

Channel Migration Analysis Summary Report

A Component of the SR 530 Sauk River Corridor Analysis



Work Order XL2778

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Channel Migration Analysis Summary Report
SR 530 Sauk River MP 54-68
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Attachments

- A: Skagit Wild and Scenic River Historic Channel Mapping Analysis.
- B: Site and Reach Assessment Evaluation of Treatment Alternatives SR 530/Sauk River Chronic Environmental Deficiency Site MP 58-59.
- C: Site and Reach Assessment Addendum.
- D: Sauk-Suiattle Confluence Emergency Site and Reach Assessment.

Introduction

SR 530 runs along the Sauk River from Darrington in Snohomish County to its confluence with the Skagit River near Rockport in Skagit County. While the section of highway only runs along the river for a distance of 12 miles, it is one of the most problematic highway segments in the entire state. Numerous repetitive damage sites, unstable slopes, and eroding banks threaten the highway. Much of the route lies in the Channel Migration Zone (CMZ). Floods and damage to the highway from erosion result in road closures and emergency project activities almost every season.

Part of the reason for the problems that plague SR 530 along the Sauk River are due to its unique geologic and geomorphic history (Tabor et al, 2002). During the last ice age glaciers blocked the modern course of the Skagit River. The entire Skagit flowed south through the Sauk and Stillaguamish River valleys before emptying into Puget Sound. This resulted in the deposition of very large Holocene floodplain terraces along the banks. These terraces often appear as parts of the valley wall, but are actually ancient floodplain deposits composed of alluvium. As such, they are quite easily eroded.

In addition, mass wasting events in the upper Sauk and Suiattle River drainages are exacerbating geomorphic processes that drive channel migration downstream. This, in turn, is driven in part by the loss of glacial ice storage on Glacier Peak, which forms the headwaters of both the Suiattle and Sauk Rivers. Much of the length of SR 530 between Darrington and Rockport is located on eroding Holocene terraces and thus is highly susceptible to channel migration.

Because of these (and other) factors, the long term prognosis for the continued maintainability of the highway is in serious doubt. While emergency and proactive bank stabilization projects have succeeded in repairing and protecting the road to some extent, the geomorphic conditions are deteriorating rapidly in terms of overall road stability. More fundamental questions about the future of the highway and the environmental impacts of maintaining it in its current alignment are coming increasingly to the forefront.

Suggestions to move the entire road, or considerable portions of it, have now been made by Treaty Tribes and regulatory agencies. This concept is figuring prominently in discussions with these entities about permits for projects aimed at highway survival (such as bank stabilization projects). The common theme in these discussions is a desire for WSDOT to take a broader look at whether such major realignments can avoid existing and potential trouble spots altogether by getting entirely out of the river's channel migration zone. Reports prepared at the reach analysis scale are not comprehensive enough to consider such major realignments outside of the channel migration zone. Therefore, a corridor level alignment analysis is needed to analyze potential routes, geomorphic and geological constraints, and environmental impacts. It will also be critical in the development of preliminary traffic geometry studies and cost estimates for right-of-way acquisition and for construction of the potential corridor level realignments. As part of that effort, WSDOT has agreed to look at channel migration trends along the existing route and project future impacts should the highway remain in place. This report presents the findings of that examination.

Methodology

For the purposes of this study data pertaining to channel migration trends and tendencies on the Sauk River was evaluated in terms of potential threats to the highway. This data came from four principal studies. Each of these is included as an attachment.

The Skagit Wild and Scenic River Historic Channel Mapping Analysis was prepared for the U.S. Forest Service in 2008 by the Skagit River System Cooperative, an intertribal organization consisting of the Sauk-Suiattle and Swinomish Tribes. This report maps channel migration from 1944 to 2007. It also examines migration trends for various river segments and presents information on private parcels and structures within the CMZ.

The Site and Reach Assessment Evaluation of Treatment Alternatives SR 530/Sauk River Chronic Environmental Deficiency Site MP 58-59 was prepared by WSDOT in 2003. This report was prepared to determine site and reach based causes of erosive failures of SR 530 and to develop and recommend solution alternatives which included both bank stabilization and relocation of portions of the highway.

The Site and Reach Assessment Addendum was prepared by WSDOT in 2007. This report updated the 2003 reach assessment. The central focus of this report consisted of analyzing an imminent avulsion of the Sauk River in close proximity to the SR 530 site at MP 58-59. The recommendations stemming from this report led the 2008 Value Engineering study which resulted in the construction of a 1000-foot long log crib wall at MP 58-59 and the commissioning of the SR 530 Corridor Analysis.

The Sauk-Suiattle Confluence Emergency Site and Reach Assessment was prepared by WSDOT in 2007. This report analyzed channel migration driven threats to SR 530 in the Sauk Suiattle confluence vicinity at MP 55-56.

Each of these reports presented extensive data and analysis of channel migration trends and tendencies covering parts of the entire corridor study area. We downloaded all of the channel mapping data into the WSDOT GIS system and then performed a spatial adjustment procedure to reconcile the channel data from the various sources and correct georeferencing errors.

Upon examination of the channel migration data it became apparent that there were distinct zones dictated by the extent of historic channel migration trends, floodplain topography, and surficial geology. These zones also correspond to areas of relative threat as evidenced by recent WSDOT maintenance history. We conducted additional field assessment to confirm the findings of the trend and maintenance history analysis. During the field assessment we measured bank heights to determine the appropriate location and slope required to achieve a stable geotechnical setback along a portion of the highway experiencing relatively minor channel migration (zone 4). A default stable slope value of 2:1 was selected after field review of stable vegetated reference slopes within the project area.

We generated cost estimates for addressing the high hazard areas along SR 530 by extrapolating project costs from recently built WSDOT projects that share similar configuration to the bank stabilization crib wall and bridge replacement projects anticipated as future needs for SR 530.

Summary of findings

Channel migration hazard zones

The SR 530 corridor along the Sauk River can be divided into five hazard zones, depending largely upon channel migration trends in the adjacent river reaches (See figures 1, 2 and 3).

- **Zone 1: Sauk Suiattle confluence (MP 55) to steel bridge (MP 56.22).** This is an area of high hazard. The highway is either within or at the edge of the channel migration zone. Channel migration in the adjacent reach is highly active and recent emergency bank stabilization projects have been undertaken.
- **Zone 2: Steel bridge SR 530/207 (MP 56.22) to MP 58.** This is an area of relatively low to moderate hazard. While channel migration is active the highway is relatively far from the river and lies outside of the jurisdictional floodplain. There is little to no maintenance history associated with channel migration or bank erosion in this area.
- **Zone 3: MP 58 to MP 60.** This area of high channel migration hazard is very active. Recent river avulsions have occurred. There are ongoing maintenance and erosion concerns in this area which have resulted in numerous emergency projects as well as a major project effort under the WSDOT Chronic Environmental Deficiencies (CED) program.
- **Zone 4: MP 60 to MP 64.** This is an area of moderate hazard. While the road runs relatively close to the river, channel migration in the adjacent reach has been very minor throughout the photographic record. While some bank stabilization activities have taken place here, most of these have not been recent. The channel is quite straight suggesting that this is a transport reach.
- **Zone 5: MP 64 to Skagit River (MP 67.34).** This is an area of relatively high channel migration hazard. The valley broadens to meet the floodplain of the Skagit River, and historic channel migration has been extensive. While this segment has not seen much in the way of recent maintenance needs, in the past the Sauk River has occupied side channels immediately adjacent to the road, requiring bank armor placements. While much of this highway segment is located well away from the river, the fact that it is in floodplain/CMZ that is shared by both the Sauk and Skagit rivers raises the objective hazard associated with channel migration. It is also important to note that even if portions of SR 530 are eventually relocated, it would still be necessary to cross the floodplain/CMZ to reach the Skagit River crossing regardless of the alignment chosen.

Geotechnical setback

The elevation difference between the road and the river was measured at seven locations in hazard zones 3, 4, and 5. Elevations range from 9.3 to 35 vertical feet with an average height value of 19.2. This indicates a setback of 38.4 feet assuming a default slope ratio of 2:1. The most likely place to use the geotechnical setback as part of the protective strategy for the SR 530 corridor is within zone 4, the area of moderate hazard located between MP 60 and 64. Historic channel migration here is limited, and sufficient land is

available to accomplish a setback. However, extensive purchase of private parcels would be required. In addition, some form of bioengineering treatment would be required to stabilize the setback slope and ensure the establishment of riparian vegetation.

Of the approximately 12.35 miles of the SR 530 corridor extending from MP 55 to the Skagit River Bridge (MP 67.34), 6.54 miles lie within high channel migration hazard zones (1,3,and 5), four miles of the subject corridor lie in the moderate hazard zone (4), and 1.8 miles lie within the low to moderate hazard zone (2).

Projected future highway preservation costs and assumptions

For the purposes of this exercise we assume a worst-case scenario in which the entirety of the high hazard zones will have to be protected within the next 25-50 years.

We also assume that the protective measures will be similar to the log cribwall constructed last year at MP 59. This structure protected 1000 feet of bank at a cost of \$3.0 million in 2008. Extrapolated, this would come to a total of approximately \$15.0 million per mile of similar structure. If that is extrapolated over the 6.54 miles of corridor within the high migration hazard zones we derive a total estimate of \$98.0 million. While it is highly unlikely that the entire road would need protection, this worst-case projection demonstrates that substantial investment could be necessary to keep SR 530 open in the future on its existing alignment. Even if the segment of the high hazard areas needing protection is only 20 percent of the total length (1.3 miles) the projected cost estimate for protective measures over the next 25-50 years would still be \$19.6 million. This estimate does not include routine maintenance or the cost of mitigation actions.

By way of comparison, armoring the same 1.3 mile corridor with a rip rap revetment would cost between \$8.0 and \$12.0 million, and the substantial environmental impacts of such a project would require considerable mitigation which are not included in this estimate. These figures are not adjusted for inflation.

In addition to the costs associated with bank and road prism stabilization, the steel truss bridge at MP 56.22 is 51 years old. Over the next 50 years, this span will reach the end of its design life. Bridge replacement cost is not included in this estimate. It should also be noted that under most of the relocation scenarios being studied as part of the larger corridor analysis effort, the continued use, protection and eventual replacement of the SR 530/207 Bridge and its approaches would still be required.

Specific bank stabilization site priorities

WSDOT has identified six bank stabilization sites and one avulsion hazard site for prioritization in terms of the potential need for future bank stabilization activities. These are shown in Figure 4, and are described below and shown in Figure 4.

Zone 1, Bank Site 1: Rank 4. Hatchery Creek to Suiattle confluence (MP 55 to MP 55.5). Length is approximately 2,500 feet. Bank is 10-15 feet high and composed of older heavy loose riprap though some areas still have riparian vegetation. The riprap armor is compromised along several stretches of this scarp and will need eventual repair or replacement with an updated protective structure. Because this area is upstream of the confluence it is not as high of a risk area as the scarp extending downstream from the confluence, and it's thus ranked 4 on the list of existing and potential bank stabilization sites.

Zone 1, Bank Site 2: Rank 1 (tied with Site 3). Confluence to Steel Bridge (MP 55.5 to MP 56.2). Length is approximately 3,000 feet. This site is the location of an active adaptive management process stemming from HPA permit requirements for previous emergency bank stabilization projects. Augmentation or replacement of the bank stabilization emplacement here will be determined by the adaptive management process, as agreed to by WSDOT and WDFW. It is in an area of high migration and instability, largely due to sediment inputs from the Suiattle River. Because of this, the need for additional work at this site is highly likely. As such, it is an area of severe risk and is ranked number one on the list of bank stabilization sites. This ranking is provisional depending upon the outcome of feasibility studies examining realignment of the highway in this vicinity.

Zone 3, Bank Site 3: Rank 1 (tied with Site 2). CED Project / Option 3 (MP 59 to MP 60). Length is approximately 1,400 feet. This site is within the project area of an active CED project that is partially funded. It consists of a high, steep riprap slope ranging from 20 to 40 feet in height. It is steeper than the proper angle of repose (1.5:1) for riprap and is thus inherently vulnerable to failure. Several large emergency riprap repairs have been implemented at this site. The river strikes the toe of the slope at a high angle of attack. The gradient of the slope and the angle of attack by the river thalweg indicate that relocation of this highway segment away from the slope is the best option. However, WSDOT does not have full funding to complete this realignment. If the highway is not relocated in the immediate future, additional placement of riprap under emergency conditions will likely be necessary to protect the highway from failure. It is important to note that because of its height the log crib wall options that lend themselves well to the other existing and potential sites within the corridor may not be viable options at this site due to constructability and slope stability concerns. Because funding and consensus for proceeding with the realignment has not been secured this site is ranked at number 1, tying with site 2. This ranking is also provisional, as moving forward with the relocation would greatly reduce (if not eliminate) the need for further bank stabilization activities at this site. The realignment allows a geotechnical setback of at least 2:1 and as much as 4:1 through most of the proposed route (see Figure 5).

Zone 4, Bank Site 4: Rank 6. White Creek (MP 60.25 to MP 60.5). Length is approximately 1,200 feet. This site is in an area of reduced channel migration. It consists of a low angle (2:1) heavy riprap slope. This site is relatively stable and has not needed maintenance for erosion damage for well over ten years. This area is subjected to occasional

slides and rockfall, however, these threats come from the slope above rather than from the river. The thalweg approaches at a high angle of attack. However, the limited channel migration, low angle of the slope, and lack of recent maintenance activity puts the site in more of a low to moderate risk range. This site is ranked at number 6.

Zone 4, Bank Site 5: Rank 5. County Bridge (MP 61.4 to MP 61.7). Length is approximately 1,000 feet. Like Site 4, Site 5 is located in a reach that has seen little channel migration throughout the photographic record (which goes back to the 1940s). It is not very high (12 to 20 feet) and its angle of repose is within acceptable parameters for rock slopes (approximately 1.5:1). There has been no recent history of maintenance at the site and the armor is in good condition. This site is ranked at number 5.

Zone 5, Bank Site 6: Rank 7. Side channel scarps (MP 64.3, 64.6, and 65.3). Total length is approximately 800 feet. This “site” consists of three closely-spaced riprap slopes along tributaries and side channels to the Sauk River. The slopes are between 1.5:1 and 2:1 with a height ranging from 9 to 14 feet. While riprap repairs of the bank have occurred in the past, there has been no work at any of these scarps in over ten years. While channel migration is high in Zone 5, these locations do not appear to be under much mainstem influence at this time. The closest position of the mainstem in relation to the highway in this vicinity is at MP 65, where the mainstem is over 500 feet to the west. This site is ranked at number 7.

Zone 5, Bank Site 7: Rank 2. Skagit River side channel at Rockport Bridge (MP 67.2 to MP 67.34). Note: length not applicable to this site because it is not a bank stabilization site so much as it is a potential avulsion site. The Skagit River is threatening to avulse into a side channel on the right bank of the Skagit River. This side channel is bisected by the fill prism for SR 530 and its approach to the Rockport bridge. If this occurs, there is a high likelihood of catastrophic highway failure. A “Site and Reach Assessment” is planned for this location under the auspices of WSDOT’s CED program. Because of the high rate of channel migration in this area and the potential level of damage that an avulsion here could cause, this site is ranked at number 2.

These sites add up to a total estimate of 9900 LF of bank stabilization. If alternative 3 realignment is implemented this total drops to approximately 8500 although some minor banks stabilization may need to take place at the southern departure point for the realignment. With the possible exception of site 3, all of the bank stabilization sites appear to be conducive to the placement of log crib walls or crib benches. Because they have a comparatively smaller footprint and incorporate large volumes of large woody debris they have fewer impacts and convey superior environmental benefits than most other traditional types of bank stabilization design. The best option for site 3 is to relocate the highway segment that is against the mainstem, as has been proposed in the scope of the current CED project. While crib walls have been successfully built in the side channel portion of this site the remaining slope is much higher and steeper and poses much more significant challenges from the standpoints of constructability and slope stability. Specific design development for the bank stabilization sites should take place within the context of either updated or new Reach Assessments which lie beyond the scope of this report.

Site seven also needs a Reach Assessment to further clarify levels of risk and to develop design solutions that can be submitted for funding, however the fact that this is an avulsion site bisected by the roadway indicates that the solution will be much different than the other sites described here.

Additional sites of concern

The US Forest Service identified two additional locations along SR 530 that, while located within areas that have the least migration in the historic record, may be vulnerable to future channel migration:

SR 530, MP 63.5



SR 530, MP 64.9



These sites may be appropriate for future monitoring. While WSDOT is not able to assess the sites because they are located on private property some distance from the highway, the agency will welcome information from property owners, USFS, or other interested stakeholders about changing conditions or other concerns.

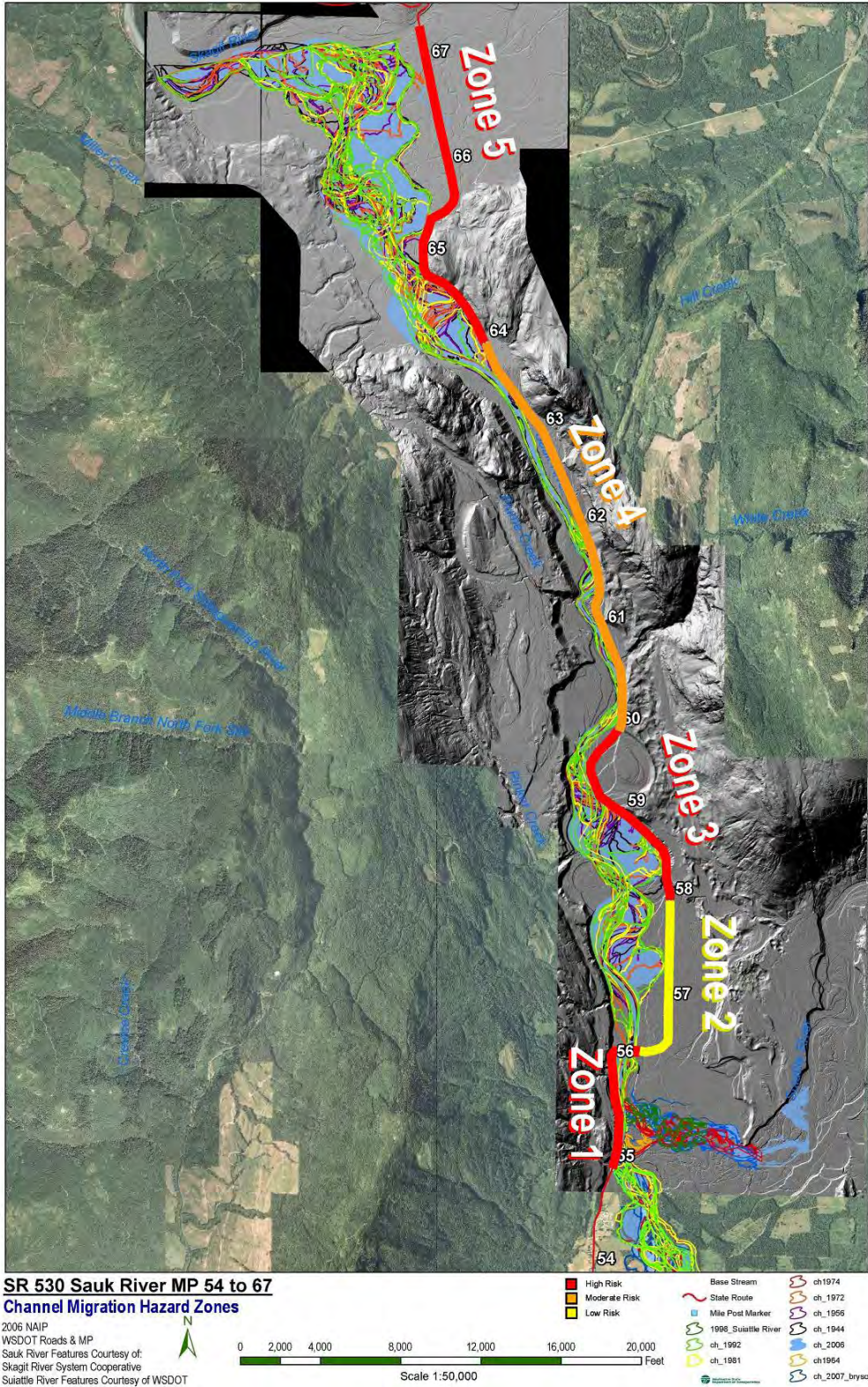


Figure 1. SR 530 hazard zones.

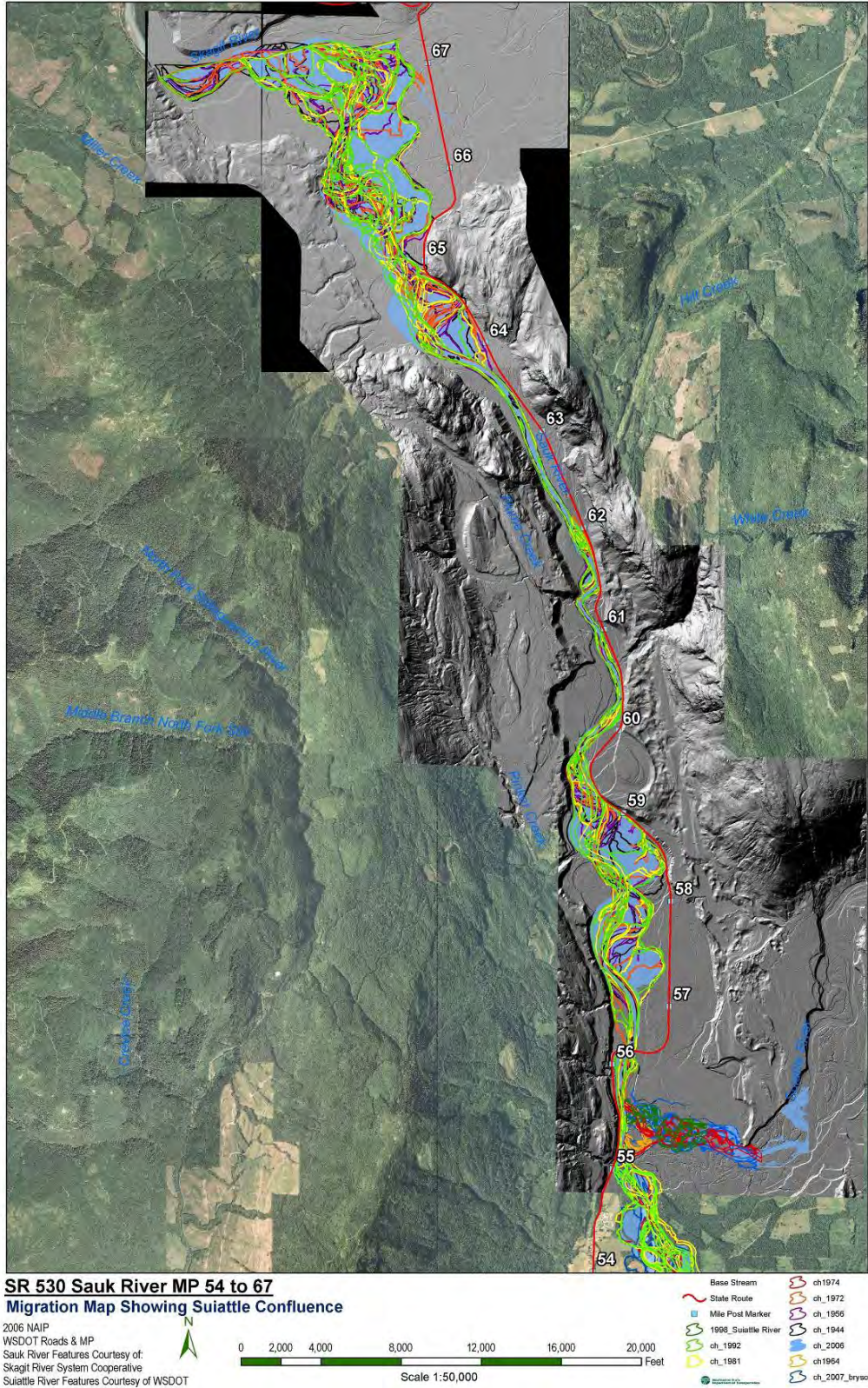


Figure 2. Sauk River Channel Migration Zones in the SR 530 Corridor.

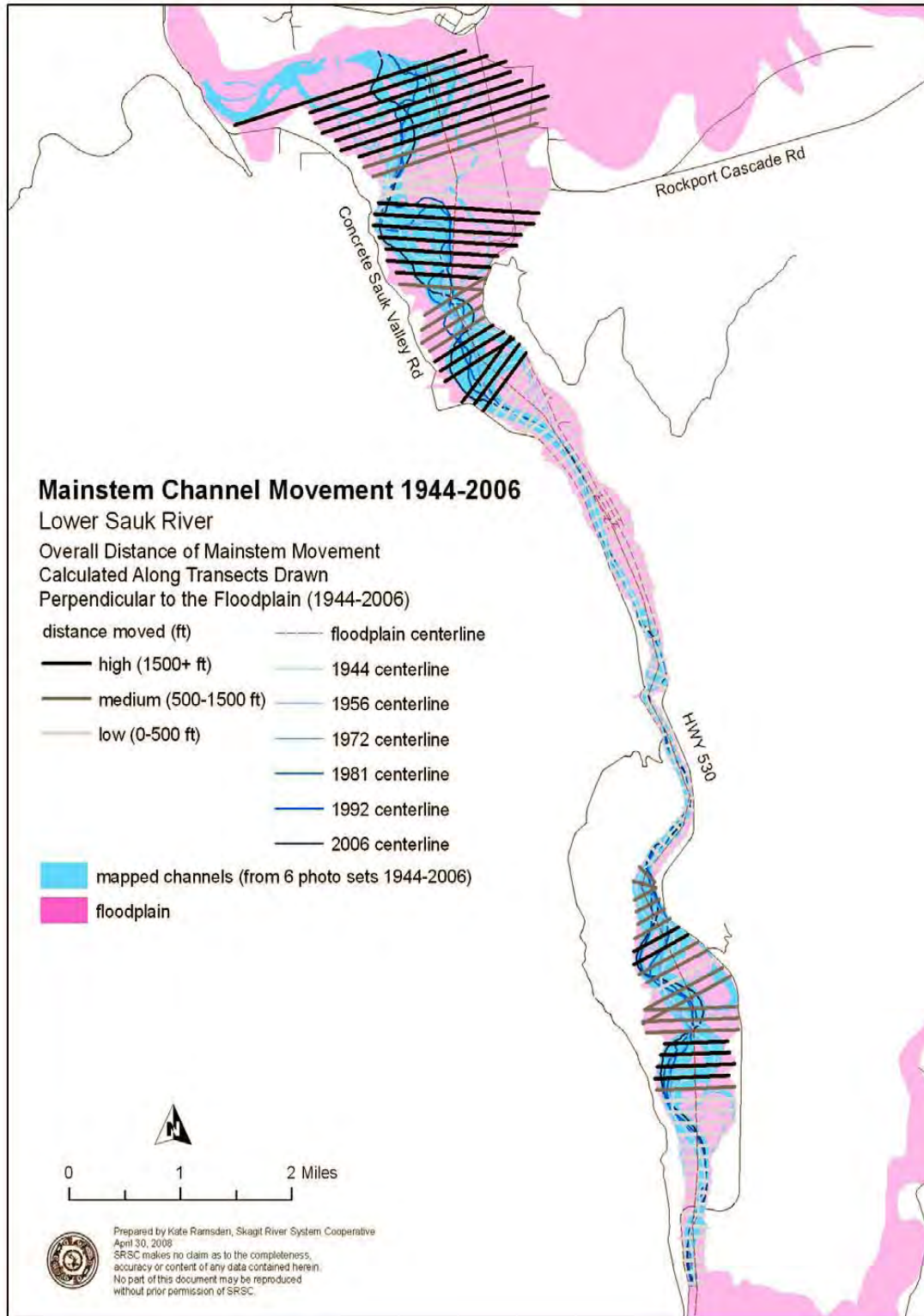


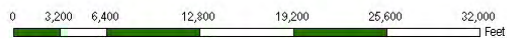
Figure 3. SR 530 Sauk River channel migration 1944-2006.



SR 530 Sauk River MP 54 to 67

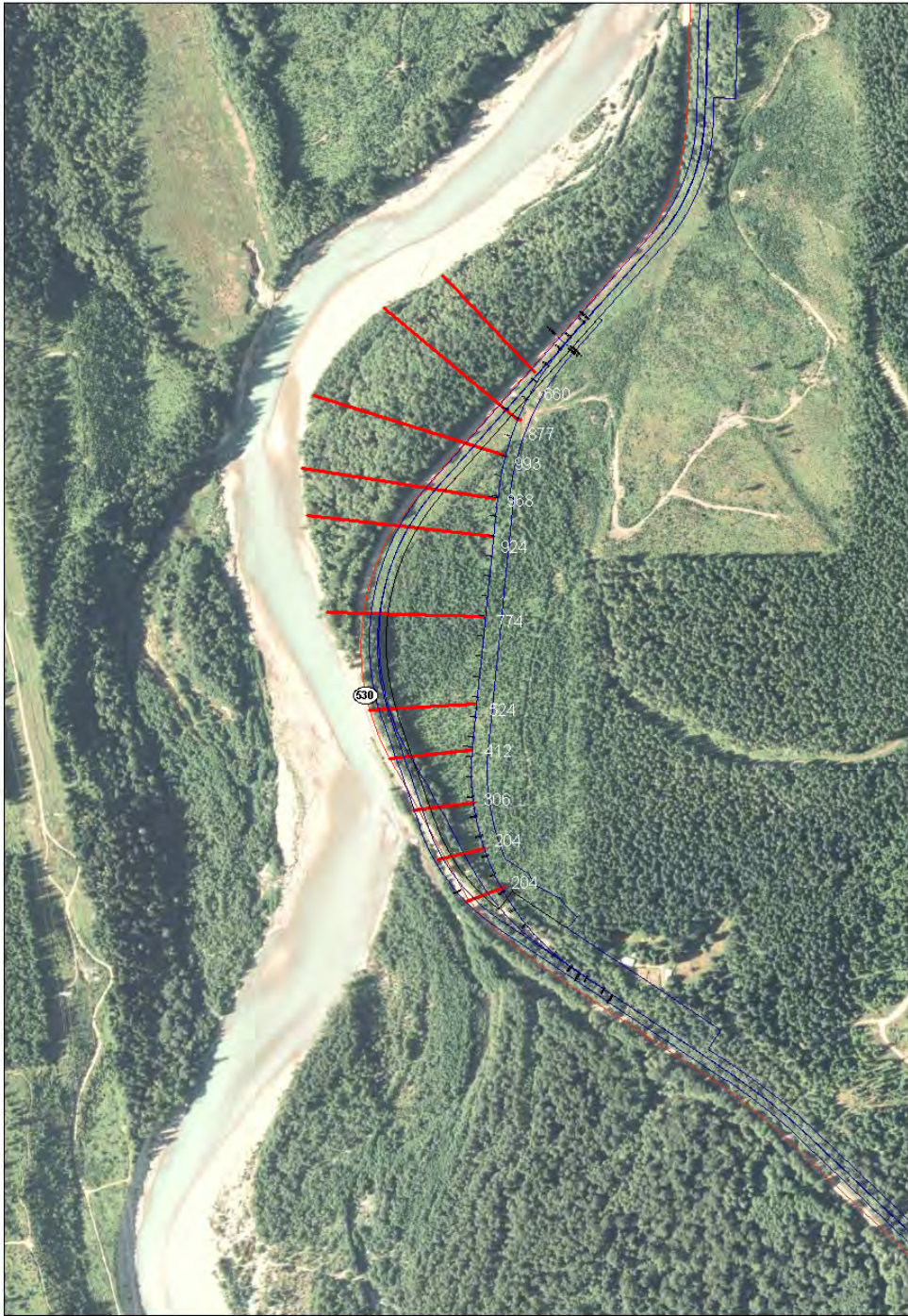
Bank Stabilization Sites

2006 NAIP
 WSDOT Roads & MP
 Features Courtesy of:
 Skagit River System Cooperative



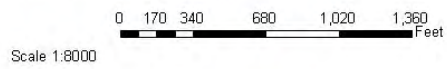
Scale 1:80,000

Figure 4. SR 530 Sauk River – Ranked bank stabilization sites.



SR 530 Corridor Analysis Project

Geotechnical setback distance from proposed new road configuration to river channel



Data courtesy of WSDOT
2009 Photo

Setback - Distance

Figure 5. SR 530 Sauk River – Geotechnical setbacks for Site 3.

References

Sauk-Suiattle Confluence Emergency Site and Reach Assessment

Site and Reach Assessment Addendum

Site and Reach Assessment Evaluation of Treatment Alternatives SR 530/Sauk River
Chronic Environmental Deficiency Site MP 58-59

Skagit Wild and Scenic River Historic Channel Mapping Analysis

Attachments

Attachment A:
Skagit Wild and Scenic River
Historic Channel Mapping Analysis

Attachment B:
Site and Reach Assessment Evaluation of Treatment
Alternatives SR 530/Sauk River
Chronic Environmental Deficiency Site MP 58-59

**Attachment C:
Site and Reach Assessment Addendum**

Attachment D:
Sauk-Suiattle Confluence Emergency
Site and Reach Assessment