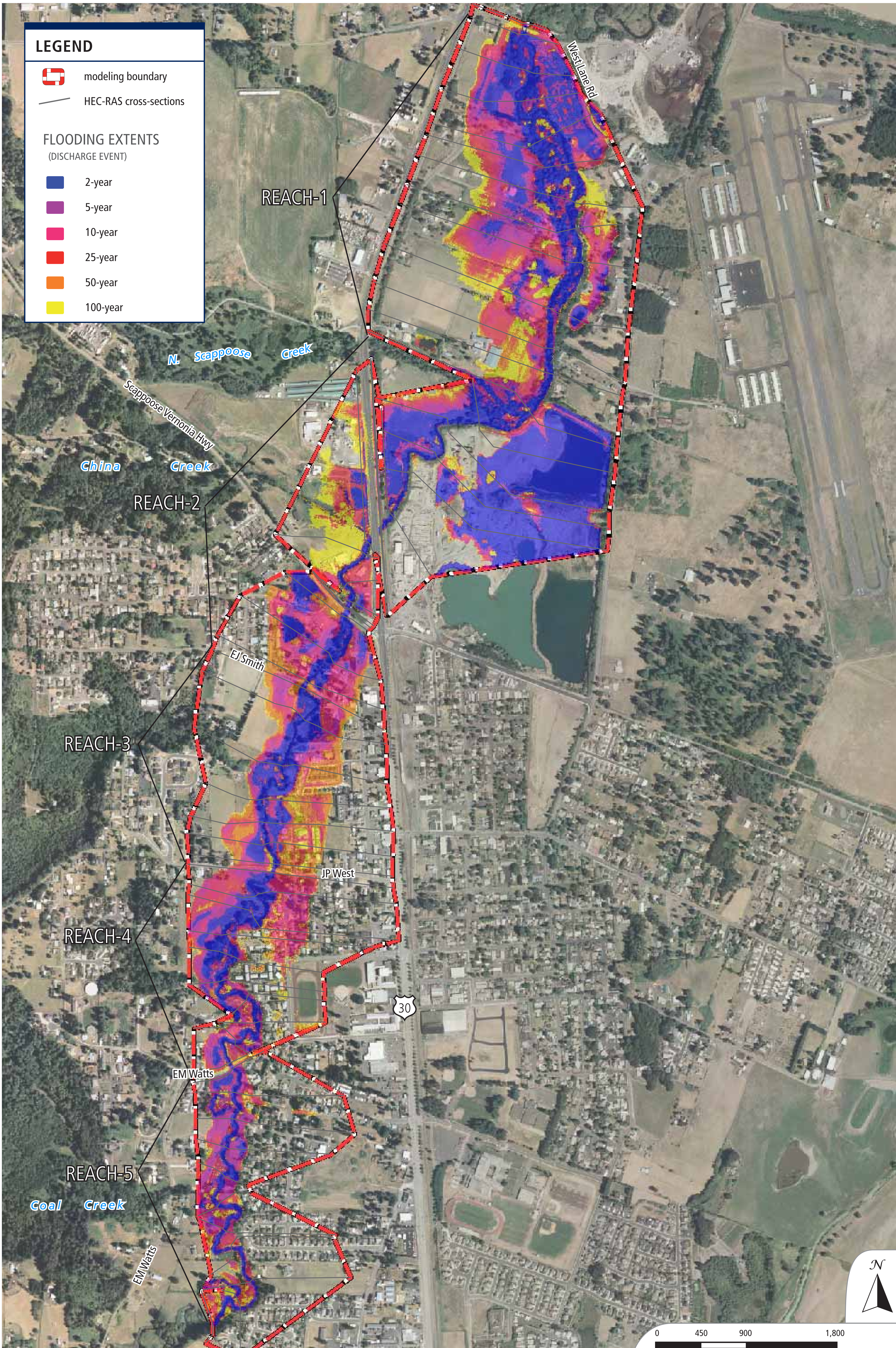

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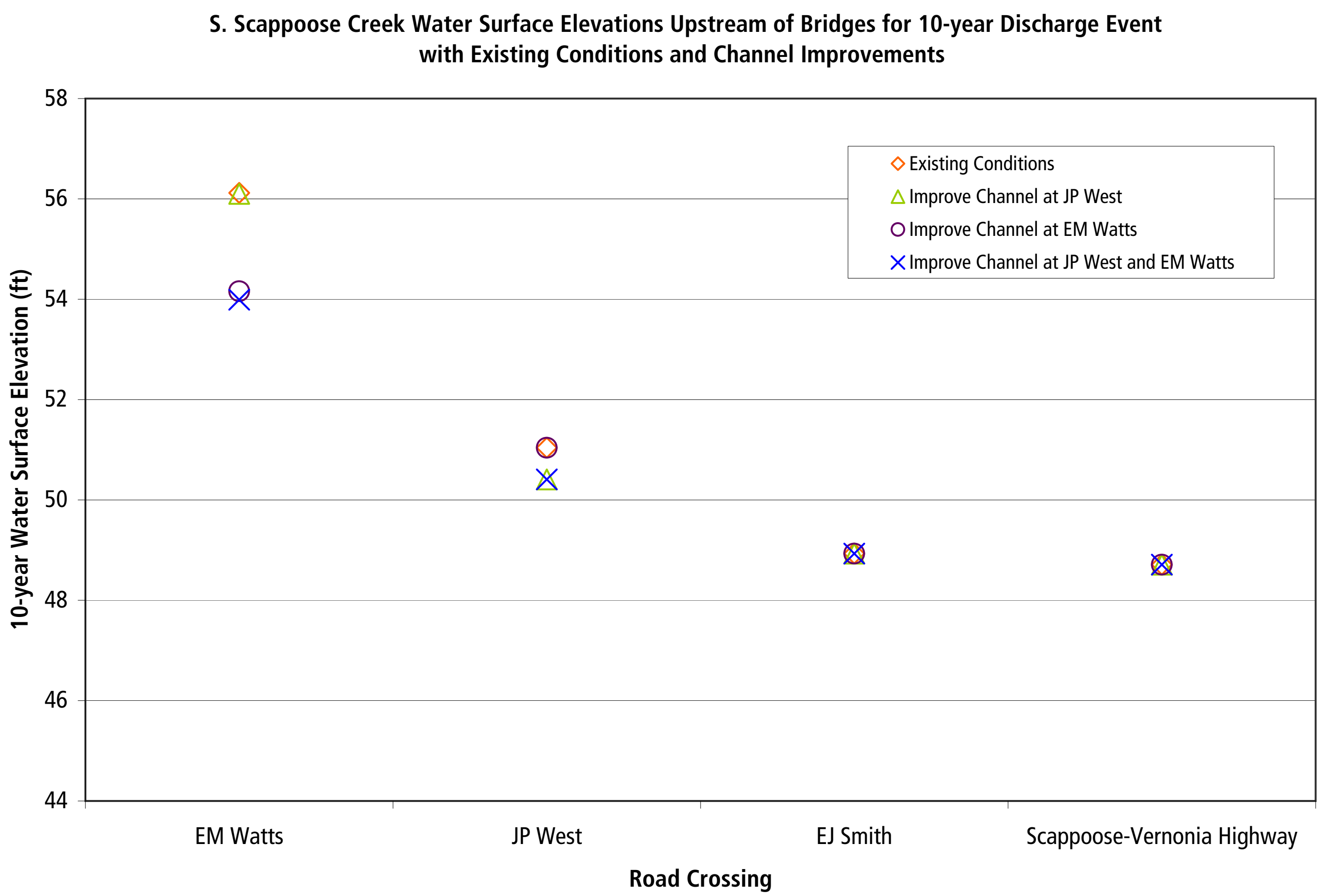
FIGURE 19: Modeled extent of flooding on South Scappoose Creek for a range of peak flows. Modeling was conducted using a HEC-RAS model and was limited to areas adjacent to the existingchannel and where LIDAR topographic data are available.



Point of Interest	SCENARIO			
	Existing Conditions	Improve Channel at JP West	Improve Channel at EM Watts	Improve Channel at JP West and EM Watts
	10-Year Water Surface Elevation (feet) Upstream of Bridge			
EM Watts	56.12	56.1	54.16	53.99
JP West	51.04	50.41	51.04	50.41
EJ Smith	48.93	48.93	48.93	48.93
Scappoose-Vernonia Highway	48.71	48.71	48.71	48.71

FIGURE 20: Summary of the hydraulic modeling results describing potential reductions in water surface elevations at several of the road crossings in the City of Scappoose reach of South Scappoose Creek resulting from modifications to the channel geometry upstream of the bridges to improve conveyance. The preliminary results suggest that improvements could be made at E.M. Watts and J.P West as a result of changes in the geometry of the channel, rather than direct modification or replacement of the bridges.

5. Enhancement Opportunities

5.1 Desired Future Conditions

A desired future condition can be defined as an expression of project goals and objectives, attainable within the human context over a specified timeframe, used to guide management of a system or specific project actions. For this project, the overarching desired future condition for South Scappoose Creek would be include a stable channel with functional floodplains and a continuous and diverse riparian corridor. Despite a desire for stability, in-channel conditions would be diverse enough so as to sustain and create physical habitat that would support a variety of aquatic species.

There is significant value to land management teams in identifying desired future conditions for a project that requires multiple phases to develop, incorporates a variety of goals and objectives, and requires attention in the future, such as maintenance or evaluation of performance. Desired future conditions:

- Provides a vision of future conditions that can be communicated to current and future managers, stakeholders and the public;
- Guides restoration and enhancement actions within the human context, and when the vision includes two or more goals, it integrates management across those targets;
- Provides a framework for identifying short-term management objectives and benchmarks;
- Provides spatial and temporal priorities for management and maintenance of the project; and
- Integrates monitoring and adaptive management into the management of the project.

There are typically three components to a desired future condition. The first is the condition that is desired for the restored or enhanced natural system. By condition, we mean the abundance, structure, composition, function and heterogeneity of the system or species we want to enhance conditions for, or the level of flood protection that we want the project to provide. The condition must be viable and sustainable and attainable within the human context. Secondly, a desired future condition needs a spatial setting. Where on the ground is the desired future condition to be maintained, managed and/or restored? Lastly, restoration and enhancement goals need to be defined within a realistic time frame.

A very important characteristic of a desired future condition is that it reflects what is attainable within the current human context. This includes the context of land use, social and political atmosphere, mission context and the limits of funding for restoration, flood control, and aesthetics. While one may prefer to restore a naturally functioning system across a large landscape, such a desired future condition is limited by what currently exists at the site, what funding is available to implement the proposed project, and what environmental stressors exist within the larger watershed context that may inhibit attainment of the desired future conditions at the site. The restoration emphasis should be on reintroducing the processes that shape habitat for a target species, community type, or site, rather than recreating a specific, idealized species abundance, structure, or composition.

To create a community vision for South Scappoose Creek, the Scappoose Bay Watershed Council has held several community discussions and workshops over the last year. These workshops have focused on soliciting information from landowners, stakeholders, regulatory agencies, and residents to understand community concerns and interests. Although creating a long-term document that clearly defines the desired future condition for South Scappoose Creek will require a long-term investment of energy and ideas from all the stakeholders, several concerns and ideas expressed at the meetings included the following:

- Residents were concerned about both bank erosion and flooding at properties adjacent to South Scappoose Creek. The immediate concern was with bank erosion, which appeared to be an ongoing problem, whereas flooding was typically more of a nuisance except in especially high flow years.
- Local residents were especially interested in safe and easy access to the creek. Currently the steep banks and dense blackberry thickets limits access in most locations. There was also interest in enhancing the value of streamside parks and pursuing creation of a trail network that would run along the edge of the entire creek.
- Some residents remembered an abundance of salmon in the creek when they were younger and would support an effort to enhance and/or restore salmon runs. There was also an interest in improving conditions for other wildlife species such as frogs and turtles.
- There was also interest by local residents to clean up the creek through volunteer efforts. Some residents were concerned about water quality and the health of the creek.

A primary objective of this study was to evaluate project opportunities and constraints that address some of the key concerns of the stakeholders and to recommend potential channel enhancement and stream restoration projects that will push the creek in a more sustainable direction. Based on our geomorphic analysis, the functional value of South Scappoose Creek, especially the portion that flows through the City of Scappoose, is limited because of the severe incision, narrow riparian corridors, and lack of a functional floodplain. According to the Simon and Hupp model, the current incised condition of the channel will likely lead to accelerated bank erosion in the future. Although in the long-term this process will lead to a more stable channel with functional floodplains and healthy riparian corridor inset into the existing valley floor, this "vision" of the creek is at conflict with the interests of adjacent properties and infrastructure. In addition, excessive erosion of banks that consist primarily of fine sediment would have negative consequences to aquatic communities that are already stressed and in decline. Consequently, enhancement opportunities that address the existing and future instability of stream banks should receive priority given what is desired by the community. Within the Simon and Hupp model framework achieving a quasi equilibrium defined under Stage 6 (quasi equilibrium) would be the desired future condition and would be achieved by active expansion of the floodplain and lowering the bank angle to reflect a more stable condition (Figure 12). The approach selected at a particular location will depend on site specific opportunities and constraints that will be identified at the project design phase.

5.2 Enhancement Opportunities

With the Simon and Hupp model in mind, the best approach to achieving a stable channel condition would be to take actions, where feasible, to push South Scappoose Creek from the Stage 4 condition to the Stage 6 condition without experiencing the negative consequences of excessive bank erosion. Where opportunities are available, floodplain can be excavated, banks can be laid back to a more stable angle, and riparian vegetation can be reestablished on the new floodplain and bank surfaces to protect the channel long-term and improve the functional value of the aquatic environment. In addition, these projects can be integrated with other enhancement measures that benefit the aquatic or human environment, such as introduction of large wood to improve habitat for salmonids, or public access improvements.

Figure 21 conceptually depicts three types of bank protection and floodplain enhancement approaches that could be used depending on site constraints. In an unconstrained site, opportunities may exist to expand floodplain, lay back banks, and improve the width of the riparian corridor along both sides of the stream channel. Limiting factors at an unconstrained site may include access, geologic constraints, or costs (e.g. – disposal of excavated sediment). In a completely constrained site where property or infrastructure is at risk, enhancement of channel and floodplain function needs to be weighed against the risks of property loss. In those situations, bank protection, using either hard or soft, bioengineered approaches may be necessary, which may potentially be offset by less constrained conditions on the opposite side of the channel. Table 5 summarizes a range of bank protection measures that could be employed at a given site under constrained conditions. The specific measures used would depend on site conditions, project objectives, and available funding.

To evaluate potential channel, floodplain, and habitat enhancement opportunities within the project area, the Watershed Council arranged access to many of the properties along South Scappoose Creek and worked closely with landowners to set up individual meetings to discuss our observations and gauge landowner interest for further cooperation and development of site specific projects on their properties. The potential project types identified during the field evaluation include the following:

- ***Riparian plantings*:** These projects consist of riparian plantings to fill gaps and expand the width of the riparian corridor. Riparian planting should focus on a mix of hardwoods and coniferous species so as to increase diversity and provide future large wood to the channel.

- ***Excavate floodplain***: The projects include laying back steep banks to reduce erosion risk and allowing for planting of riparian vegetation along with more significant excavation work that would create a low floodplain bench for frequent flows to access.
- ***Reactivate historic channels***: These projects consist of enhancing existing floodplain features that may have been cut off from the existing channel due to adjacent land use or due to incision. These channels provide complex floodplain habitat, high roughness, low velocity areas during peak flow events for aquatic organisms to escape to, and sources of large woody debris to the primary channel. Enhancement may include removing a sediment plug at the upstream or downstream end, lowering an "island" to create a better hydraulic connection between the primary are floodplain channel, or enhancing the channel with riparian vegetation.
- ***Fish enhancements***: These projects would consist primarily of engineered log jams or other large wood installation to improve in-stream complexity, scour pools, and provide cover habitat for salmonids and other aquatic organisms.
- ***Public access:*** These projects would consist of controlled access to restored floodplain areas or the waters edge. Additionally, public access could include visual overlooks and interpretive signage to educate the public about the value of stream and riparian environments. The goal would be to make the creek an amenity for the public to enjoy.

Following our identification of potential site specific projects and discussions with the SBWC and individual landowners, it became clear that a comprehensive management strategy for the project area would be limited by a site specific focus on individual projects and prioritizations. Instead, a preferred approach would recognize the fact that the goals and objectives of a management strategy are regional in nature and multiple landowners must be engaged to address the larger issue of channel stability and floodplain function. Consequently, SBWC and SH+G devised a project prioritization strategy that focuses on enhancement activities within Management Zones, the boundaries of which are roughly defined by parcel boundaries and ownerships along the channel, similarities in proposed project types, and the degree to which landowners have participated in the process. A total of 18 Management Zones were defined in the project area, from A to R. The boundaries of each of the Management Zones are shown in Figure 22, along with the proposed project types occurring within each of the Zones and their approximate locations.

The primary advantage of the Management Zone concept is that it allows a degree of flexibility for resource managers to identify and pursue specific project actions within each of the Management Zones in response to landowner interest or funding opportunities. The Management Zone approach still allows for definition of a long-term prioritization strategy but those prioritizations are tied to the Management Zones rather than site specific projects. The approach used for this project to identify short and long-term strategies to achieve the desired objective for South Scappoose Creek included the following steps:

- **Step 1:** Description of conditions within each of the defined Management Zone,
- **Step 2:** Identification of project actions that would be pursued in the Management Zone to achieve the desired future condition,
- **Step 3:** Conduct prioritization workshop with stakeholders and technical advisors to

prioritize Management Zones,

- **Step 4:** Conduct an internal prioritization effort using assessment criteria, such as site accessibility, ecological benefit, degree of landowner cooperation, community benefit, and relative cost of proposed actions, to create an independent Management Zone prioritization, and
- **Step 5:** Resolve difference between the stakeholder defined Management Zone priorities and the ranking based on assessment criteria to define a final prioritization for all 18 Management Zones. Prioritization rankings were converted to a prioritization timeline representing projects that would be implemented in five year blocks, with all management activities completed within a fifteen year timeframe.

Table 6 summarizes the results from Step 1 through Step 3. For Step 3, nine stakeholders attended the workshop representing interests ranging from the City of Scappoose, Columbia County, the SBWC, Oregon Department of Fish and Wildlife, and private landowners. Each stakeholder was given 20 points to assign to individual Management Zones. Out of the 18 Management Zones, 13 received points with the remainder receiving zero. Based on the points received, the Management Zones were ranked.

Step 4 of the prioritization process was conducted internally using a variety of assessment criteria. The assessment criteria represent the key factors that are often used in a cost-benefit analysis. In this case a qualitative rating from High to Low was assigned to each of the assessment criteria based on experience gained from the project team over the course of the project and an understanding of the primary benefits that would be achieved if the projects identified within each Management Zone were implemented. The results of this analysis are presented in Table 7. The Low, Moderate, and High rating were then assigned values from 1-3 and summed for each Management Zone. It was decided by the project team and the stakeholders that the assessment criteria would be weighted equally. Based on the final score, projects were ranked based on a timeline of fifteen years with projects in higher priority Management Zones being implemented within the first five years.

To resolve prioritization conflicts between the results of Steps 3 (Stakeholder Prioritization) and 4 (Project Team Prioritization), scores were summed and averaged and a Management Zone prioritization was determined based on the implementation timeline strategy. The results for this analysis are presented in Table 8 and Figure 23. Project opportunities outlined within each Management Zone were identified through discussions and site visit with property owners, with the exception of the riparian planting projects, which were identified via an aerial photo analysis. Well-defined breaks in the final prioritization score was used to group Management Zones into the five year implementation blocks. Using this approach, six Management Zones fell into the first five years of implements (MZ's: A, C, G, H, J, O), five in the second five years (MZ's: E, I, K, L, Q), and seven in the last five years (MZ's: B, D, F, M, N, P, R). Within the Management Zones classified as High Priority, several conceptual designs have been developed for proposed projects in Zones C, G, and O (Appendix A).

TYPE	DESCRIPTION	APPLICATIONS	ADVANTAGES	DISADVANTAGES	LIFE SPAN	HABITAT VALUE	APPEARANCE	COST
Reed Clump Planting	Reeds are planted in clumps or "plugs"	Low velocity terraces and floodplains	Plants can improve water quality through uptake of nutrients and by inducing sediment deposition.	Need moist, fertile soil and sunlight. Short construction period, in early spring. 3 years to reach full growth.	Long-term	Very high	Natural	$
Live wood Stakes	30"-80" long branches (often Willow), of ½" to 3" diameter stripped of most leaves and staked into soil.	Used in all velocity conditions where soil, sunlight, and water are available in sufficient quantity.	Simple to plant, with high success rate. Root strength provides excellent enhancement bank strength. Low design cost.	Installation is seasonally dictated, unless irrigation is provided. May require long-term maintenance where conveyance is limited.	Long-term	Very high	Natural	$
Root-Wad Revetment	Large root crowns are secured at the toe, often with trunk buried in bank, or cabled in place.	Used in medium to high velocity zones, where reduced conveyance due to increased roughness is acceptable	Provide excellent habitat and scour resistance, through use of what is often an affordable and readily available resource.	Material availability or transport may be a challenge. Added roughness may cause unwanted sediment deposition or snag debris.	Medium-term	Very high	Natural	$
Deflector Groins	Rock or log groin that extends into channel to deflect flows away from banks	Used on outside bank of bends and at points of flow incidence, where increased sediment deposition is desirable	May reduce material and placement costs by avoiding protection of entire bank. Can trap large amounts of sediment to rebuild floodplain.	High design cost. May induce scour elsewhere. May trap excessive sediment, leading to reduced conveyance. Placement causes high impact to stream.	Long-term	High-Very high	Constructed	$$
Vegetated Rock Slope Protection (RSP)	Rock is placed on angle of slope, with tubes and/or soil backfill for planting. Often filter fabric is used at rock/soil interface.	High velocity toes and banks, where geometric constraints require "hard" treatment.	Vegetation can obscure rock, once grown. Rock is flexible and adjusts to minor changes in subgrade conditions. Design costs are relatively low. Very reliable and versatile.	Purchase and transport costs of rock may be high. Uniform and sterile appearance of rock can be poor, if vegetation component is not properly planned and implemented.	Long-term	Medium	Color, size and placement dependent.	$$$
Rock Breast Wall	Stone wall with or without mortar	Used in high velocity locations, where steep bank angle is required	Can achieve steep slopes, allowing for use in highly constrained conditions. May retain weak slopes.	Rock source and transport are required. Skilled labor is required. Design costs are relatively high. Appearance is often poor.	Medium-term	Very Low	Constructed	$$$$
Gabion Wall	Rectangular wire basket with rock infill	High velocity or shear locations where near-vertical bank angle is required	Can achieve steep slopes, while still allowing for some settlement. Revegetation is possible.	Wire corrodes and may snag debris. Requires stable foundation, keyed below scour. High cost. Poor aesthetics	Medium-term	Low, unless backfilled with soil to allow planting.	Constructed	$$$$

TABLE 5: Examples of specific bank protection techniques, their pros and cons, and potential cost. Only certain techniques may be feasible at a specific project site, depending upon the conditions, site constraints, and risks to existing infrastructure.

South Scappoose Creek Restoration Plan								
Management Area	Description	Restoration Activities					Implementation Priority	
		Riparian Enhancement	Floodplain Enhancement	Reactivate Floodplain Channel	Fisheries Enhancement	Public Access	Points Awarded at Prioritization Workshop	Priority Ranking
A	Channel in moderate condition with eroding and unvegetated right banks. Bridge is a constriction at high flows causing sediment depositional and lateral migration. County property located at downstream end.	X				X	16	5
B	Channel in good condition. Well shaded assessment zone with mature riparian vegetation. Riparian width could be expanded along right bank.	X					0	NA
C	Located at the confluence of South and North Scappoose. South Scappoose is incised which has caused incision of the North Scappoose fan and subsequent abandonment of a secondary channel. Local incision has resulting in significant bank erosion.	X		X	X		21	3
D	This assessment zone is located downstream of Highway 30 and the Railroad Bridge and adjacent to the Scappoose Sand and Gravel Quarry. It lacks significant riparian vegetation and is somewhat incised.	X					0	NA
E	This assessment zone consists of the stretch of channel between EJ Smith and Highway 30, including Scappoose-Vernonia Highway. The assessment zone is incised and lacks riparian vegetation. Floodplains consist primarily of industrial and residential land use.	X					3	11
F	This assessment zone is located upstream of EJ Smith and consists of one large parcel on the left bank and several smaller parcels on the right bank. The property owners have not been approached about projects but the channel is incised and lacks a continuous corridor of riparian vegetation.	X	X				1	12
G	This assessment zone includes the recently completed Scappoose Community Park. The City owns the majority of the property on either side of the channel and is opened to the option of expanding floodplain, improving the riparian corridor and enhancing habitat conditions.	X	X			X	31	1
H*	This zone occurs just upstream of JP West and includes a large, single parcel along the left bank. The Buxtons are open to a project to improve riparian and channel condition through this incised reach. Riparian conditions are moderate but discontinuous. There are also historic floodplain channels present that could be reactivated.	X	X	X			24	2
I	This zone is located downstream of EM Watts and would need to involve multiple landowners. The channel is incised and erosion is severe along the right bank with a significant threat to homes. Riparian habitat is discontinuous. There is potential to improve riparian and expand floodplain but would need to be combined with more expensive bank protection approaches to protect residences.	X	X				8	10
J*	This zone is located upstream of EM Watts. The parcel on the left bank just upstream of EM Watts includes a mitigation wetland and levee. The levee could be removed to improve floodplain conditions and modifications could be made adjacent to the bridge to lower flood elevations during moderate events. The zone also includes an existing City park that could be enhanced to improve riparian and floodplain habitat and public access to the creek.	X	X			X	18	4
K	Riparian vegetation through this zone is in good condition though the corridor is narrow along the right bank where a number of parcels are affected by severe bank erosion and potential threats to structures. The left bank consists of several land owners that may be willing to enhance floodplain and riparian habitat to the benefit of the properties across the creek.	X	X				10	9
L	This zone consists of three large parcels, all of which are interested in potentially cooperating to enhance riparian and floodplain conditions. The channel is heavily incised, lacks a continuous riparian corridor, and is threatening several structures along the right bank.	X	X	X			13	8
M	This zone is located downstream of the Dutch Canyon crossing. The reach is heavily incised and lacks a continuous riparian corridor. Although the reach would benefit from riparian and floodplain enhancement, it is unclear whether landowner cooperation would be forthcoming.	X					1	12
N	This zone consists of an incised channel upstream of the Dutch Canyon crossing. The reach was not assessed in detail due to lack of access to the property. The zone would most likely benefit from improvements to the riparian corridor.	X					0	NA
O	This zone consists of several large parcels. Substrate conditions in the channel begin to improve due to slightly higher gradient conditions that create pool-riffle sequences and potential spawning habitat. The channel is moderately incised with some areas of significant bank erosion. A project has been proposed on two of the downstream parcels to excavate floodplain, add large wood structures, and improve riparian habitat.	X	X		X		16	5
P	This zone consists of a single large parcel with a channel that is transitional between a less incised conditions upstream and a moderately incised condition downstream. Significant sediment deposition occurs through this reach suggesting a break in slope. The riparian canopy is discontinuous and the channel becomes more sinuous with some bank erosion occurring.	X					0	NA
Q	This zone consists of a single parcel on the right bank and several parcels on the left bank. The reach is bounded by two private bridges that appear to affect the hydrology and risk of flooding. The riparian canopy is generally in good condition but is relatively narrow. Property owners have expressed interest in installing large wood structures to improve habitat.	X			X		14	7
R	This zone is located downstream of the Raymond Creek confluence. The channel is dominated by cobble and gravel, the habitat in relatively good conditions and a good riparian canopy exists. The reach could benefit from improved variability and installation of large wood. The most significant problem area occurs downstream of the Raymond Creek Bridge where there is significant bank erosion.				X		0	NA

*** - Denotes a project that could be combined with a project at the bridge to lower flood elevations.**

TABLE 6: Summary of the prioritization matrix used at the stakeholder workshop. The matrix includes a description of the Management Zone, enhancement activities that have been proposed within each Management Zone, and prioritization scores developed by the nine project stakeholders that attended the workshop.

Mangement Area	Accessibility	Ecological Benefit	Landowner Cooperation	Community Benefit		Cost	Score[2]	Ranking
				Public Value	Health & Safety		High = 3 Moderate = 2 Low = 1	1 = Year 1-5 2 = Year 5-10 3 = Year 11-16
A	High	Moderate	High	High	Low	Low	15	1
B	Moderate	Low	Low	Low	Low	Low	9	3
C	Low	High	High	Low	Low	Moderate	11	2
D	Low	Moderate	Low	Low	Low	Low	9	3
E	High	Moderate	Low	Low	Low	Low	11	2
F	Moderate	Moderate	Low	Low	Low	Moderate	9	3
G	High	Moderate	High	Moderate	Low	Moderate	13	1
H[1]	High	High	High	Moderate	Moderate	Moderate	15	1
I	Moderate	Moderate	High	Low	Moderate	High	11	2
J[1]	High	Moderate	Moderate	Moderate	Moderate	Moderate	13	1
K	Moderate	Moderate	High	Low	High	High	12	2
L	Moderate	High	High	Low	Moderate	High	12	2
M	Moderate	Moderate	Low	Low	Low	Low	10	3
N	Moderate	Moderate	Low	Low	Low	Low	10	3
O	High	High	High	Low	Low	Moderate	13	1
P	Moderate	Moderate	Low	Low	Low	Low	10	3
Q	Moderate	High	High	Low	Low	Low	13	1
R	Low	Moderate	Low	Low	Low	Low	9	3

[1] Denotes a project that could be combined with a project at the bridge to lower flood elevations.

[2] Scoring of High = 3, Moderate = 2, Low = 1 applies for all categories except for Cost where the opposite scoring system applies.

TABLE 7: Summary of the prioritization matrix developed by the Project Team that relies on qualitative rankings of key assessment criteria.

Management Area	Pro ect eam Prioriti ation		echnical Ad isory Committee Prioriti ation		Final Proriti ation	
	Score	Ranking 1 = Year 1-5 2 = Year 6-10 3 = Year 11-15	Score	Ranking 1 = Year 1-5 2 = Year 6-10 3 = Year 11-15	A erage Score	Ranking 1 = Year 1-5 2 = Year 6-10 3 = Year 11-15
A	15	1	16	1	15.5	1
B	9	3	0	3	4.5	3
C	11	2	21	1	16	1
D	9	3	0	3	4.5	3
E	11	2	3	3	7	2
F	9	3	1	3	5	3
G	13	1	31	1	22	1
H	15	1	24	1	19.5	1
I	11	2	8	2	9.5	2
J	13	1	18	1	15.5	1
K	12	2	10	2	11	2
L	12	2	13	2	12.5	2
M	10	3	1	3	5.5	3
N	10	3	0	3	5	3
O	13	1	16	1	14.5	1
P	10	3	0	3	5	3
Q	13	1	14	2	13.5	2
R	9	3	0	3	4.5	3

TABLE 8: Summary of the proposed final prioritization of Management Zones in the South Scappoose project area. Prioritizations are lumped into a timeline of 1-5 years, 6-10 years, and 11-15 years.

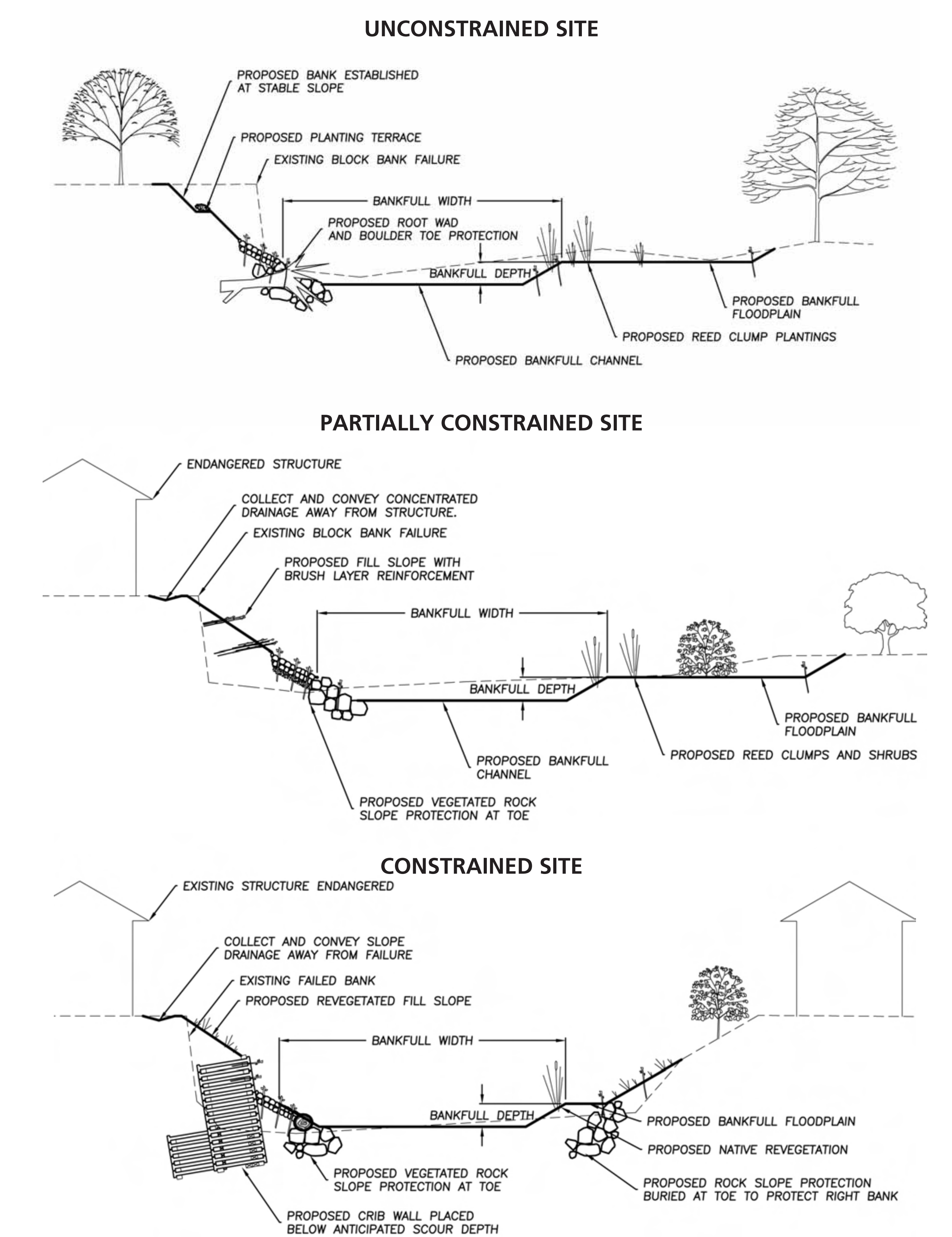


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FIGURE 21: Conceptual view of bank protection and floodplain enhancement approaches in an unconstrained, partially constrained, and constrained setting. Specific treatments will depend upon conditions unique to each site.

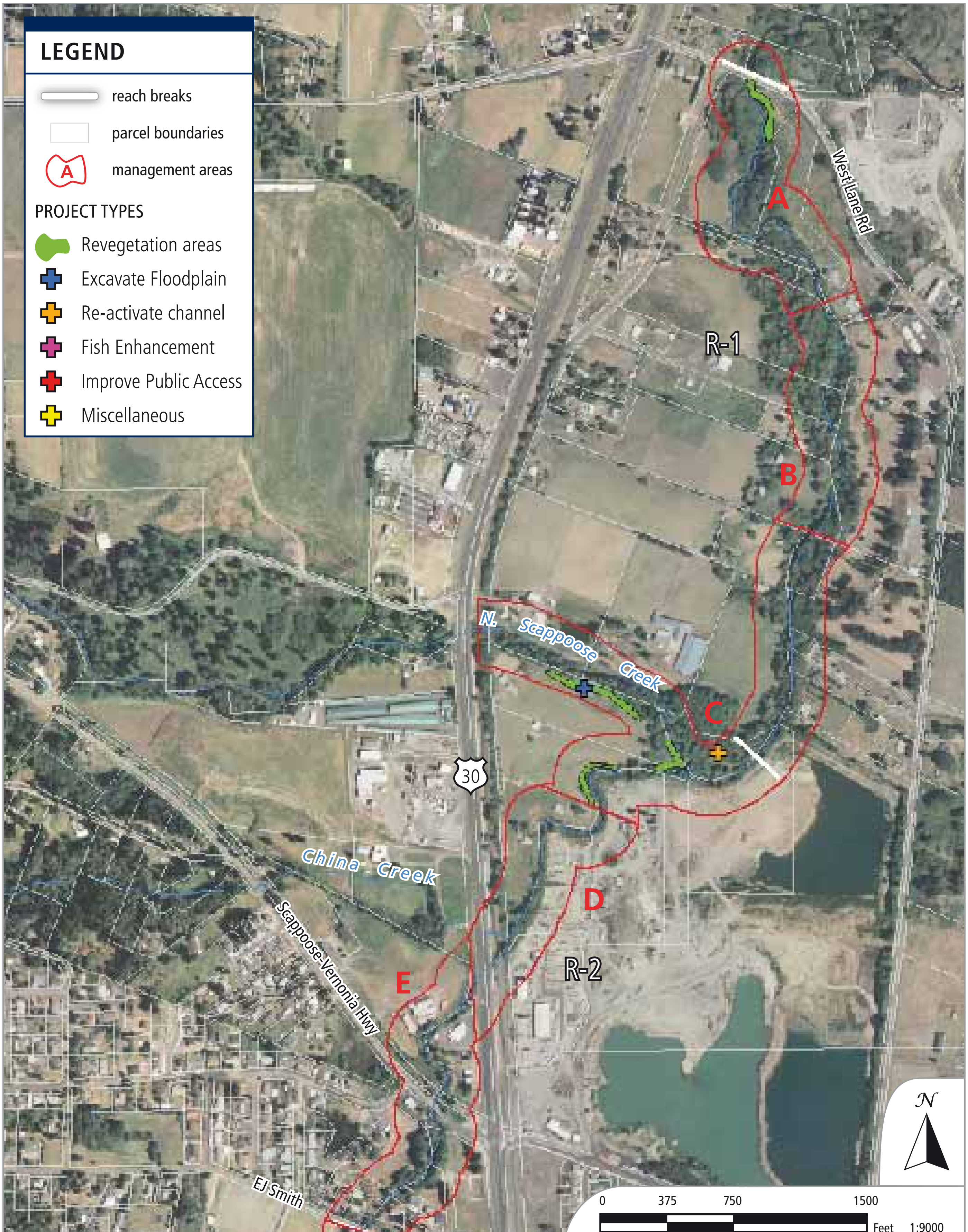

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FIGURE 22: Map of potential projects identified during field assessments and focused meetings with land owners. Specific project sites will need to be evaluated in more detail prior to development of conceptual designs.

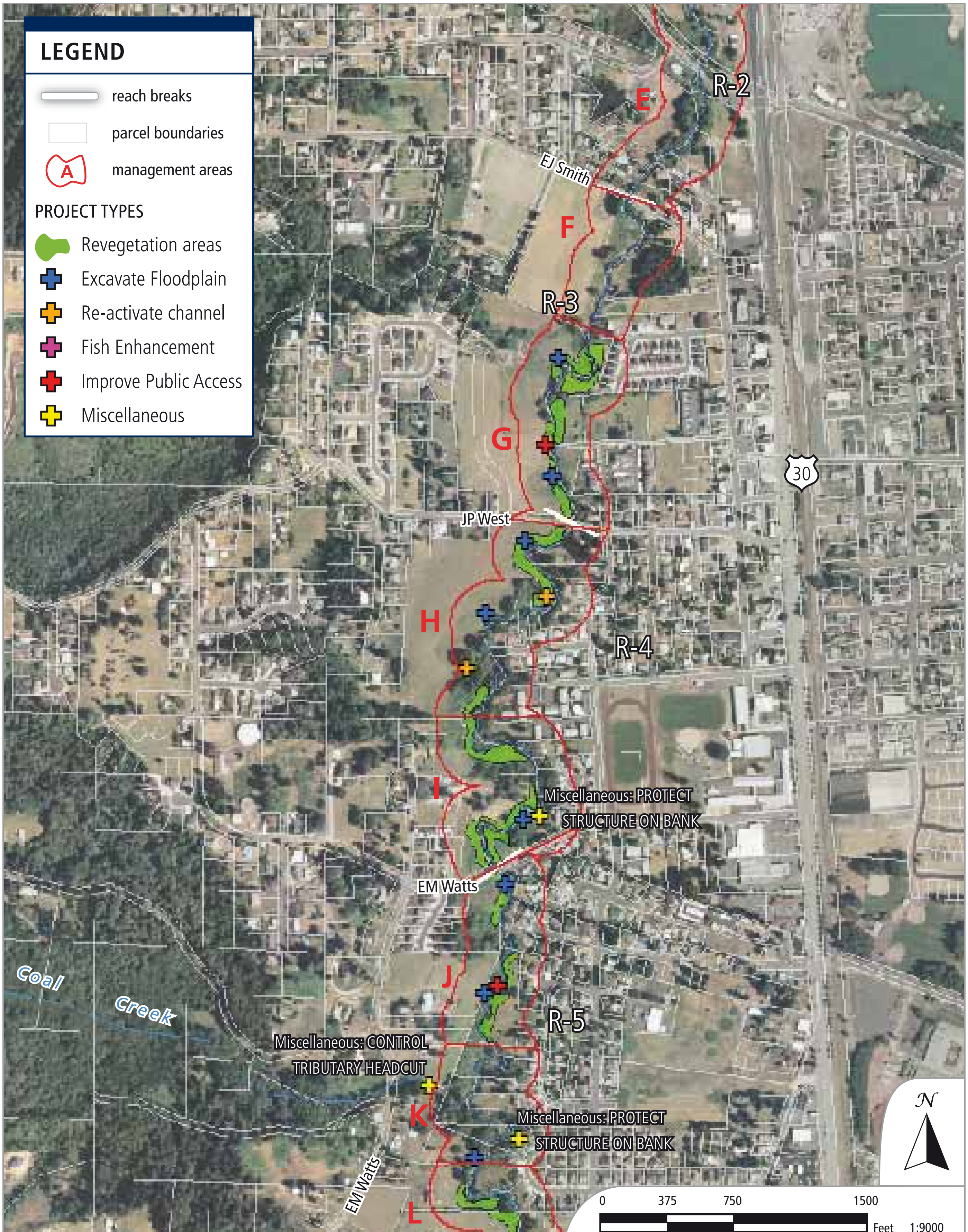

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FIGURE 22 continued...

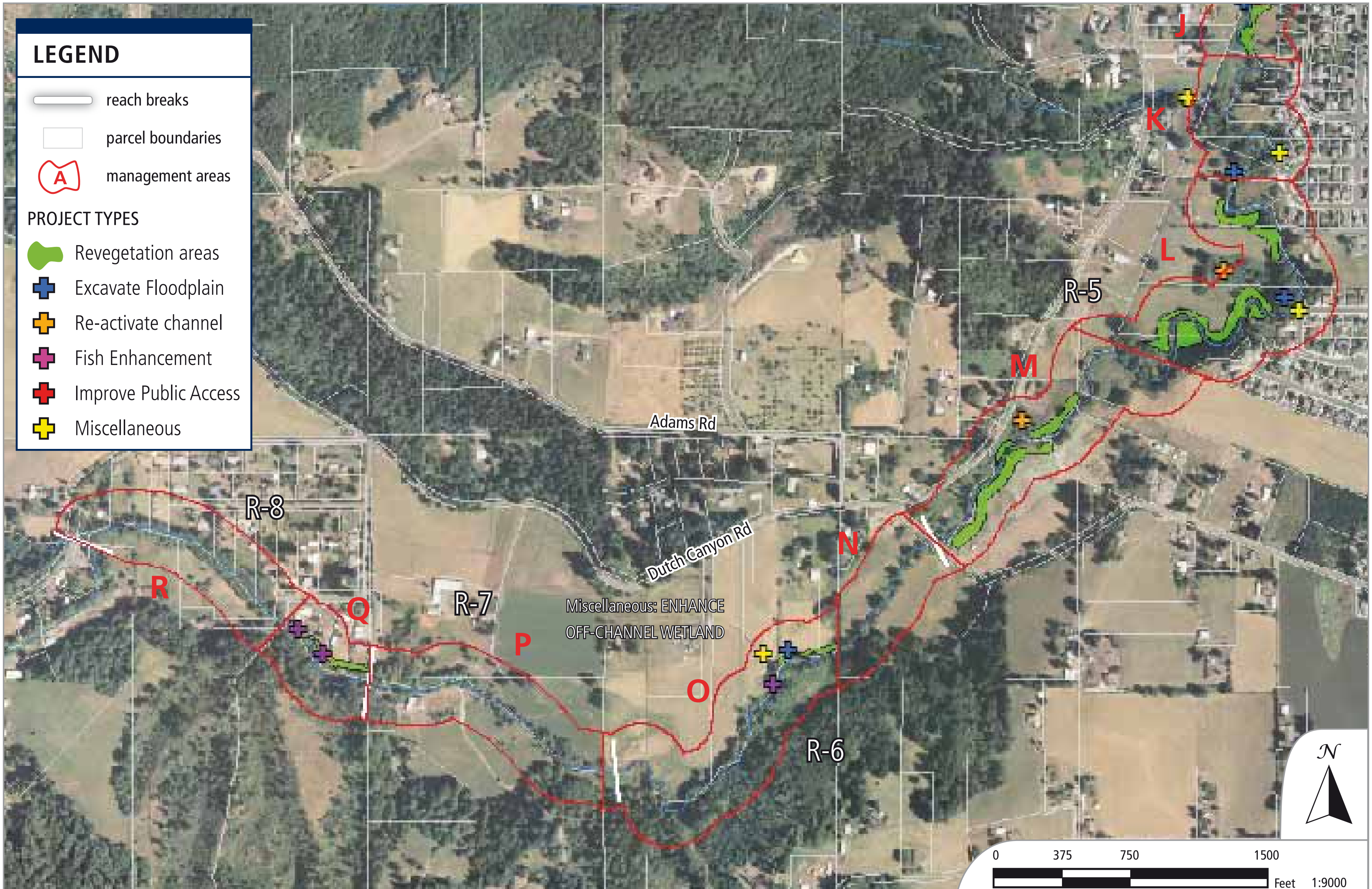

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FIGURE 22 continued...

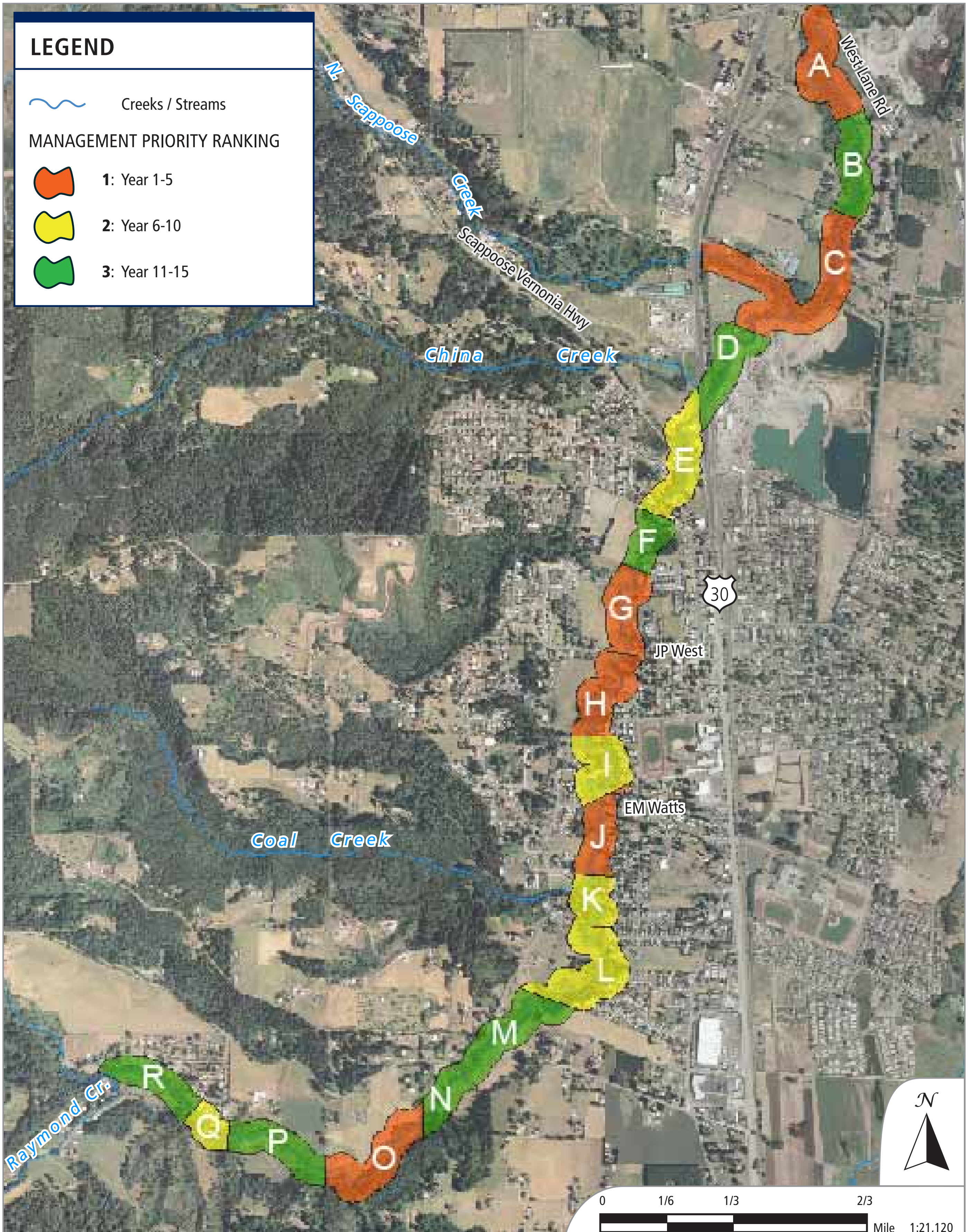

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FIGURE 23: Overview of the proposed final prioritizations for Management Zones A through R in the South Scappoose study area. The final prioritizations were derived by integrating a Project Team analysis of project evaluation criteria with results derived

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7. Glossary

Alluvium - An unconsolidated accumulation of stream-deposited sediments, including sands, silts, clays or gravels.

Colluvium - A general term applied to loose and incoherent deposits, usually at the foot of a slope or cliff and brought there chiefly by gravity.

Debris flow - The rapid downslope movement of coarse material with a high water content, with a course guided by stream channels. This form of mass movement is less deep seated and rarer than a landslide.

Fluvial - Refers to the processes associated with rivers and streams and the deposits and landforms created by them.

Geomorphology - Science of describing and interpreting landform patterns and processes of landscape formation. For rivers, this includes the distribution and movement of substrate (sediment and larger material) that makes up the channel bed and banks.

Graded stream - A stream whose gradient is in equilibrium with the dynamics of the region; i.e. the stream flow is sufficient to carry any sediment supplied.

Headcut - A break in slope or knickpoint of a channel that forms a "waterfall", which in turn causes the underlying soil to erode uphill.

Hydraulic force - The force of water on a streambed or bank, which includes cavitation and fluvial plucking.

Incised channel - A river which cuts its channel through the bed of the valley floor, as opposed to one flowing on a floodplain; its channel formed by the process of degradation.

Planform - In fluvial geomorphology, the two-dimensional horizontal geometry of a stream channel.

Shear stress - The force acting tangentially to a surface. In the case of open channel flow, it is the hydraulic force of moving water against the bed of the channel, and largely drives sediment transport.

Width-depth ratio - Quotient of the width by the mean depth of a channel at bankfull discharge.

SOUTH SCAPPOOSE CREEK
RESTORATION PLAN

APPENDIX A

PROPOSED PROJECT - CONCEPTUAL DESIGN

CONARD PROPERTY

MANAGEMENT AREA C

CONCEPTUAL DESIGN

CONARD PROPERTY

SOUTH SCAPPOOSE
AND
NORTH SCAPPOOSE CONFLUENCE

BACKGROUND

The proposed project was identified during development of the South Scappoose Restoration Plan (Restoration Plan). The Restoration Plan included an evaluation of physical conditions on a five mile reach of South Scappoose Creek with the purpose of identifying causative factors related to excessive fine sediment delivery into Scappoose Bay, loss of high quality spawning and rearing habitat for salmonids, and incision within many of the primary channels. The impacts of the incision on channel and floodplain interaction, morphologic variability, and the ability of the stream to support and maintain the physical habitat features that provide for good aquatic habitat was evaluated.

The results of the Restoration Plan indicate that past land use impacts, including filling of historic floodplains and secondary channels, straightening and realignment of the channel, loss of riparian corridors, and floodplain constriction at road crossings have profoundly altered the functions and values of South Scappoose Creek. Consequently, one of the primary recommendations to improve channel and floodplain function on South Scappoose Creek is to increase the frequency with which high flow accesses overbank areas by creating and/or expanding floodplain area and complexity. Expansion of active floodplain areas would benefit the system by reducing localized shear that is currently acting on the channel banks and causing erosion of fine sediment directly into the creek and loss of narrow riparian corridors. By expanding floodplain areas, localized erosion of fine sediment will be reduced and healthy riparian corridors will be restored. Functioning riparian corridors, consisting of a mix of conifers and hardwoods, reduce stream temperatures and provide a future source of large wood to the creek channel, both of which improve aquatic habitat.

PROJECT DESCRIPTION

The Conard family owns a large tract of land on the west side of South Scappoose Creek that encompasses its confluence with North Scappoose Creek (Figure 1). Much of the land is currently in hay production, although an extensive riparian forest consisting of a mature overstory of alder, maple, and cottonwood occurs at the confluence. Historically, the mouth of North Scappoose Creek appears to have supported an alluvial fan as coarse gravel and cobble was delivered from the more confined portion of North Scappoose Creek to the broad floodplain of South Scappoose Creek. As is typical of active alluvial fans at tributary confluences, the morphology of the channel was represented by a network of primary and secondary channels that became activate and inactive in response to sediment supply and debris loading. Consequently, the exact location of the confluence with South Scappoose Creek was continually changing on the order of every 10 years in response to flood events.

Due to land use impacts and the changed dynamics of Scappoose Bay and the Columbia River lowlands, South Scappoose proceeded through a period of channel incision that appears to have been arrested through grade control enforcement at crossing locations such as bridges. In response to incision on South Scappoose tributary channels including North Scappoose, have also incised. On North Scappoose, headcutting through the tributary fan can be observed, though the rate of incision has been slowed by the presence of coarse bed material consisting primarily of large gravel and cobble. The result is an oversteepened channel profile through the upper end of the fan surface (Figure 2), loss of fan function (i.e. – lack of coarse bed load deposition on the fan surface), and abandonment of the network of secondary channels in all but the highest flow events. The loss of fan function has resulted in enforcement of the flow into a single channel and development of vegetated bar deposits that are causing North Scappoose Creek to move laterally into banks primarily composed of fine sediment.

The proposed project on the Conard Property seeks to address both the issue of a functional alluvial fan at the site as well as the influx of fine sediment inputs to North and South Scappoose Creek. The main element of the proposed project would be to construct a large engineered log jam (ELJ) at the head of the fan (Figure 3). The ELJ will act to aggrade that portion of the fan, limit further fan incision, and increase the frequency with which high flows enter the network of secondary channels that already exists on site (Figure 3) and interacts with floodplain channels. Because the existing secondary channel currently receive flow only during periodic high flow events and have limited high quality physical habitat, the project would also focus on improving the entrance area via minor excavation of fine sediment deposits, place large wood in the secondary channel to encourage pool formation and development of complex aquatic habitat (e.g. – pool formation, escape cover, etc), and excavate the downstream end of the secondary channel as it enters South Scappoose Creek to encourage development of backwater habitat on South Scappoose. In addition, a heavily eroding, vertical stream bank on the south side of North Scappoose Creek, just upstream of the confluence, will be laid back, revegetated, and protected using bioengineering techniques. ELJ's will also be strategically placed in the mainstem of North Scappoose Creek to improve aquatic habitat.

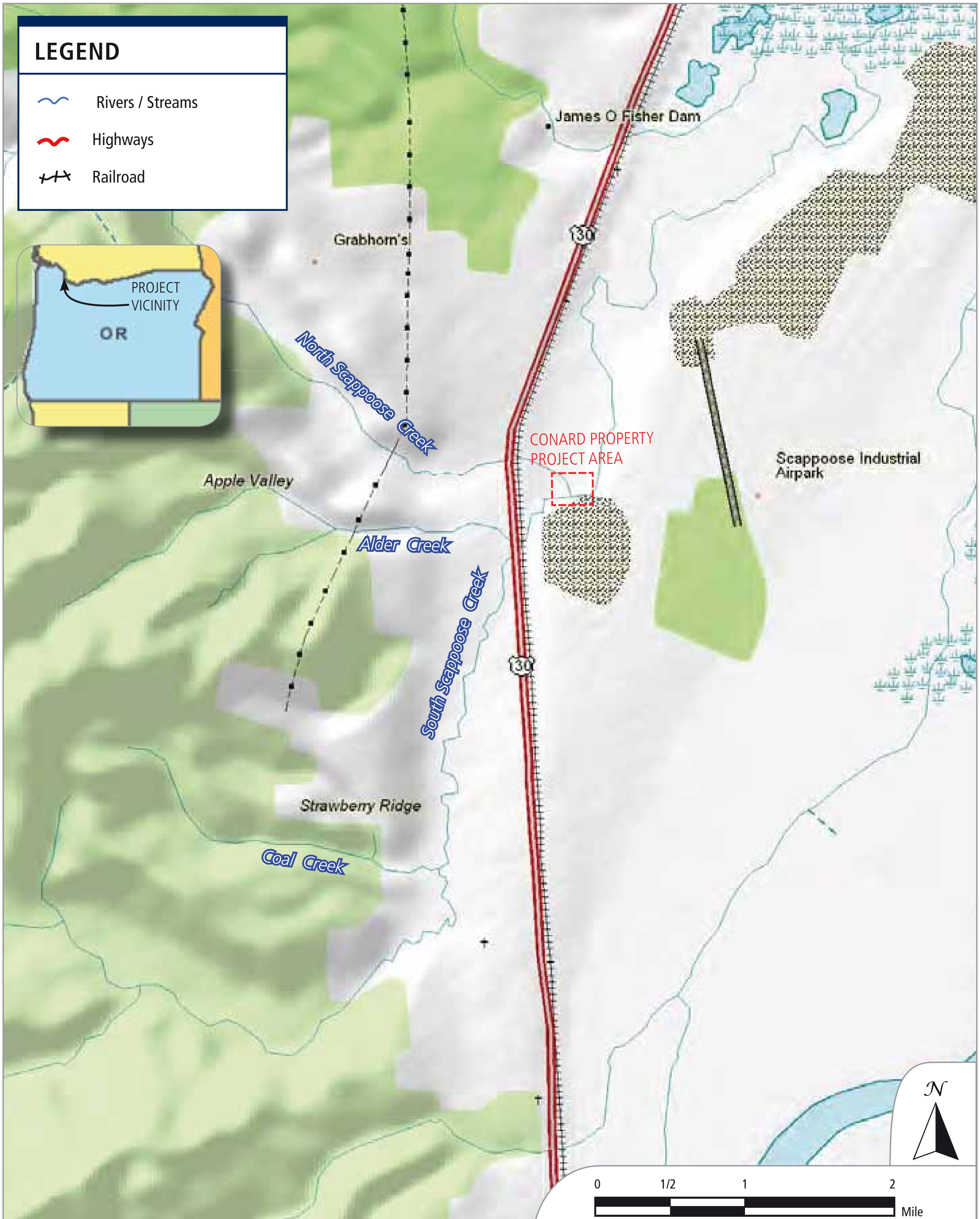

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FIGURE 1: Vicinity map.

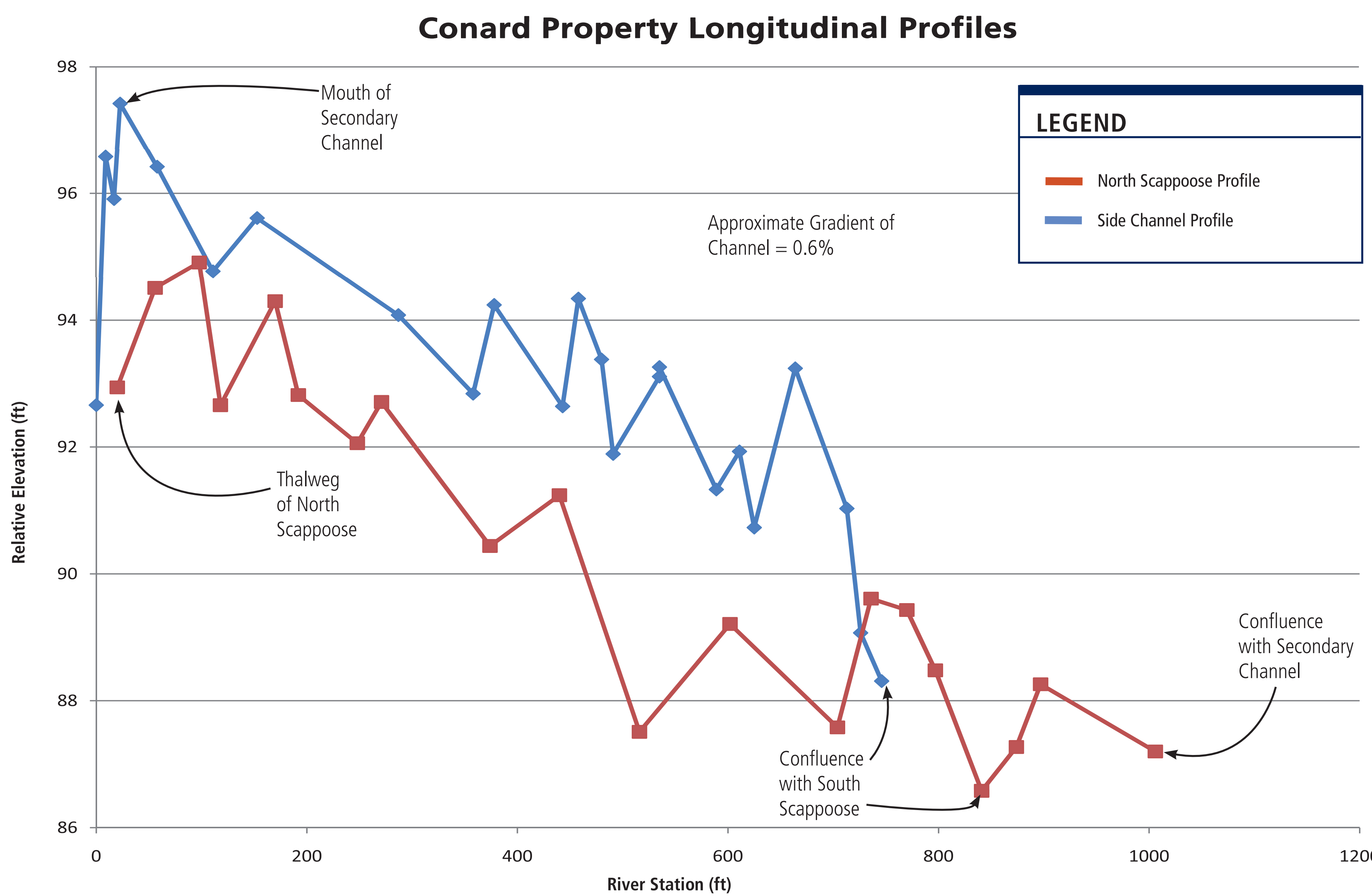

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FIGURE 2: Longitudinal profile of North Scappooose Creek project reach.

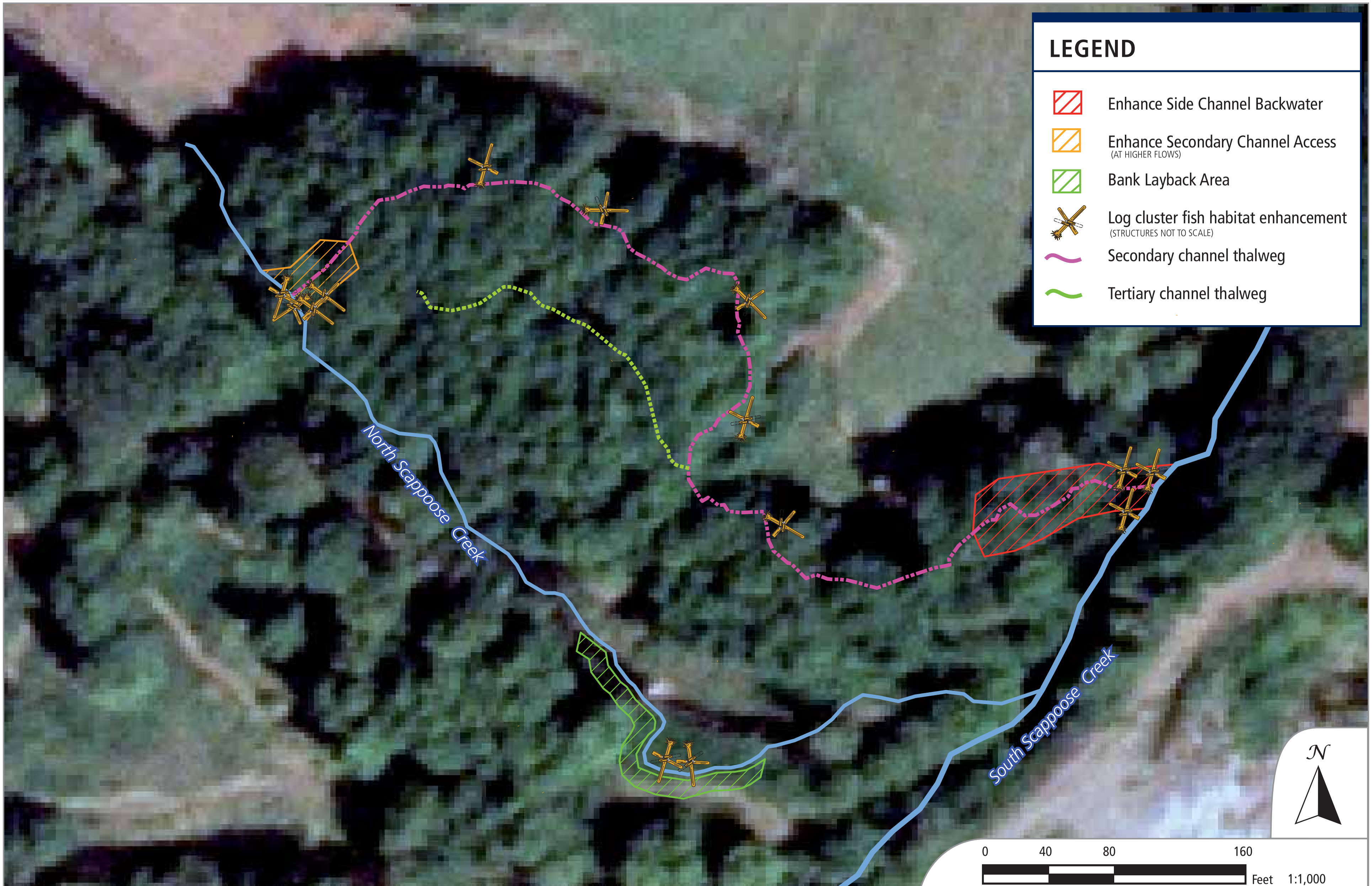

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FIGURE 3: Plan view of conceptual restoration options on Conard Property.

SOUTH SCAPPOOSE CREEK
RESTORATION PLAN

APPENDIX A

PROPOSED PROJECT - CONCEPTUAL DESIGN

VETERANS PARK - SCAPPOOSE

MANAGEMENT AREA G

CONCEPTUAL DESIGN

VETERAN'S PARK – CITY OF SCAPPOOSE

SOUTH SCAPPOOSE CREEK

BACKGROUND

The proposed project was identified during development of the South Scappoose Restoration Plan (Restoration Plan). The Restoration Plan included an evaluation of physical conditions on a five mile reach of South Scappoose Creek with the purpose of identifying causative factors related to excessive fine sediment delivery into Scappoose Bay, loss of high quality spawning and rearing habitat for salmonids, and incision within many of the primary channels. The impacts of the incision on channel and floodplain interaction, morphologic variability, and the ability of the stream to support and maintain the physical habitat features that provide for good aquatic habitat was evaluated.

The results of the Restoration Plan indicate that past land use impacts, including filling of historic floodplain and secondary channels, straightening and realignment of the channel, loss of riparian corridors, and floodplain constriction at road crossings have profoundly altered the functions and values of South Scappoose Creek. Consequently, one of the primary recommendations to improve channel and floodplain function on South Scappoose Creek is to increase the frequency with which high flow accesses overbank areas by creating and/or expanding floodplain area and complexity. Expansion of active floodplain areas would benefit the system by reducing localized shear that is currently acting on the channel banks and causing erosion of fine sediment directly into the creek and loss of narrow riparian corridors. By expanding floodplain areas, localized erosion of fine sediment will be reduced and healthy riparian corridors will be restored. Functioning riparian corridors, consisting of a mix of conifers and hardwoods, reduce stream temperatures and provide a future source of large wood to the creek channel, both of which improve aquatic habitat.

PROJECT DESCRIPTION

The proposed project is located on South Scappoose Creek within the City limits of the City of Scappoose. The project area encompasses approximately 1,500 lineal feet of channel and adjacent floodplain area downstream of the JP West Road crossing (Figure 1). The City of Scappoose owns large parcel where a City park, referred to as Veteran's Park, was recently construction. City ownership includes Veteran's Park, the creek channel, and an adjacent large parcel on the opposite side of the creek. Development at the park includes a parking area, pedestrian trails, baseball diamonds, and other recreational facilities. In anticipation of channel and riparian restoration occurring along South Scappoose Creek, the City dedicated setbacks from the Creek during the design and development of the Park. The parcel on the opposite bank remains undeveloped.

Over much of the length of City-owned property, the banks are steep and devoid of mature riparian vegetation. Some mature stands of trees have persisted in isolated areas, providing some protection to the banks, but in most cases the bank is steep and actively eroding. The channel gradient through the project area is relatively flat due to backwatering from the EJ Smith Road crossing which is located approximately 1000 feet downstream of the project area. Most of the project area consists of flatwater with some deeper scour pools and scattered large woody debris. A small, unnamed tributary enters South Scappoose Creek at the downstream end of the project area. The tributary mouth is perched above the South Scappoose channel with some headcutting occurring. It is likely that the tributary will headcut further in the future in an effort to achieve a similar grade as South Scappoose.

The proposed project on the Veteran's Park property consists of excavating active floodplain along both banks, reducing bank angles, establishing a diverse riparian and upland vegetation canopy, protecting the tributary channel from further headcutting and establishing a wetland on the tributary before it drops down to the enhanced South Scappoose floodplain (Figure 2). Floodplain excavation would occur along both banks of South Scappoose but would alternate to avoid existing stands of mature riparian and upland vegetation. The floodplain benches will vary between 20 and 100 feet, depending upon the space available, and the banks will be cut back anywhere from 3:1 to 5:1 (Figure 3). The exact dimensions of the proposed floodplain bench will depend on site opportunities, design considerations, and costs associated with excavation, off-haul, and disposal of the material. It is expected that the bench will be excavated to the bankfull elevation (i.e. – approximate 1.5-year flood elevation) which will be determined once additional topographic data is collected at the site and a hydraulic model is developed (LIDAR data are available for the site but additional topographic data will be necessary to obtain bathymetry). A small seasonal wetland will also be excavated in the upland area, in line with the tributary channel, to create functional wetland habitat and manage stormwater from existing impervious surfaces upstream of the Park property. The site will be revegetated with native wetland plants.

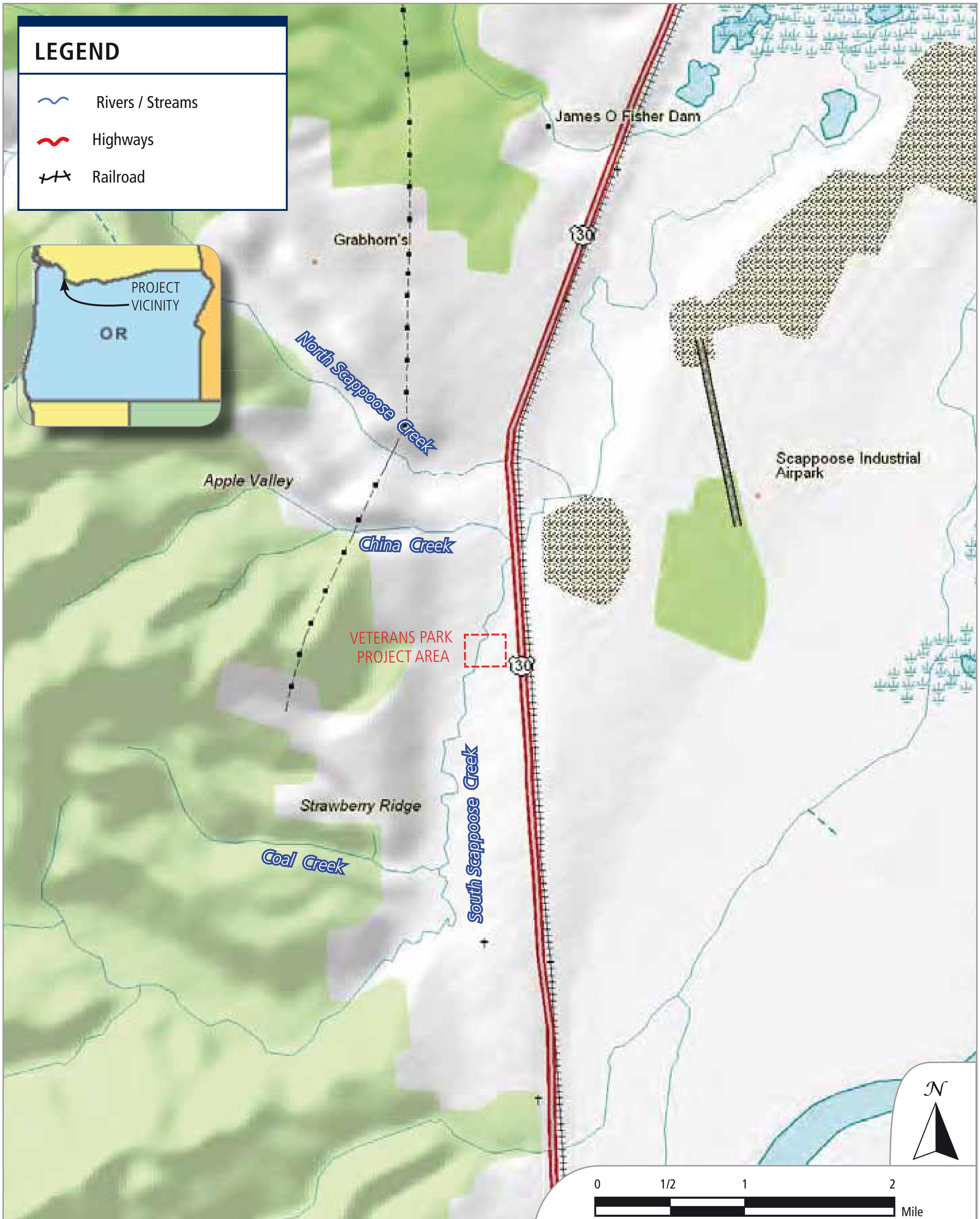

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FIGURE 1: Vicinity map.

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FIGURE 2: Plan view of conceptual channel restoration design options on property owned by the City of Scappoose adjacent to Veterans Park.

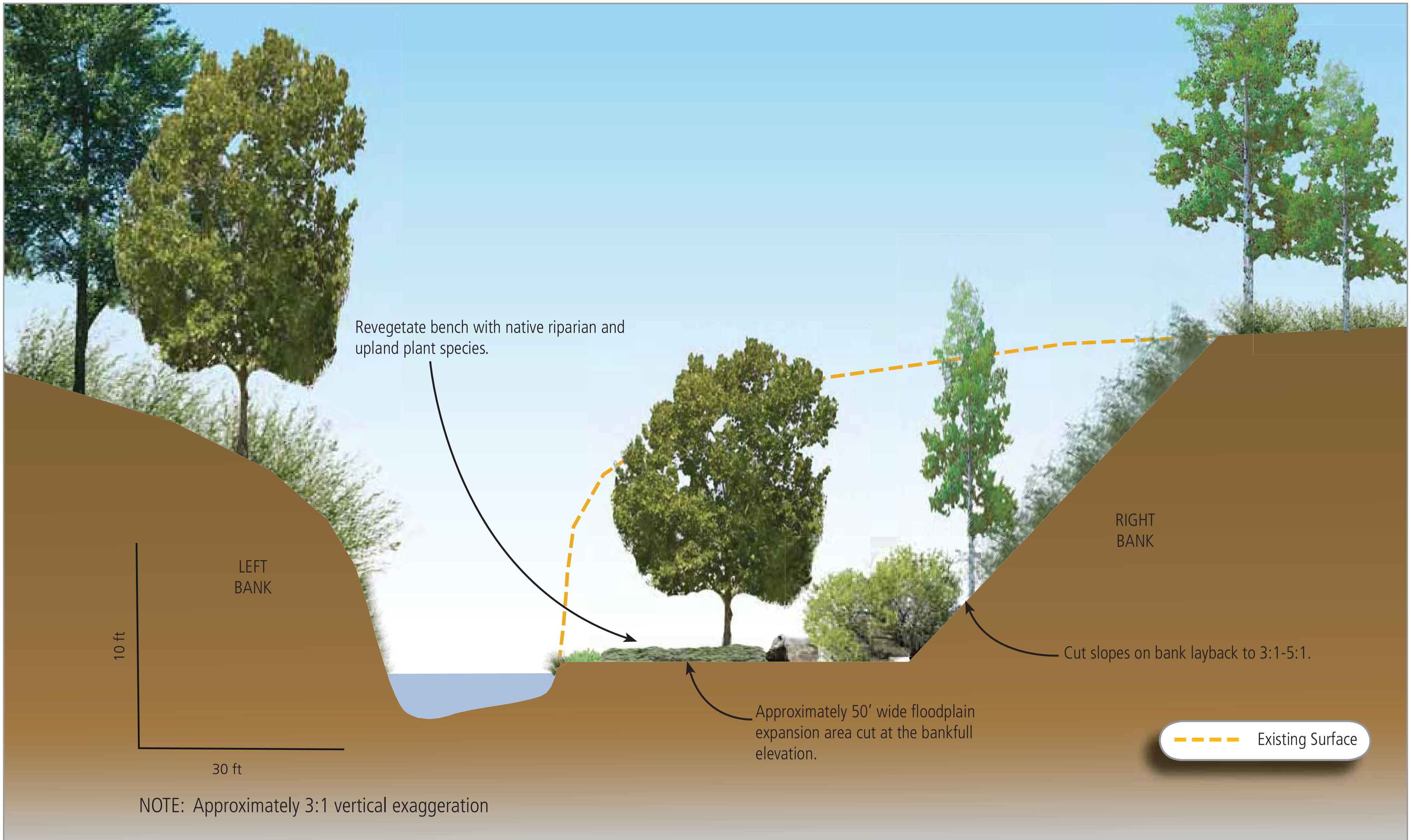

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FIGURE 3: Typical cross section of proposed channel restoration design adjacent to Veterans Park. The proposed enhancements improve channel and floodplain function by creating a low terrace, thereby reducing local shears that currently result in excessive bank erosion.

SOUTH SCAPPOOSE CREEK
RESTORATION PLAN

APPENDIX A

PROPOSED PROJECT - CONCEPTUAL DESIGN

SNOOK PROPERTY

MANAGEMENT AREA O

CONCEPTUAL DESIGN

SNOOK PROPERTY

SOUTH SCAPPOOSE CREEK

BACKGROUND

The proposed project was identified during development of the South Scappoose Restoration Plan (Restoration Plan). The Restoration Plan included an evaluation of physical conditions on a five mile reach of South Scappoose Creek with the purpose of identifying causative factors related to excessive fine sediment delivery into Scappoose Bay, loss of high quality spawning and rearing habitat for salmonids, and incision within many of the primary channels. The impacts of the incision on channel and floodplain interaction, morphologic variability, and the ability of the stream to support and maintain the physical habitat features that provide for good aquatic habitat was evaluated.

The results of the Restoration Plan indicate that past land use impacts, including filling of historic floodplains and secondary channels, straightening and realignment of the channel, loss of riparian corridors, and floodplain constriction at road crossings have profoundly altered the functions and values of South Scappoose Creek. Consequently, one of the primary recommendations to improve channel and floodplain function on South Scappoose Creek is to increase the frequency with which high flow accesses overbank areas by creating and/or expanding floodplain area and complexity. Expansion of active floodplain areas would benefit the system by reducing localized shear that is currently acting on the channel banks and causing erosion of fine sediment directly into the creek and loss of narrow riparian corridors. By expanding floodplain areas, localized erosion of fine sediment will be reduced and healthy riparian corridors will be restored. Functioning riparian corridors, consisting of a mix of conifers and hardwoods, reduce stream temperatures and provide a future source of large wood to the creek channel, both of which improve aquatic habitat.

PROJECT DESCRIPTION

The Snook Property, located in Dutch Canyon (Figure 1), is approximately five acres and encompasses 800 lineal feet of channel along the west bank of South Scappoose Creek. The Snook family recently built a new house on the property away from the creek and floodplain and is looking to partner with the Scappoose Bay Watershed Council to improve South Scappoose Creek. Much of the west bank, which flows adjacent to the Snook Property, is devoid of mature riparian vegetation and in several locations the bank is actively eroding (Figure 2). The channel gradient through the project area is approximately 0.4 percent and includes a series of short riffles and long pools (Figure 3). The riffles consist of a mix of cobble and gravel but the pools are dominated by fine material that is likely a mix of locally eroded bank material and sediment delivered from upstream. A few in-channel log jams, consisting of 3-7 small logs no greater than 12" diameter, exist through the project reach. Juvenile salmon have been observed in the pools. Comprehensive fish surveys have not been completed.

The proposed project on the Snook Property consists of excavating active floodplain along the west bank, reducing bank angles, establishing a diverse riparian and upland vegetation canopy, and installing several engineered log jams (ELJ) to improve in-channel habitat complexity (Figure 2). A 20-30 foot wide floodplain bench will be established along the existing west bank and the banks will be cut back anywhere from 3:1 to 5:1 (Figure 4). The exact dimensions of the proposed floodplain bench will depend on site opportunities and design considerations. It is expected that the bench will be excavated to the bankfull elevation (i.e. – approximate 1.5-year flood elevation) which will be determined once detailed topographic data is collected at the site and a hydraulic model is developed. The ELJ's will be placed at the riffle-pool transition to maximize pool scour and provide escape cover habitat for fish during summer rearing and winter high flows. Each ELJ will consist of 5-8 pieces of large wood with a minimum length of 20 feet and a minimum diameter of 18". They will be keyed into the channel bed and banks. A small seasonal wetland will also be excavated to increase the hydroperiod and improve wetland function. The site will be revegetated with native wetland plants. All excavated material will be disposed of on-site in an upland area approved by the property owner.

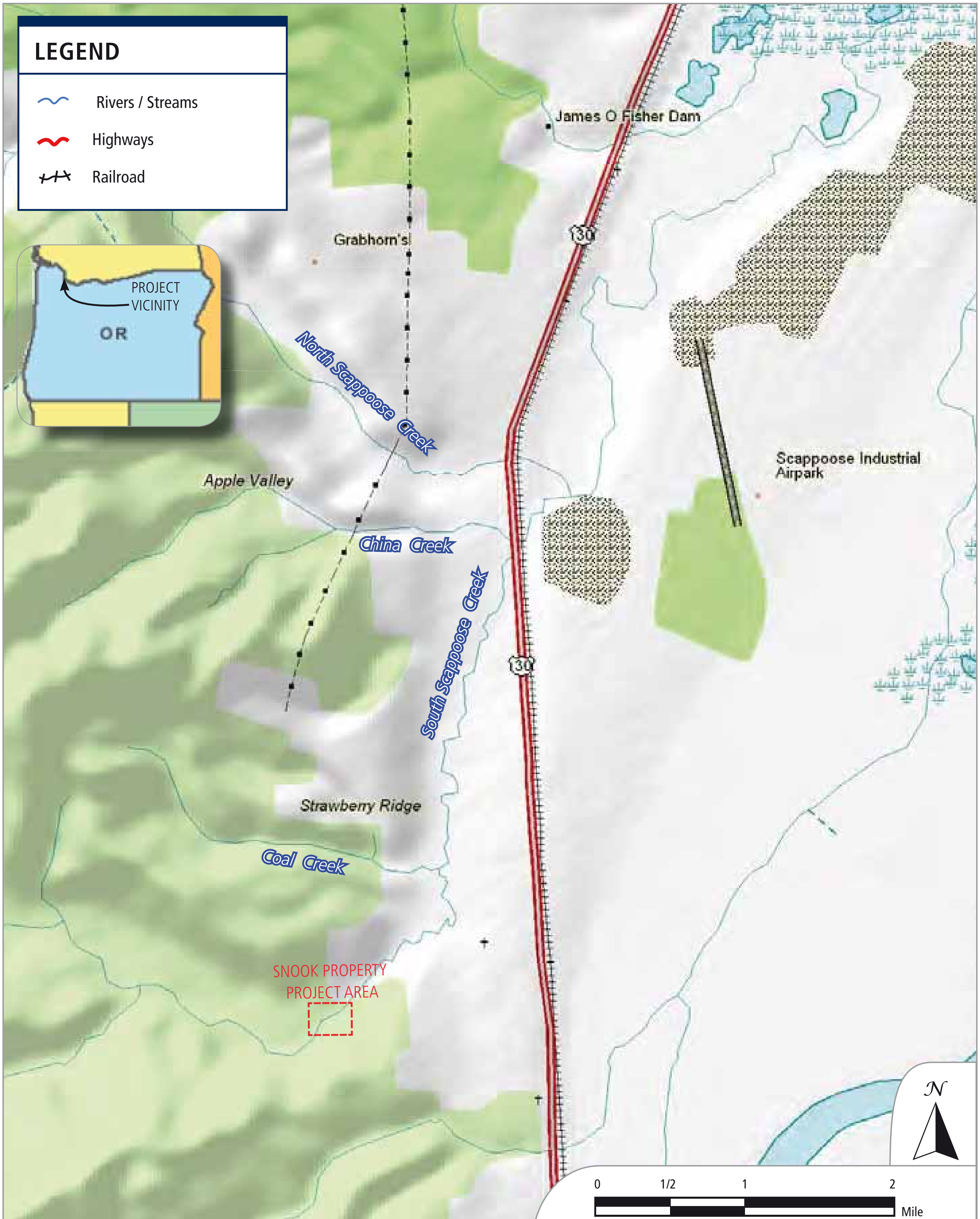

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FIGURE 1: Vicinity map.

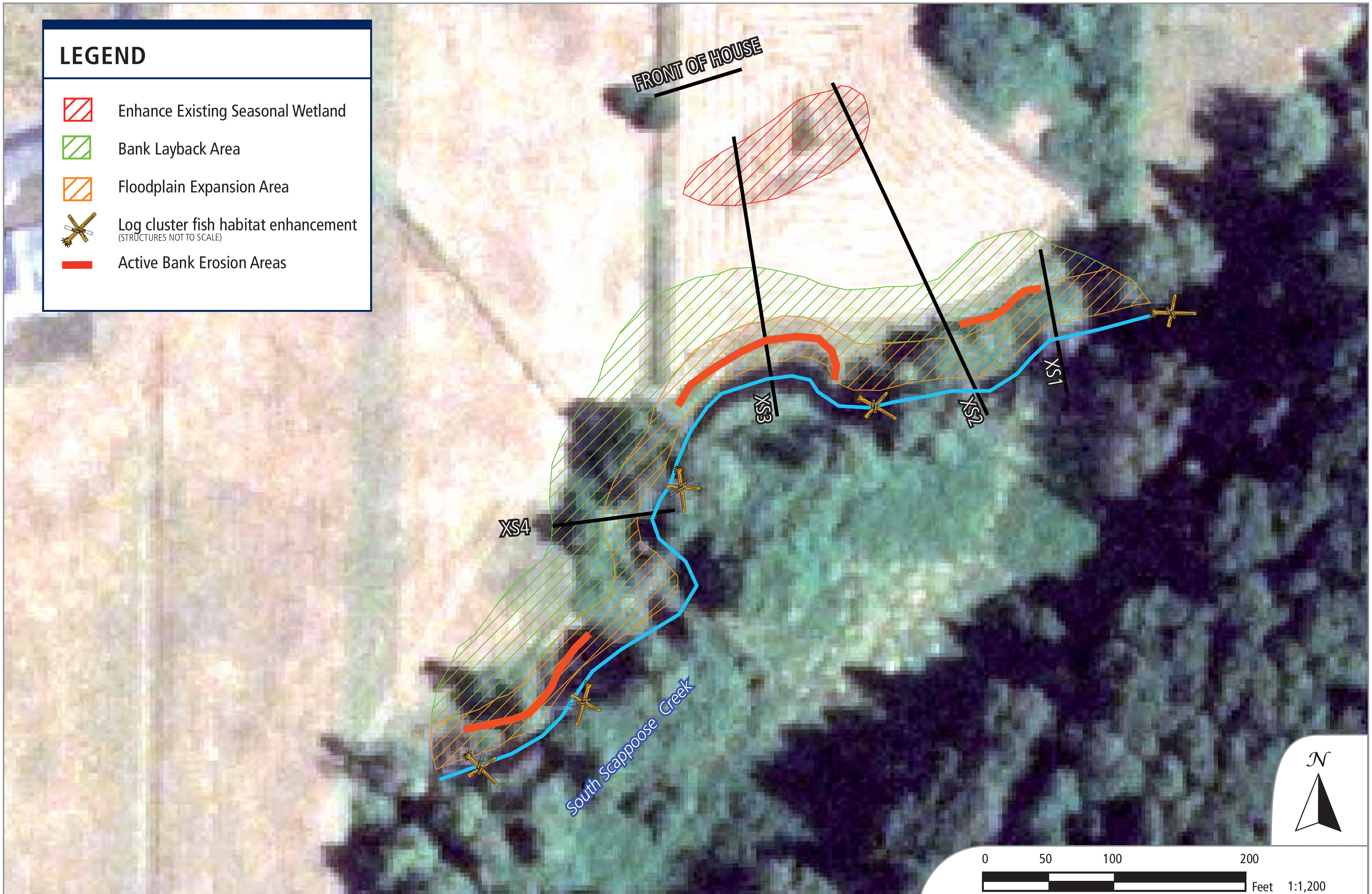

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FIGURE 2: Plan view of conceptual restoration options on Snook Property.

South Scappoose Creek Longitudinal Profile

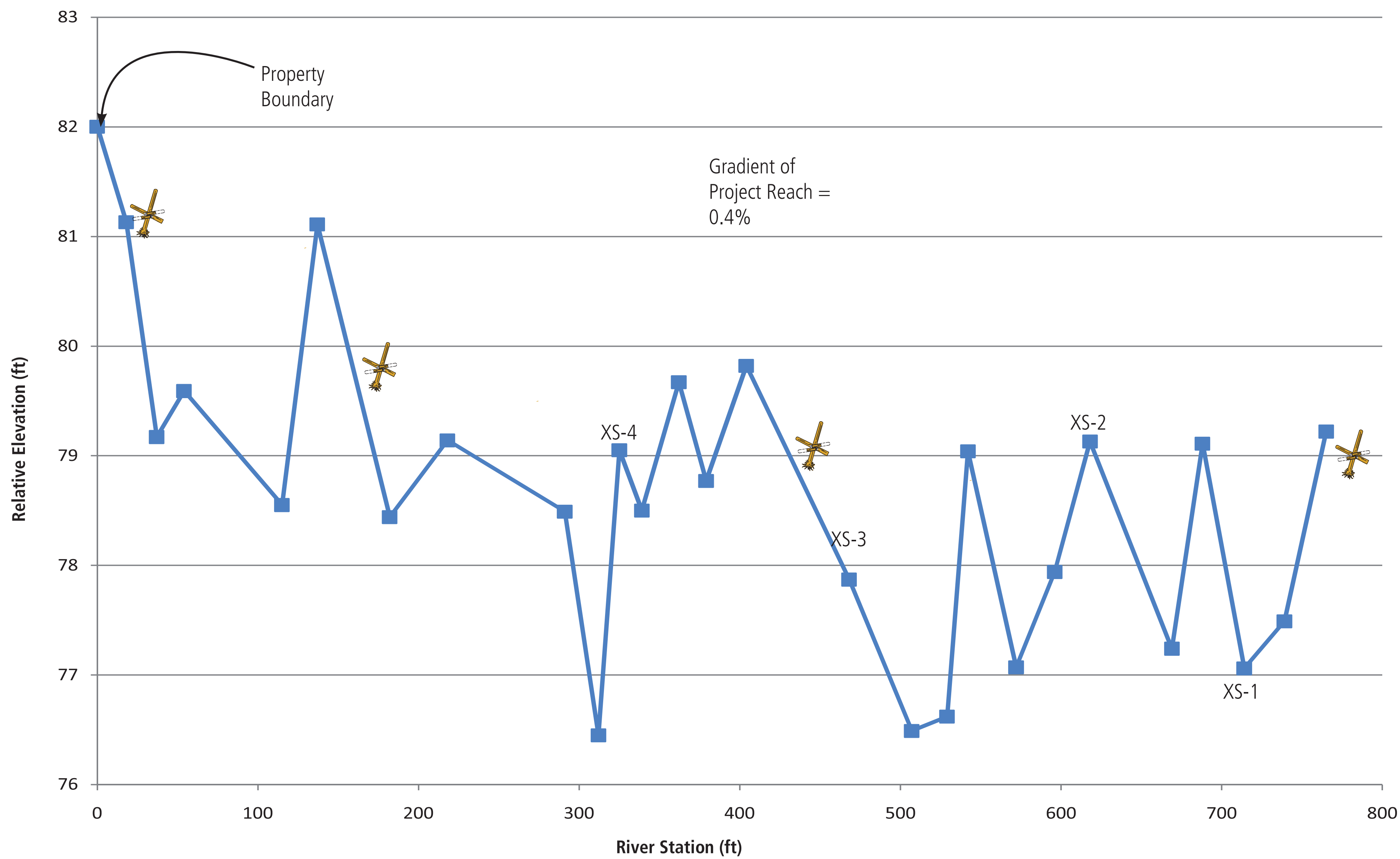

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FIGURE 3: Longitudinal profile of South Scappoose Creek Channel project reach.

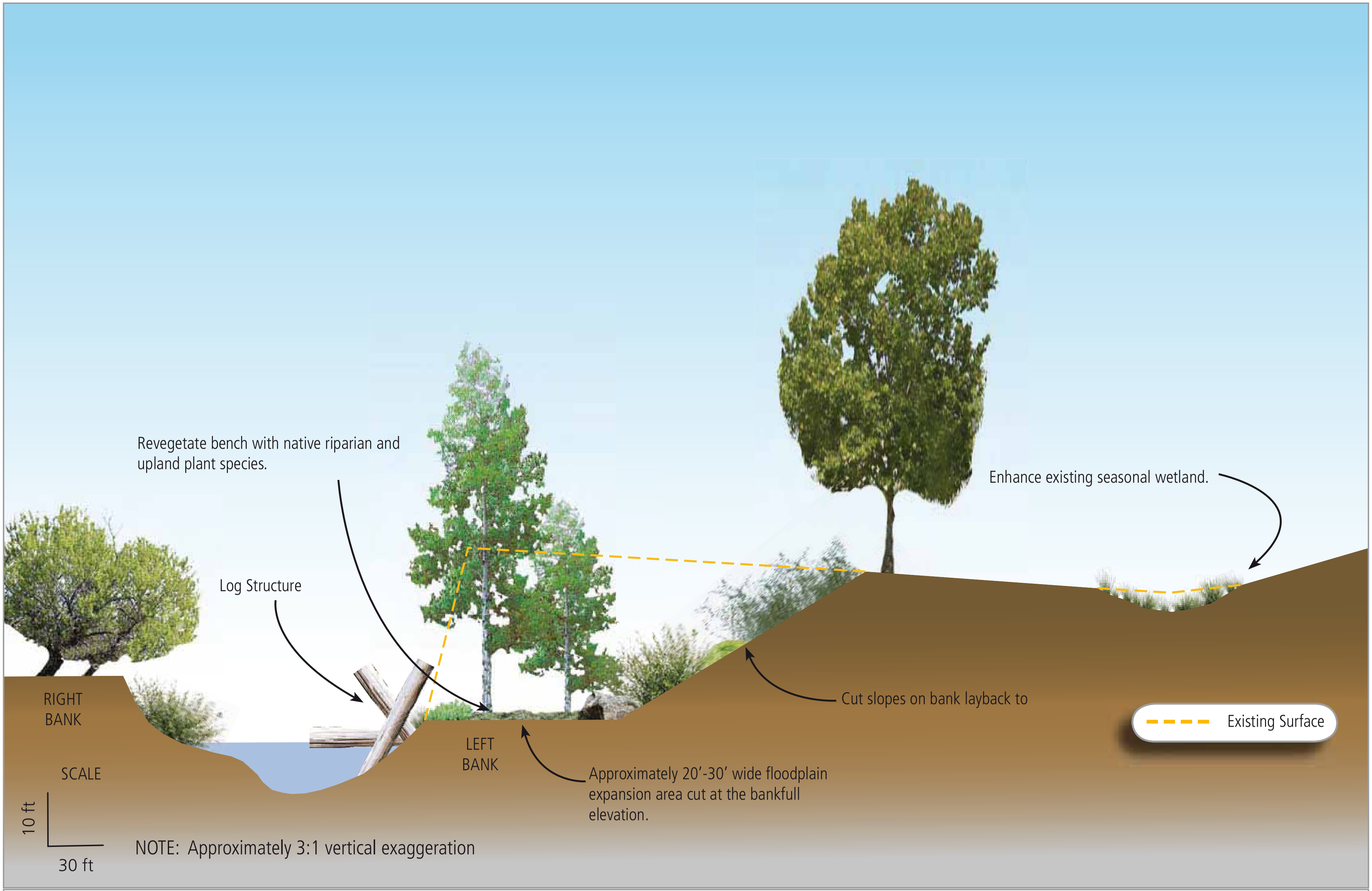

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FIGURE 4: Conceptual cross section of proposed conditions on South Scappoose Creek. Existing surface is based on Cross Section 3 topo data.