Muddy Creek Sediment Management Altneratives Feasibility Study

Prepared for Skagit County Public Works

August 27th, 2011

ELEMENT solutions

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The Muddy Creek watershed is located within Skagit County near the town of Hamilton. The watershed drains a portion of Mount Josephine and flows into the Skagit River at Hamilton Junction, west of Hamilton. Muddy Creek has been an ongoing maintenance problem for Skagit County at the Lyman-Hamilton Highway Bridge for many decades. Maintenance and repairs of the road surface and road shoulder, replacement of the bridge, and periodic dredging have been frequent. Regulatory agencies have stated that the periodic dredging management strategy has negative impacts on fisheries habitat and requested that Skagit County consider other management strategies to mitigate these impacts. In response to this request, Skagit County retained Element Solutions to assess Muddy Creek from a watershed perspective and identify management alternatives and assess their feasibility.

The study identified widespread upper basin instability. Sediment sources and quantities are variable over time and during large mass wasting events, a virtually unlimited sediment source exists in the upper watershed. During quiescence however, Muddy Creek transports a minor to moderate quantity of sediment to the vicinity of the Lyman-Hamilton Highway and its deposition reduces conveyance under the bridge that can result in flooding of Cabin Creek Road. The amount of sediment that deposits at the bridge is exacerbated by higher water elevations in the Skagit River.

It is the Skagit River that is the cause of the most significant damages that occur at the Lyman-Hamilton Highway Bridge and Cabin Creek Road, and thus contributes to the greatest management costs over time. The estimated $1.7 Million in damages between 1990 and 2010 to the road and bridge are all related to flooding from the Skagit River that results in water surface elevation differences between Skagit River at flood stage and Davis and Jims Slough. Floodwater from the Skagit River flows northwest into Davis and Jims Slough beginning at a 2-year recurrence interval event, and significant damage to Lyman-Hamilton Highway and Cabin Creek Road occurs at a 20-year flood event or greater. During these conditions, Muddy Creek is an insignificant, secondary influence on the infrastructure.

A planning-level alternatives analysis was conducted to determine what alternatives best met the objectives and abilities of Skagit County and the stakeholders. This analysis concludes that the construction of setback levees upstream of the bridge offers both sediment and flood storage benefits enhancing salmon habitat in the most habitat-impaired reach. This alternative, combined with potential engineering modifications at the bridge and potential periodic localized dredging to maintain fish habitat connectivity between Muddy Creek and Davis Slough could add to the overall benefits to both flooding and fish habitat objectives. And finally, to reduce the greatest long-term infrastructure costs for Skagit County, the study presents options to modify, and/or potentially abandon portions of existing infrastructure (including Cabin Creek Road, Lyman-Hamilton Highway, and the Cockreham Levee) that can be implemented as opportunities become available in the future. Implementation of the proposed plan may cost and estimated $1.2 M to implement, but is estimated to save Skagit County over $3 M over the next 25 years by reducing maintenance and repair costs.

1 Introduction

The Muddy Creek watershed is located in Skagit County, Washington east of Mount Vernon near the town of Hamilton (Figure 1). The Lyman-Hamilton Highway crosses Muddy Creek west of Hamilton at Hamilton Junction north of the Muddy Creek - Skagit River confluence (Figure 2). The Lyman-Hamilton Highway, Muddy Creek Bridge, and Cabin Creek Road have a long history of damages, maintenance and repairs. Dredging of the sediment that accumulates under the bridge has been part of the maintenance strategy for many decades. Currently, conveyance under the bridge is dramatically decreased from its historic conditions. If the sediment in the channel is not maintained, it is anticipated that Muddy Creek will flood into Davis Slough, which is topographically lower than Muddy Creek and is connected by a sediment-filled channel and culvert. If this occurs, flooding of Cabin Creek Road will result since the culvert that connects Muddy Creek to Davis Slough is undersized for Muddy Creek flows. In addition, Davis Slough currently has no outlet, so an increased water elevation in Davis Slough could inundate local farmlands and wetlands adjacent to the slough. In the event that Muddy Creek flows into Davis Slough, the out-migrating anadromous fish population would be cut off from the Skagit River, and incoming spawners would not be able to reach the spawning habitat in the middle Muddy Creek watershed.

In 2010, Washington Department of Fish and Wildlife required mitigation for fish impacts and that the County consider alternative management strategies that do not involve dredging at Muddy Creek (Appendix A). Skagit County is committed to working with agencies and stakeholders to develop a management plan that meets the following objectives:

1. Manage flood impacts to the existing infrastructure and properties
2. Reduce long-term management costs
3. Reduce impacts to fish habitat
4. Identify projects that can be implemented within the means and resources available to the County

Skagit County Public Works recognizes that there are apparent benefits from both a flood and fish habitat management perspective and is necessary to manage the sediment in such a way that it decreases impacts to fisheries resources. To this end, Skagit County retained Element Solutions to assess the Muddy Creek watershed and develop alternatives and evaluate their feasibility from a watershed context with a focus on a process-based management approach.

1.1 Study Objectives

The objectives of this study are to:

- Gain a comprehensive understanding of management issues from a watershed perspective (fish habitat conditions, land use, stream morphology, flooding, slope stability, sediment transport, public safety, infrastructure management);
- Identify and perform an analysis of management alternatives;
- Identify the most viable and sustainable management alternative to address the problems of Muddy Creek at the Lyman-Hamilton Highway;
- Develop a funding strategy for implementation.

1.2 Work Program

The work program for this study is summarized in Table 1.

Table 1: Work Program

Task	Description
1. Project Initiation	▪ Meet with County to review the scope and schedule, confirm responsibilities, identify key stakeholders, discuss stakeholder engagement strategy, set future key meetings, obtain rights of entry, and collect and review existing data. ▪ Obtain existing GIS data and reports, including LiDAR and digital orthophotos, maps and assessments of the watershed basins, existing studies, and land use information.
2. Sediment Budget	▪ Identify, map and quantify sources and quantities of sediment contribution. ▪ Perform field analysis of grain-sized distribution of sediment contributions from each source. ▪ Estimate sediment stored in the channel, bars and floodplain. ▪ Estimate the rate of sediment transport and throughput. ▪ A GIS model will be set up as part of the sediment budget assessment.
3. Habitat Assessment	▪ Conduct field assessment of the stream for existing fish and wildlife habitat conditions on the alluvial fan. ▪ Document field findings.
4. Alternatives Identification	▪ Inventory a range of alternatives to address the sediment management for the watershed, which may include: o managing point sources o managing in-stream storage o allowing for natural storage; and o infrastructure modifications. ▪ Conduct an initial alternatives vetting and coordinate with Skagit County representatives for the consideration of alternatives feasibility and limitations.
5. Alternatives Analysis	▪ Evaluate the alternatives based on criteria established by Skagit County and the vested interests, including WDFW, Upper Skagit Tribe and the Skagit River System Cooperative, WA Dept. of Transportation, and potential local representation. ▪ Identified criteria include: likelihood of implementation; impacts on fish; ongoing maintenance needs. ▪ Estimate approximate costs for both near-term and long-term. ▪ Determine whether a relative cost-to-benefit assessment (integrating a relative resource value into project costs and then comparing this to the alternative's overall relative benefit), will help to inform the decision-making process.
6. Plan Documentation	▪ Document the Sediment Budget, Habitat Assessment, and the Alternatives Analysis. ▪ Develop a plan that incorporates our findings and recommendations. ▪ The plan will include identification and discussion of funding sources and strategies to best achieve plan implementation in both short and long-term time frames.
7. Plan Presentation	▪ Present the Muddy Creek Alternatives Feasibility Study and Plan to Skagit County upon completion of the project.

1.3 Project Team

A compact team of geomorphologists, watershed analysts, and fisheries biologists evaluated the sediment sources, the nature of the sediment transport, the characteristics of sediment deposition, and the consequences of sediment deposition and channel maintenance activities on fish and wildlife habitat within the Muddy Creek Basin. The team reviewed existing information, developed a sediment budget, conducted field verification and assessment of data, developed alternatives, consulted with local governments and regulatory agencies, and assessed the feasibility of sediment and habitat management alternatives and implementation strategies.

The Element team gratefully acknowledges the assistance of the following individuals for providing project information:

Kara Symonds – Skagit County
John Cooper – Skagit County
Chris Kowitz – Skagit County
Jeff McGowan – Skagit County
Mike Janicki – Property owner
Mike Dynes – Property owner
Dave Tucker – Geologist
Jon Riedel – National Park Service

2 Muddy Creek Watershed Analysis

This section provides a description of the Muddy Creek watershed from desktop and field observations, and a summary of relevant background reports and research.

2.1 Watershed Physiography

The Muddy Creek watershed is located on the southern slope of Mount Josephine at the western front of the Cascade Mountains along the Skagit Valley (Figure 2). The watershed consists of multiple ephemeral and perennial mountain streams that drain a steep upper watershed onto a low gradient, relict glacial landform where the streams confluence into one branch. After flowing across this low gradient landform, a change in geology and a steeper gradient result in Muddy Creek entering an incised canyon prior to its exit onto the greater Skagit Valley.

2.2 Watershed History

2.2.1 Channel location(s)

The location of Muddy Creek through the lowlands and where it enters the Skagit River has been altered over historic times, both by humans and potentially by natural processes. The earliest mapping (1879 GLO survey) shows Muddy Creek taking a more westward course and entering what is now Jims Slough prior to the entering the Skagit east of Lyman (Figure 3). Migration of the Skagit River at Hamilton Junction by 1937 shows that the 1879 Muddy Creek alignment into Jims Slough would have been intercepted by the Skagit River. The location of Muddy Creek cannot be discerned in the 1937 air photo. By the mid 1950s, the channel had been realigned by landowners and anecdotal information suggests it may have outlet to the Skagit River via Careys

Slough. Today it follows an artificial alignment that is contained by levees downstream of SR20 and outlets directly into the Skagit River.

Davis Slough, Jims Slough, and Careys Sloughs represent former Skagit River channel alignments, but now only interact with the Skagit River during flooding. Many of these relict channels have been cut off by levees or road alignments. Relict channel forms from Muddy Creek can be observed in the upper and middle watershed (discussed further in Section 2.1.4), but the lower watershed has been heavily modified and many of the relict channels have been obliterated.

2.2.2 Land Clearing – Forestry and Agriculture

Clearing of the land began in the late 1800s with the harvesting of trees and the creation of farmland in the valley bottom. By 1937, much of the valley bottom looks as it does today. Clearing for timber began to migrate up the slopes of the foothills once the valley bottom was cleared. The advent of new technologies (railways, steam and diesel/gasoline motors, and hydraulics) allowed for more thorough and rapid clearing of the slopes above the valley bottom. By the 1950s, forestry roads had reached much of the upper watersheds in the region. The changes to landuse have likely impacted the hydrology, sediment delivery and stability of the basin, plus created the need to manage the stream for flooding or erosion impacts to road networks and private property.

2.2.3 Historic Infrastructure Development

For this analysis, infrastructure is defined as technical structures that support society, including roads, water supply, power grid, telecommunications, trails, and levees. Figure 4 shows the present infrastructure in place in the lower Muddy Creek watershed. Today, major infrastructure includes Washington State and Skagit County roads and bridges and larger private industry developments.

Infrastructure in the Hamilton Junction has included railway lines, ferry landings, and a road network, that were put in to facilitate the removal of natural resources beginning in the late 1800s and early 1900s. The infrastructure allowed ingress and egress into areas previous only accessible by foot or boat. Railways were one of the first infrastructure improvements and by the late 1800s and early 1900s railways were being constructed rapidly. Eventually roads were put in to accommodate the introduction of automobiles in the early 1900s and by 1937 many of the roads that exist today were in place, including the roads within the project area at Hamilton Junction. There have been several Lyman-Hamilton Highway Bridges over the years and it is not know when the first bridge was constructed, but one appears present in the 1937 air photo (Figure 3). The original bridge was replaced in 1955 and was in use until 1995 when it was finally damaged beyond repair and subsequently replaced (1997). The current bridge is scheduled for replacement in approximately 2030.

Also in the Skagit Valley, river management has undergone dramatic developments. Dams created for hydropower were installed in the early part of the 20th Century and play a role in managing floods and affecting sediment transport. The creation of levees to facilitate agriculture probably started modestly prior to the 1930s since levees would have been built by hand. The Works Progress Administration and Civil Conservation Corps, created during the depression, were the first widespread and significant use of public resources to construct larger levee systems in the Skagit Valley. The advent of mechanical earthmoving equipment around this era also increased the size and number of levees and many of these levees are still in place today. Recent infrastructure improvements include buried pipelines and cable networks. Much of the river management and transportation infrastructure was not built with accommodating natural processes in its design; therefore, the creation of this infrastructure has also created the need to manage the natural process that cause impacts to the infrastructure.

2.2.4 Historic Infrastructure Damages

Lyman-Hamilton Highway looking west: damage –1996

Lyman-Hamilton Highway and Cabin Creek Road at Hamilton Junction have a history of damage from flooding. Review of the existing photos and records has shown that the damages to the road are caused primarily by flooding from the Skagit River. As the Skagit River rises to a certain elevation, it flows northwest west toward the topographically low areas of its floodplain, Davis Slough and Jims Slough in this vicinity (Figure 5). Additional Skagit River floodwater from Hamilton may join with the overtopping at the Lyman-Hamilton Bridge (Hamilton Junction) and increase the flood depths and velocities moving north and west across the roads and through the bridge. The velocities are such that scour to the bridge abutments and to the downstream side of the road shoulder, and ultimately to the pavement occurs (shown in image above). Many occurrences of flood damages have occurred since 1990, significant events are shown below and records are presented in Appendix B.

Table 2: Notable damages to the Lyman-Hamilton Highway Bridge at Muddy Creek and Cabin Creek Road*:

Year	***Damage***
1990	Road beds (Cabin Creek Road and Lyman-Hamilton Hwy) washed away, pavement impacted (based on file notes and photos)
1995a	Road and shoulder damage (both roads), damage to bridge footings
1995b	Bridge footings destroyed and bridge collapse, Cabin Creek Road destroyed (file notes, photos, anecdotal accounts)
1996	Damage to road surface and shoulder (based on photo)
2003	Erosion of shoulder, damage to road surface
2009	Shoulder erosion

*Records prior to 1990 were not located. Records for damages, repairs, and maintenance are not well documented. These descriptions were prepared by Skagit County Staff based on a combination of anecdotal accounts and partial records and from photographs.

2.2.5 Current Development and Landuse

Currently developments and landuse within the watershed are regulated by the local land disturbance/development permits or DNR Forest Practice Rules. In addition, the Critical Areas Ordinance, Shorelines Master Program, and the National Flood Insurance Program (NFIP) amongst other local regulations may apply for some types of development. Most development occurring in the vicinity of the Skagit Valley are related to single-family residences, small to mid-scale agricultural operations, and light industrial build out. Forestry landuse dominates the majority of the watershed. Review of historic air photos showed that the watershed has had a history of forest harvesting for most of the century and that harvesting activities appear to have been most widespread in the 1960-1970s era.

2.2.6 Existing Plans

Four existing reports were identified for the vicinity of Muddy Creek and are summarized below:

2.2.6.1 Site and Reach Assessment Evaluation of Treatment Alternatives: SR 20 MP 76.25 (Red Cabin Creek) Chronic Deficiency Site (Lautz and Beall, 2005)

The Washington Department of Transportation (WSDOT) established a Chronic Environmental Deficiency (CED) program where repeated maintenance and preservation activities create unacceptable environmental impacts. This assessment was conducted for a CED at MP 76.25 on Hwy 20 on Red Cabin Creek in Skagit County, Washington (the Site). Red Cabin Creek is located west of Muddy Creek and flows into Jim's (also known as Etach) Slough before entering the Skagit River. Sediment deposition has been a recurring problem at this Site since the mid-1970s. Dredging is generally done on an annual basis to maintain conveyance and there have been multiple cases of inundation of SR 20 possibly attributable to culvert blockages on Red Cabin Creek and adjacent bank erosion. The Washington Department of Fish and Wildlife (WDFW) has identified the current maintenance practices at the Site as "an unacceptable adverse impact to fish life." Emergency excavation was required as a result of the floods that occurred in October and November of 2003 and complete excavation of the sediment wedge occurred as recently as 2003 as well.

Site based factors that may contribute to excessive deposition at Site were identified as:

- Naturally low gradient of the channel in the vicinity of the Site
- Straightening and leveeing of channel upstream of SR 20 crossing
- Presence of two sharp (70°-90°) bends downstream of the Site
- Low crossing of SR 20

Land use, geology, and hydrology were similar to that of the Muddy Creek. Peak flows for Red Cabin Creek were identified using peak flow data from nearby Alder Creek (USGS ID 1219600) and are similar to those predicted for Muddy Creek with peak 100-year flows of approximately 400 cfs. Similar to Muddy Creek, Red Cabin Creek has documented use of coho and chum and presumed use by steelhead and bull trout.

Evaluation of Alternatives

Four alternatives were considered for redressing the chronic environmental deficiencies a the Site:

1. No action
2. Elevation of the road grade at the SR 20/Red Cabin Creek crossing
3. Channel modification
4. Construction of a sediment retention facility

WSDOT recommended Alternative 2 based on the objectives to reduce impacts to salmonids without substantial work outside the WSDOT right-of-way.

2.2.6.2 Reach Level Analysis for the Middle Skagit River Assessment (Smith and Ramsden, 2010) and the Plan for Habitat Protection and Restoration in the Middle Reach of the Skagit River (PHPR)(Skagit Watershed Council, 2011)

Freshwater rearing habitat was identified as limiting factor for Chinook and the Middle Skagit River was considered vital for habitat recovery goals. The report recommended following restoration actions:

- Remove or upgrade hydomodifications by reconnecting historic off-channel habitat in floodplain
- Restore floodplain processes that create and maintain off-channel habitat and complex mainstem edge habitat
- Restore mainstem edge habitat complexity
- Protect and restore riparian habitat in floodplain reaches
- Protect existing floodplain and complex mainstem edge habitat

The Cockreham reach was rated as one of the top reaches for the amount of floodplain inundated during the 25-year flow. The Cockreham reach also rated high for the amount of existing off-channel habitat in the floodplain normalized by mainstem channel length as well as current habitat function.

The Cockreham Island reach (which includes the outflow of Muddy Creek) rated the highest for floodplain impairment from hydromodifications and roads as well as forest conditions, indicating that this reach should be targeted for restoration at a minimum and, based on its current habitat function, protection should be a priority as well. Reconnection of Davis Slough was ranked 7th in overall project restoration strategies and identified as a near-term project to implement in the PHPR.

2.2.6.3 Cockreham Island Buy-Out Feasibility Study (GeoEngineers, 2007)

GeoEngineers conducted a floodplain buy-out feasibility study for Cockreham Island. Purchasing private property on the Island could provide a wide range of future land use and land management approaches while minimizing need for public infrastructure and associated costs. The study assessed the river and land management strategies for maintaining the existing Cockreham Levee, removing the levee, and partial levee removal and adaptive management strategies.

The assessment recommended removing the lower portion of the Cockreham Island training levee and allowing or promoting the river to cut a new channel through the south portion of the island. Potential benefits of this scenario were identified as:

- Reduced maintenance costs associated with maintaining the levee
- Reduced risk of catastrophic failure of the levee
- Reduced erosion along the toe of the remaining levee
- Reduced or no river induced bank maintenance along the South Skagit Highway
- Reduced hydraulic energy along the levee at Lyman
- Reduced backwater and flooding up Muddy Creek
- Enhanced in-stream and off –channel habitat conditions
- Increased open space along the river corridor

Backwater conditions on the east (upstream) side of Cockreham Island were found to be exacerbated the presence of the levee. This information has implications for the processes that affect the Lyman-Hamilton Bridge, Muddy Creek, Davis Slough, Red Cabin Road, and Jims (Etach) Slough.

2.3 Watershed Assessment

The hydrology, geology and geomorphic investigation and interpretation of the Muddy Creek basin integrated existing research, desktop analysis using existing data, and direct field observations performed by a geologist. The following were the datasets used in the GIS desktop analyses.

Table 3: Data used for desktop analyses

Data	Format	Date	Source
Aerial photography	Mr Sid	2009	USDA - NAIP, Skagit County Pictometry (Bing), Google Earth, Mr Sid 1937 Scanned by Skagit County
LiDAR	Bare earth grid	2006	USGS
Geology	Shapefile	1998-2000	DNR 1:100,000 Digital Geology
Soils	Shapefile	2009	USDA
Land Use/Zoning	Shapefile	Unknown	Skagit County
Historic Mapping	tif	1880	GLO (scanned by UW)

2.3.1 Hydrology

The drainage area of Muddy Creek is approximately 2.75 square miles with a relief of approximately 3,700 feet. The elevation at the Lyman-Hamilton Highway Bridge is approximately 94 feet (NAVD 1988). The mean average precipitation within the basin is approximately 64 inches (Sumioka et al, 1998). High rainfall in the Skagit Valley generally occurs during the fall and winter when Pacific cyclones cause prolonged, orographically enhanced precipitation. These storms can last for several days and are often the cause of flooding in the Pacific Northwest. The associated flooding can be exacerbated by rapid rises in freezing level associated with warm marine weather fronts from the central Pacific.

The Muddy Creek basin faces south and includes a range of elevations at which transient winter snow line elevations are common, and therefore the watershed is susceptible to rain-on-snow type hydrologic events. In western Washington, the transient snow zone generally occurs at elevations ranging between 1,200 ft and 4,000 ft (365 m to 1220 m) (Washington Forest Practices Board, 1997). Mount Josephine, in the upper watershed is approximately 3,800 feet (NAVD 1988). Within the transient snow zone, it is not uncommon for shallow snowpacks to develop several times each year. These shallow snowpacks are subject to rapid melt when warm fronts from the central Pacific move into the area. Depending on the snowpack characteristics (e.g. water equivalent and meteorological conditions during a storm), the amount of additional meltwater released from snowpacks can be significant. Rain-on-snow conditions are considered to be the primary cause of peak flows throughout much of the western Washington Cascades (Acme Watershed Analysis, 1999).

A 2-year return period discharge for Muddy Creek (approximately bankfull) is approximately 100 cubic feet per second (cfs). These events are significant for channel forming processes and sediment transport. A 100-year return period peak discharge is approximately 350 cfs for clear-water type floods. Larger events are important for landscape forming processes. No gauging station exists for Muddy Creek or nearby basins; therefore, peak discharges were estimated using published regional regression equations (Sumioka et al, 1998) and are presented in Table 4. These estimated discharges do not take into account rain-on-snow events or other processes, such as debris flows or dam outburst type flooding, which can greatly increase instantaneous peak discharges beyond the estimate clear-water type floods (Jakob, 1996).

Table 4: Estimated Peak Discharges for Muddy Creek at SR 20

Return Interval	Discharge (cfs)	Standard Error (%)
2-year	115	56
10-year	210	53
25-year	261	53
50-year	308	53
100-year	346	54
500-year	457	54

Skagit River hydrology is integral in the infrastructure management impacts at the Muddy Creek Bridge on Lyman-Hamilton Highway. The following table shows larger events on the Skagit River since 1975. Blue highlighted events are ones in which damages to either the Lyman-Hamilton Road, Muddy Creek Bridge, or Cabin Creek Road were reported. Damages occurred prior to 1990 but were not documented for this study.

Table 5: Significant Skagit River Hydrologic Events 1975 to present

STATION	***YEAR***	***DATE***	***GAGE***	***DISCHARGE (CFS)***
Concrete	**1975**	**Dec. 4**	**36.88**	**122,000**
Mount Vernon	1975	Dec. 4	35.66	130,000
Concrete	**1979**	**Dec. 18**	**38.57**	**135,800**
Mount Vernon	1979	Dec. 19	33.99	112,000
Mount Vernon	1980	Dec. 27	34.16	114,000
Concrete	**1984**	**Jan. 5**	**34.94**	**109,000**
Mount Vernon	1984	Jan. 5	31.14	88,200
Concrete	**1989**	**Nov. 10**	**33.83**	**101,000**
Mount Vernon	1989	Nov. 11	31.19	88,600
Concrete	**1989**	**Dec. 4**	**36.39**	**119,000**
Mount Vernon	1989	Dec. 5	32.39	97,800
Concrete	**1990**	**Nov. 10**	**40.18***	**149,000**
Mount Vernon	1990	Nov. 11	36.61	142,000
Concrete	**1990**	**Nov. 24**	**39.79***	**146,000**
Mount Vernon	1990	Nov. 25	37.37	152,000
Concrete	**1995**	**Nov. 8**	**39.79***	**141,600**
Mount Vernon	1995	Nov. 9	31.64	92,000
Concrete	**1995**	**Nov. 29**	**41.57***	**160,000**
Mount Vernon	1995	Nov. 30	37.34	141,000
Concrete	**2003**	**Oct. 21**	**42.21***	**166,100**
Mount Vernon	2003	Oct. 21	36.19	129,000
Concrete	**2004**	**Dec. 11**	**33.78**	**99,400**
Mount Vernon	2004	Dec. 11	29.13	76,000
Concrete	**2006**	**Nov. 7**	**39.74**	**145,000**
Mount Vernon	2006	Nov. 7	33.73	121,000
Concrete	**2009**	Jan 5	26.26	52,300
Mount Vernon	2009	Jan. 8	27.75	72,900
Concrete	**2011**	**Jan. 17**	**28.59****	**65,700**
Mount Vernon	2011	Jan. 17	29.21	74,700

Legend/Notes

🟦 = **Substantial infrastructure damages reported.* *For a substantial damage threshold, we used a flood stage of 39-feet at Concrete which is approximately a 20-year recurrence interval event (25-year flow = 150,000 cfs at Concrete Gage). This elevation was met or exceeded 6 times since 1990.*

🟩 = ***Observed backwater flooding at the Muddy Creek Bridge with reverse flow (northward) and the initiation of infilling of Davis Slough with floodwater from the Skagit River. This flood-stage elevation is considered the threshold elevation for this occurrence and roughly correlates to a 2-year recurrence interval event (2-year flow = 72,500 cfs at Concrete Gage). No damages were reported for this event. This elevation was equaled or exceeded at least 10 times in the past 10 years (2001-2011), including the events shown below (stage and discharge are for the Concrete gage). These observations and correlations are supported by the hydraulic modeling performed by Pacific Northwest National Laboratories (2010).*

Table 6: Additional flows exceeding 28 feet at Concrete, 2001-2011.

Date	*Discharge (cfs)*	*Stage*
1/7/2002	94300	33.06
1/26/2003	65500	28.6
12/4/2007	77900	30.6
11/12/2008	67000	28.84

2.3.2 Geology and Geomorphology

Overview

The Primary geologic processes that created and shaped the 36 million year old Cascade Mountains and Skagit Valley are tectonic (accreted and uplifted terranes) and glacial (erosion and deposition) (Tabor, et al, 2003; Dragovich et. al., 2000, DNR, 2000: Figure 6). The most recent and prevailing influence on the geomorphology of the Skagit Valley was the Pleistocene glaciation. The Fraser Glaciation occurring in the late Pleistocene and transitioned into the Holocene (approximately 21,000 to 10,000 years before present). Glacial deposits mantle the valley walls and create vast areas of cuts and fills. Understanding of the glacial sequencing and impacts is still evolving (Riedel, 2007 and Riedel and Tucker, 2011). Holocene developments of the Skagit Valley in the vicinity of the project site include slow down cutting with intermittences of deposition by volcanic mudflow deposits (estimated ages of 5,000 to 1,700 years before present) that originated from Glacier Peak (Dragovich et. al., 2000).

Interpretations

For this assessment, we subdivided the Muddy Creek Watershed into three primary reaches based on stream and slope geomorphology. The reaches are the Upper Watershed Reach, Mid Watershed Reach, and the Lower Watershed Reach and are described in this order below (Figure 7; Figure 8 – sample profile graph shown below).

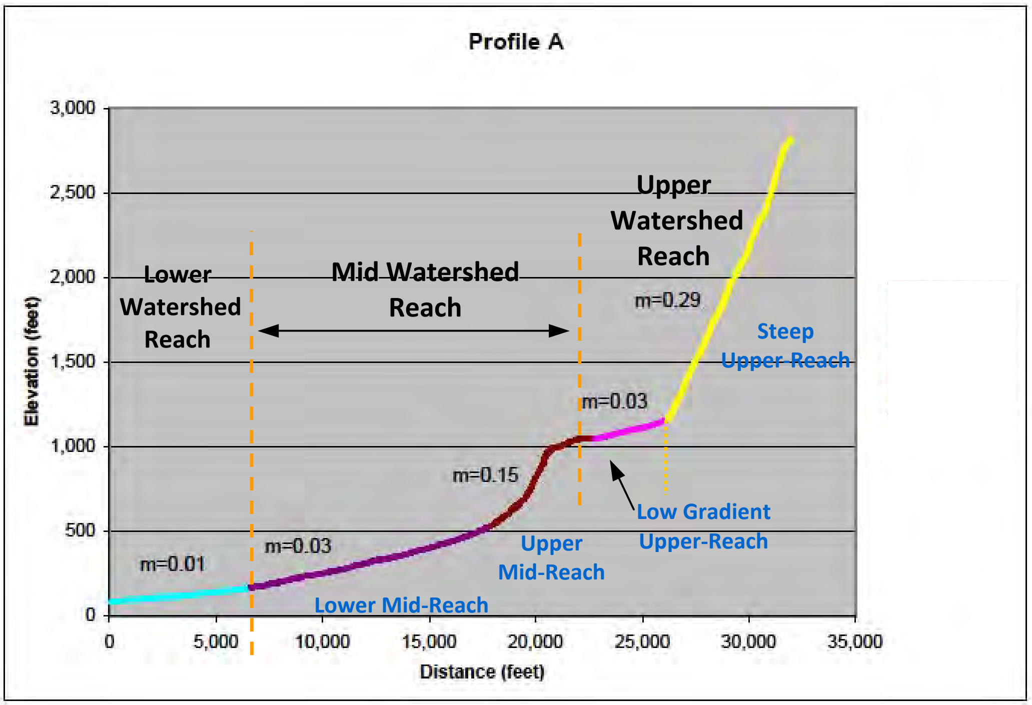


Figure 8: Muddy Creek Stream Profile (East Fork) - Primary Reach Subdivisions (bold black font) and Secondary Subdivisions (blue font). The m-value is the average stream gradient in percent.

Upper Watershed Reach

Upper watershed to middle DNR road crossing

The geology in the upper Muddy Creek watershed includes phyllite bedrock and glacial deposits. The interpretation of the phyllite unit is contested. According to the DNR geology mapping, the unit is Darrington Phyllite (Jurassic phyllite, phylonites, and greenstone) whereas the USGS interprets the phyllite as Mt. Josephine (Tabor et al, 2003; DNR 2000, Figure 6). We observed that phyllite geology was prevalent in the upper watershed. Some of the bedrock had a glacial mantling we observed ranging between 1 to 4 feet in thickness at several locations in the upper watershed. We observed several deep-seated landslides that were not identified in the geologic maps.

The upper Muddy Creek watershed is steep with stream gradients approaching or exceeding 0.3% (Figure 7) and slopes ranging between 20 and 80% for most of the uppermost watershed (Figure 9). Much of the Muddy Creek upper watershed is located on either Holocene head scarps or slide mass morphology that we interpreted to be active (Figure 9). We interpreted these deep-seated landslides to be Holocene slow creep earth flows because the slide mass overlies Pleistocene glacial till fabric but no lower viscosity slide runout was observed. Forester Kevin Killian (DNR Northwest Region) in a personal communication mentioned that road maintenance is frequent in the upper watershed of Muddy Creek and we observed instances of recent vertically and horizontally displaced road sections in our field visits of May 2011. We interpret that the stream morphology in this upper watershed is affected by the slope instability (Figure 10). Many abandoned, relict channels were observed, as well as streams located in relatively un-incised channels. This morphology is characteristic of 'channel robbing' that is common where topographic changes frequently occur. The rill-like stream morphology observed in the upper Muddy Creek watershed as opposed to the more typical dendritic stream pattern is also indicative of slope instability.

The steep upper watershed meets abruptly with a low gradient (0.02% slopes) landform that we interpret as a glacially eroded bedrock landform overlain by a veneer of Pleistocene glacial basal till (Figures 11; image at right). Both of these geologic units are overlain by Holocene deposits, either alluvial fan, debris flow deposits, or depressional accumulations of biomass and silt.

East Fork Muddy Creek

We observed that the eastern sub-watershed drains onto an alluvial fan and then onto a very low gradient landform with adjacent depressional basins. The channel network across this basin is low gradient, meandering morphology that is incising into silty matrix laden organic (wood) debris that we interpreted to be debris flows. We interpreted that one of the debris flow was recent because we observed cut timber ends in some of the buried wood (photo at right). In the air photos we could locate for this study, we were not able to see evidence, either source or deposition, of this deposit, but we estimate it to be early 20th century. Evidence of older debris flow layers could also be seen in some of the cuts in this eastern fork of Muddy Creek. The floodplain of this fork of Muddy Creek was occasionally inundated and is poorly drained, as evidenced by the vast area of skunk cabbage and standing water. Part of this floodplain drains east and exits the Muddy Creek watershed, entering Carey Creek watershed. The alluvial fan at the transition between upper and mid-watershed is part of the basin boundary. Future events may result in the east fork of Muddy

Creek leaving its present watershed for Carey Creek watershed (Figure 12). The geomorphology interpreted in the bare earth LiDAR imagery indicates this has happened in the past.

We observed neither glacial sediments nor bedrock in the east fork of Muddy Creek upstream of the west fork confluence to the alluvial fan. Based on the elevation of the bedrock observed at the confluence, we would expect that both the glacial sediments and bedrock lie just beneath the debris flow deposits we did observe. We also observed that sediment transport was supply limited in the low gradient reach as very little bedload deposition (bars and substrate) was observed. Most of the bedload sediment was depositing on the alluvial fan area and effectively starving this area of bedload sediment. Besides being low gradient, the reach had abundant instream wood that added to the channel roughness and decreased the sediment transport abilities. We expect that bedload throughput on the east fork of Muddy Creek was essentially nil.

West Fork Muddy Creek

We estimated that the flows of the west fork of Muddy Creek were more than double of those of the east fork during the time of our field visit. The sub-basins of each reach are fairly similar, and we do not understand the water loss we observed for the east fork. We hypothesized that some of the water may be leaving the Muddy Creek basin at the east fork alluvial fan, but we did not observe any field indicators that allowed us to test this hypothesis. In addition to having higher flows, the west fork is also more capable of sediment transport than the East Fork and we observed numerous indicators of both sediment transport and deposition such as channel bars (point, mid-channel) and high flow deposits of bedload sediment. The dominant source of sediment was the phyllite geology, however, we observed non-local lithologies for less than 20% of the sediment in this reach, indicating that inputs from glacial geology also occurred.

We observed some minor erosion of glacial deposits within the reach. We estimated that the stream velocities of the west fork were greater than the east fork and we observed that bedload size fractions were larger (average range of 1-3 inches, B-axis). The west fork was observed flowing across the phyllite bedrock in many locations. An alluvial fan at the transition between the upper watershed and the mid-watershed topographic break was less prominent than in the east fork; however, the potential for channel avulsion at the alluvial fan could create conditions where the west fork of Muddy Creek escapes its watershed and joins another, Red Cabin Creek in this instance (Figure 12). Similar to the east fork, the west fork had evidence of debris flows, but rather than being of a silty matrix, the debris flow matrix was of courser size fractions (image at above). It is anticipated that most debris flows from the upper watershed attenuate through the low gradient reaches of both the west and east forks.

Mid Watershed Reach-Canyon

Middle DNR road crossing to alluvial fan apex

The east and west forks confluence just north of the middle DNR forest road crossing. The confluence occurs at the southern extent of the underlying phyllite geology. South of the confluence, we did not encounter the phyllite geology, rather we encountered thick glacial sediments. We observed glacial till, lacustrine, and outwash sediments exposed in the banks of this reach. The stream gradient abruptly transitions from a low gradient (0.02%) to a steep gradient (0.18%). The steeper gradient stream incises deeply into the Pleistocene glacial sediments. The channel form becomes straight and the bed is armored with large glacial erratics. Over time, both downward and lateral erosion in this reach results and contributes sediment incrementally over a broad geographical and temporal scale. While there is some storage retention of sediment in the upper portion of this incised reach, it is minor both in scale and with a short temporal duration. Sediment storage and retention durations increase in the downstream direction as stream gradient decreases and channel width increases. We observed stable bars (both point and mid-channel), wood debris storage, and vegetated floodplains and terraces. We observed some debris flow deposits and the generation and transport through this reach is certainly possible since the gradient is sufficient and the channel is fairly confined, two conditions that favor debris flow transport. Debris flows in this reach could reach the developed area north of Cemetery Road.

We observed that the channel bed sediment lithology changed in a downstream direction and decreased in percentage of phyllite to glacial geology provenances (lithologies other than phyllite) such that glacial provenances dominate the sediment composition downstream of the canyon.

Lower Watershed Reach

The lower watershed is characterized by a decreasing stream gradient (0.01%) and reduced channel confinement as the stream exists the foothills and enters the Skagit Valley. A broad, low gradient alluvial fan exists at the valley margin and extends as far downstream as the Lyman-Hamilton Highway Bridge. The low gradient alluvial fan suggests that debris flows that reach this far down gradient are very likely of low viscosity typically associated with fine-grained, silt-rich matrix debris flows. A discussion on alluvial fan hazards is presented in Appendix C. Avulsions on alluvial fans are possible in the event of a debris flow that is large enough to fill the channel with sediment. These events can occur, but less frequent than the conditions creating the management problems that this analysis is tasked with.

The alluvial fan surface of Muddy Creek is slightly incised from the apex to SR 20. Manipulation of the landscape south of SR 20 has obliterated the natural topography and channel forms and flooding in this reach is more likely to occur, especially if the levees are eroded. Muddy Creek is also slightly incised as it reaches the Skagit River confluence. The interaction of Muddy Creek with the Skagit River is important to understanding the dynamic conditions near the Lyman-Hamilton Bridge. When the Skagit River is low, the response of Muddy Creek is to incise;

however, when the Skagit River is at higher flows, it affects the base level of Muddy Creek and deposition can occur. This occurrence was observed and documented by Skagit County Staff in January of 2011 (Martin Luther King Jr. Flood) when water levels of the Skagit River were sufficient enough to create ponded or still-water and reverse flow conditions. During these conditions, sediment that would normally transport through the Muddy Creek bridge reach is deposited as it would in a delta.

The Lyman-Hamilton Highway Bridge at Muddy Creek is located both at the distal end of the alluvial fan, on the Skagit River floodplain, and adjacent to Davis Slough, a relict Skagit River channel abandoned prior to 1879. Muddy Creek confluences with Davis Slough at the upstream (north) side of the bridge. Davis Slough used to drain beneath Lyman-Hamilton Highway via the bridge and a culvert that is now buried. Currently, sediment deposition from Muddy Creek has created a blockage of outflow from Davis Slough to the Skagit River. Currently, Davis Slough is reconnected to the Skagit River during higher flow events (Stage 28-feet at Concrete or greater) when the overbank flows from the Skagit River inundate Davis Slough.

2.3.3 Watershed Soils

The soil maps show that soils are predominantly loams ranging from silt loam to gravels loam typically with low permeability (Figure 13, soils from 2009 USDA-NRCS).

Table 7: Muddy Creek Basin Soil Units*

Symbol	Description
1	Andic Cryochrepts-Rock outcrop complex, 65 to 90 percent slopes
5	Barneston gravelly loam, 0 to 8 percent slopes
6	Barneston very gravelly sandy loam, 8 to 30 percent slopes
7	Barneston very gravelly sandy loam, 30 to 65 percent slopes
15	Borohemists, 0 to 3 percent slopes
40	Crinker-Rock outcrop complex, 30 to 65 percent slopes
44	Diobsud gravelly silt loam, 30 to 65 percent slopes
50	Dystric Xerorthents, 50 to 80 percent slopes
58	Getchell gravelly silt loam, 30 to 65 percent slopes
59	Giles silt loam
61	Gilligan silt loam
94	Montborne very gravelly silt loam, 3 to 30 percent slopes
95	Montborne-Rinker complex, 30 to 65 percent slopes
97	Mukilteo muck
102	Norma silt loam
109	Rock outcrop
134	Springsteen very gravelly loam, 30 to 65 percent slopes
150	Typic Cryorthods-Rock outcrop complex, 65 to 90 percent slopes
153	Vanzandt very gravelly loam, 0 to 15 percent slopes
154	Vanzandt very gravelly loam, 15 to 30 percent slopes
157	Wickersham silt loam, 0 to 8 percent slopes
163	Wollard-Springsteen complex, 3 to 30 percent slopes
164	Wollard-Springsteen complex, 30 to 65 percent slopes

**No soil description available for symbols not represented on list*

2.4 Sediment Analysis

The stream sediment of interest in this analysis is bedload sediment that is deposited in the reach of the Lyman-Hamilton Highway Bridge at Muddy Creek. The bedload size fractions depositing in this area are dominantly course sand through cobble (Table 8). Collectively, the size fractions between granule and cobble are termed “gravel”. To evaluate the sources, transport nature, and volumes of the sediment in the Muddy Creek watershed and to assess the conditions at the bridge, we performed a reconnaissance-level sediment budget.

Table 8: Sediment Grain Size Fractions (Wentworth Scale)

Inches	Millimeters	Wentworth Grade
> 10	> 256	Boulder
> 2.5	> 64	Cobble
> 0.16	> 4	Pebble
> 0.08	> 2	Granule
> 0.04	> 1	Very coarse sand
> 0.02	>0.05	Coarse sand

2.4.1 Reach Characterization

The Muddy Creek watershed sediment processes generally follow the watershed gradient subdivisions described in Section 2.3.2 (Figure 7). The reaches are:

- Upper Watershed (east and west basins)
- Mid Watershed
- Lower Watershed

Upper Watershed Sediment Processes

The upper Muddy Creek basin is the source of phyllite sediment in Muddy Creek. The upper basin is steep with unstable areas with historic mass wasting. Erosion of the upper watershed and transport of phyllite bedload sediment was observed in the field visits. The upper basin can be divided into two sub-basins, the east basin and west basin, each with different sediment regimes.

The east upper basin delivers virtually no bedload sediment to the subject reach during typical stream flows and the sediment generated in this upper basin is deposited on an alluvial fan located at the base of the steep topography (approximately 0.3% slope) and the mid-basin topographic break (approximately 0.03% slope). We observed no field indicators supporting significant bedload movement through the low gradient reach as bars and channel bed substrate were in lacking and the stream was incising into a fine-sediment deposit with large woody debris interpreted to be a relict debris flow deposit.

The upper west basin is both larger in surface area and has higher stream flows than the east basin. Some portion of the bedload sediment from the steep upper basin (0.13% -0.25%) is transported through the low gradient reach (0.03%) as evidenced by field indicators (well sorted bedload substrate, point and mid-channel bar development, stream meandering). While some sediment is deposited on the alluvial fan at the base of the steep topography, there is a portion of throughput.

Mid-Watershed Sediment Processes

The mid-reach begins at the middle DNR forest road crossing and goes downstream to the apex of the Muddy Creek alluvial fan at the Skagit Valley margin. The mid-reach has two distinct reaches divided by stream gradient and sediment processes. The two reaches are the upper mid-reach (0.15% slope) and the lower mid-reach (0.03% slope). Both reaches are incising into Pleistocene glacial geology (tills, lacustrine, and outwash) and long-term incision of the mid-reach is anticipated.

The upper mid-reach is very incised and little storage of bedload sediments was observed. Field indicators suggest that incision is actively occurring and hillslope contribution from erosion and bank collapse was evident. The channel bed substrate is predominantly boulders, most in excess of three feet (1 meter), and some tens of feet in diameter and therefore well armored. The subject sediment size fraction (gravel) being recruited from this reach, as well as the throughput from the west upper basin reach, is transporting through this reach as virtually no storage is occurring within the upper mid-reach.

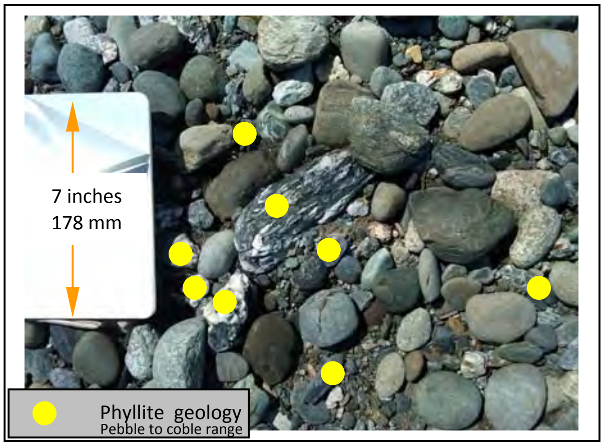
We observed sediment recruitment (colluvial/hillslope, mass wasting, erosion – image at right) within the lower mid-reach reach in addition to storage of bedload sediments (boulder through course sand). The confinement of the lower mid-reach is less than the upper reach with a decreased slope and therefore supports the storage of sediment in this reach. We interpreted that sediment storage in this reach is temporary because we observed only very few terraces and none with old growth trees or stumps. In addition, most high flow bar deposits had young deciduous trees species growing on them. It is possible that very large flood events or debris flows can remobilize this stored sediment and transport it to the alluvial fan. Potential releases of stored sediment from this reach can dramatically increase the sediment volumes delivered to the alluvial fan and deposited at the project site.

Lower Watershed Sediment Processes

The lowest reach of Muddy Creek is an alluvial fan and has a gradient of approximately 0.01% and slope decrease gradually in the downstream direction across the alluvial fan. The channel across the alluvial fan is either slightly incised or levied and this impacts the streams ability to deposit sediment, therefore this reach is currently a transport reach with virtually no sediment storage either in stream or on the alluvial fan surface. The alluvial fan transport reach ends abruptly at the Lyman-Hamilton Highway Bridge where both the levees and alluvial fan end and Muddy Creek enters the Skagit Valley floodplain. The project area at the bridge is the first opportunity to deposit sediment transported from the mid reach area. Currently, a slight gradient decrease exists at the distal end of the alluvial fan where Muddy Creek enters the Skagit River floodplain at the Lyman-Hamilton Highway Bridge. At this location, Muddy Creek incises into the Skagit River floodplain when the Skagit River water levels are low and a small headcut migrates upstream. During these occurrences, sediment is gradually transported from the project area. When the water levels in the Skagit River are high, the project area becomes a deposition area. The flood occurrence of January 2011 led to the deposition currently observed at the bridge.

2.4.2 Deposition at the Bridge to Skagit Reach (project area)

Field measurements indicated that the sediment deposited at the project site during the winter of 2010-11 following the 2010 sediment removal activities consisted predominantly of the gravel size class as defined in Table 8 and was composed of sediment dominated by glacial lithologies (greater than 75% non-phyllite sediment) with phyllite bedrock (phyllite and associated quartz hydro-thermal inclusions) representing the smaller portion of total lithologies represented in our test plots (representative photo at right).



The higher percentage of glacial lithologies to watershed bedrock (phyllite) indicates that the dominant sediment production for the deposited material in the winter of 2010-11 was from the Mid Watershed area. It is anticipated that this pattern is predominantly the case, but certain events such as major mass wasting or debris flows in the upper watershed can increase Upper Watershed production, and thus the percentage of phyllite geologies represented in the depositional area. Investigation of the alluvial fan stratigraphy could help to identify long-term trends and large event frequencies; however, that level of investigation was not part of this analysis.

The volume of sediment from the winter of 2010-11 was measured from areas we interpreted to have been recently deposited. We estimated the 2010-11 deposition to be approximately 1,000 cubic yards. It is not known based on measurements whether this amount represents an average annual deposition rate or is high or low over longer time periods; however, we hypothesis that this rate is low.

It is anticipated that a portion of the sediment delivered to the project site occurs as throughput and ends up in the Skagit River. If a sediment retention facility were to be designed, it would have to accommodate this throughput volume to be sized properly. We speculate that higher rates of sediment transport and deposition than observed in 2010-11 are certainly possible and may actually better represent “average rates”. Although we do not know the frequency or magnitude of larger sediment transport occurrences, we speculate that the 2009 flood event may fit within this category. On a longer-term scale, we are aware that sediment removals from this bridge were frequent; however, volume estimates for this maintenance were not available.

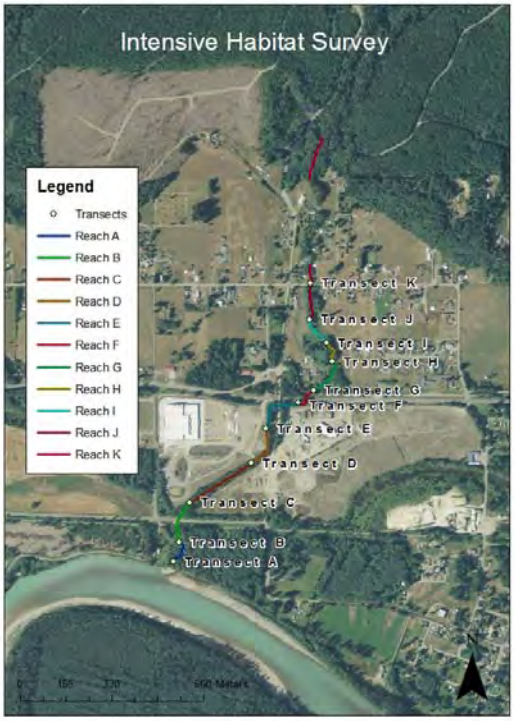
~1972 Muddy Creek Bridge (looking downstream)

Photographs from the 1970’s and 1980’s show significantly more conveyance beneath the Lyman-Hamilton Highway Bridge than currently exists (photo at right versus front cover image). By simple comparison of these images, net deposition at the bridge site is the long-term trend. Anecdotal information from a local resident living nearby since the 1960s suggests that the 1995 flood changed the sediment conditions at Muddy Creek dramatically and deposition from this event both buried the bridge, had extreme velocities, and blocked off the connection that had existed between Davis Slough and Muddy Creek (Skagit County personal communication with Mike Dynes, June 21, 2011). Therefore, long term sediment process trends observed at the Lyman-Hamilton Highway Bridge are not only a response to inputs from the Muddy Creek watershed; trends that affect the Skagit River water elevations can also impact the sediment processes observed at the bridge. It is not known if the trends of damages observed in the 1990s were in response to changes in the Cockreham Levee that may have occurred in the 1990s (SRSC, 2010).

2.5 Fish Habitat Assessment

Vasak Biodynamics performed a stream habitat and large woody debris assessment for a section of Muddy Creek in May 2011 using the Timber-Fish-Wildlife (TFW) monitoring protocol (Pleus et al. 1999; Schuett-Hames et al. 1999) and Environmental Monitoring and Assessment Program (EMAP) Rapid Visual Assessment methods (Lazorchak et al. 1998). The full report, including historic habitat information, is presented in Appendix D and is summarized below.

The habitat assessments was conducted in two phases: 1) intensive habitat assessment (Map to right), including: an upstream identification and measurements of all habitat unitis and downstream survey of large woody debris (LWD), spawning habitat, and stream slope, and 2) rapid visual assessment describing general characteristics of entire reaches.



From habitat assessment, Vasak Biodynamics, 2011; Appendix D

The survey included measurements of several instream characteristics for each habitat unit including: type, length, width, pool depths, bank vegetation, canopy cover, and sediment type. Transects were surveyed every twenty habitat units and bankfull width and depth, wetted width and depth, Wolman Pebble Counts, and latitude/longitude were recorded. Approximately 5,480 ft of Muddy Creek was intensively surveyed from the mouth of Muddy Creek to 584 feet above the property line of the most upstream residence. Along the entire distance, only one short reach was omitted due to an electrified fence over the creek. The instream conditions above and below the omitted reach appeared similar to the adjacent reaches except that cattle were observed in the creek.

In summary, over the length of the surveyed stream, they identified diverse instream and riparian conditions in Muddy Creek. They found that the instream and riparian condition of Muddy Creek related closely to land use. Industrial and residential areas tended to have the most degraded instream habitat and reduced riparian zones whereas the forestlands had good instream habitat and intact and mature riparian zones. The stream channel within the forestlands supported numerous fish, which were consistently observed. The most impaired reach occurred immediately upstream of the Lyman-Hamilton Highway Bridge.

Anecdotal accounts (Dynes, 2011 communication), historical images, reference in a 1997 HPA for the Lyman-Hamilton Bridge replacement, and the PHPR (2011) that a connection of Muddy Creek and Davis Slough previously existed and that Davis Slough supported migrating salmonid species, including Chinook. The 1997 permit was conditioned to maintain the connection between the two water bodies. Currently, there is no connection between Davis Slough and Muddy Creek and the habitat of Davis Slough has become isolated due to sedimentation at the bridge.

Off channel and floodplain habitat for freshwater rearing has been identified as a limiting factor in Skagit Chinook recovery (SRSC and WDFW, 2005). In addition, the Cockreham reach (Reach 3) in the PHPR was shown to have some of the best juvenile Chinook rearing habitat based on habitat modeling (Connor, 2011). Reconnection of Davis Slough ranked 7th in the PHPR project prioritization. It seems likely that activities to both increase a process-based approach to managing sediment and that reconnect the isolated habitat in Davis Slough to Muddy Creek and the Skagit River could have significant habitat benefits for Chinook, especially rearing life-stages.

3 Alternatives Identification and Analysis

3.1 Alternatives

Eight conceptual sediment management alternatives were developed with stakeholder input and are described below (Appendix E). The alternatives consider Muddy Creek as a stand-alone project. While there are large potential projects involving the modification of existing levees as part of the Middle Skagit Initiative, the timing and nature of those projects are unknown at this time. None of the alternatives provided below limit or prevent the potential implementation of the developing Middle Skagit management strategies. At such time that these management strategies are more developed and implementation is planned, Muddy Creek can easily be integrated into them and may provide additional benefits to those projects.

1) No Action

If Skagit County were to cease managing sediment in Muddy Creek, the Lyman-Hamilton Highway Bridge could eventually fill in or erode existing stockpile levees to the point that overbank flooding at or near the bridge would result. The primary consequences of flooding from Muddy Creek are impacts to Cabin Creek Road and impacts to fish passage. It should be noted that most of the damages to the Skagit County maintained infrastructure in the Hamilton Junction vicinity occur from Skagit River flooding rather than flooding from Muddy Creek. Although Muddy Creek adds to the problem, its effects are minor in comparison to the effects of Skagit River flooding. Therefore, with or without management action to address Muddy Creek sediment, damages to the Lyman-Hamilton Highway and Cabin Creek Road should still be expected since those damages result from the Skagit River during larger flood events (approximately 10-year flood events, significant damage occurs at a 20-year events and larger) that are independent of the Muddy Creek sediment conditions at the Lyman-Hamilton Highway Bridge. Over $1.7 Million has been spent on Muddy Creek since 1990. Since the damages will still occur, future costs will likely be consistent with historical costs. Over a 25-year time period, these cumulative damage costs (1990-2035) are estimated to rise to $5.5 Million*, excluding dredging maintenance.

Additional consequences if No Action were to occur would be flooding from Muddy Creek at the bridge. When this occurs, it is expected that two lowland routes could direct water away from the existing crossing at the bridge. The most likely flooding route would be to the west and Muddy Creek would likely flow into Davis Slough where a channel already exists and the gradients are favorable (Davis Slough is lower than Muddy Creek). Flooding of Muddy Creek into Davis Slough has historically occurred during Skagit River floods that meet or exceed a flood stage of approximately 28 feet at Concrete and occurred recently during the Martin Luther King Jr. flood of January 17, 2011. The culvert under Cabin Creek Road is undersized to accommodate Muddy Creek and therefore flooding over this road would be anticipated. In addition, fish passage and potential stranding of fish, especially out-migrating juvenile salmonids, could be impacted since Davis Slough has no outlet or low-flow connection to the Skagit River.

An additional Muddy Creek flood route could be to the east along a topographic swale that exists along the north side of the Lyman-Hamilton Highway and outlets into Careys Slough. Historically, Muddy Creek occupied this area and crossed the highway closer to Hamilton at the west end of Careys Slough that runs through Hamilton. This scenario is not anticipated unless Muddy Creek breaks from its current alignment by eroding through a left bank (east) stockpile levee upstream of the Lyman-Hamilton Highway Bridge. The consequences to infrastructure are anticipated to be minor, but some erosion of the roadbed fill could occur. The impacts to fish were not assessed.

**Note: This value was obtained by taking the past 20-years of known damages, adjusting them to 2010 dollars, and then dividing by 20 to arrive at the "average annual damages". We then projected that average annual cost 25 years into the future and adjusted for inflation by using the past 10-year average Consumer Price Index inflation rate of 4.3%.*

2) Stabilization of Upper Watershed Sediment Sources

We considered the possibility of building log-jam/boulder structures or stabilizing slopes in the upper watershed to retain sediment in the upper watershed. These sorts of features form naturally in Muddy Creek and were observed during fieldwork. The structures essentially form a low weir in the channel, which allows material to deposit on the upstream side, leading to the formation of sediment 'wedges' in the channel.

Although log-jam/boulder structures do form naturally in Muddy Creek and act to retain sediment in the channel, ultimately the logs will gradually rot and compromise the stability of the structure. It is therefore likely that the structure will fail eventually, and release the impounded sediment. Since a failure is more likely to occur under high flow conditions (when forces exerted on the structure will be greatest), the sediment that is released will have a high likelihood of being mobilized and moved down the system. Although it is not possible to predict, such failures might result in larger-scale destabilization of the streambed.

We observed that sediment recruitment was prolific and widespread with many localized point sources as well as many non-point sources (overall incision). Sediment delivery quantities are also vary substantially with movements of the larger deep-seated landslides. Stabilization of the larger landslides would be both technically challenging and extremely expensive. Control of the numerous localized point sources would also be challenged because of the very large number of them and the extremely limited access.

Given the likely eventual failure of any of these structures, there could be legal implications and on-going maintenance obligations for the County. For this reason, this option is not likely to be acceptable to the County.

3) Construction of a Sediment Basin and/or Managed Sediment Removals

The creek profile has a slight grade break and change in confinement at the Lyman-Hamilton Bridge as the low gradient Muddy Creek alluvial fan encounters the modern Skagit River floodplain; therefore this is a location where sediment deposition would occur naturally. The reach of creek downstream of the bridge has been identified as good spawning and rearing habitat for salmon. In comparison, the reach upstream of this bridge has the lowest habitat value for spawning and rearing in the entire watershed. One option might be to develop and manage a sediment basin or sediment removals at the bridge so that ongoing management activities are located in a lower habitat value reach. Management of sediment at the bridge may allow for reconnection of Davis Slough to Muddy Creek and the Skagit River, which could provide for a potential large off-channel rearing area for juvenile salmonids. Currently the deposited sediment from Muddy Creek blocks off that connection and isolates Davis Slough.

The basin or removal area would need to be sized based on the County's proposed schedule of maintenance, as well as with consideration of likely sediment delivery. The basin will capture a greater volume of sediment than currently observed since the basin would be capturing sediment that would otherwise have transported through the bridge reach. In addition, on-going monitoring of the basin and the downstream reaches would be prudent, to assess the response of downstream reaches to the interruption of sediment supply.

Currently, the County removes sediment from the bridge on an as-needed basis, which is often every year. The removal volumes vary and were quite small in 2010 (~50 cubic yards). In addition, the County, WSDOT and private entities have historically dredged the channel throughout the alluvial fan area. It is not known how frequently this was done, nor were the volumes quantified, but existing stockpile levees are still in place in many locations.

The historic maintenance strategy can be considered to be of two strategies; a "less-frequent but large disturbance" approach, and a "more frequent but smaller disturbance" approach. The impacts of each have not been fully quantified, but the more frequent, smaller disturbance approach were recently favored by WDFW as specified in a 2009 HPA for Coal Creek to the west of this project. A more frequent, but smaller sediment removal strategy may have slightly higher associated costs for the County (given the increased mobilization/ demobilization costs of conducting annual removals), but this is likely minimal.

The feasibility of a sediment basin is subject to approvals by WDFW. Currently, sediment basins are not favored by that agency and sediment removal has negative impacts to salmon habitat. The 2010 HPA, while granted, specified that alternative management strategies with less impacts to fish habitat needed to be considered.

It should be noted that sediment removal does not mitigate the damages to the bridge and roads caused by the Skagit River.

Routine sediment removals, permitting and monitoring cost an estimated $10,000 to $20,000 per year (assuming removal of 1000-2000 cubic yards annually). These costs do not include mitigation.

4) Infrastructure Abandonment

By removing the bridge at the Lyman-Hamilton Highway, the County would essentially eliminate the infrastructure damages and maintenance costs. Over-bank flooding that might result from sediment accumulation in the channel could conceivably be considered to be a natural process that may alleviate some of the County's responsibility. The Lyman-Hamilton Highway does not provide egress during flood events related to the Skagit River and is not a viable escape route for Hamilton during flood events. The same applies for the Cabin Creek Road. Traffic counts on the Lyman-Hamilton Highway are relatively small (under 200 trips per day) and alternate routes do exist. The alternate routes were identified for this analysis and we evaluated the travel times for bridge removal given affected routes. The worst-case delay would be to travel from Hamilton Junction west of the bridge to Hamilton east of the bridge, a delay of approximately 5 to 7 minutes. Most traffic going to Hamilton, likely including emergency response vehicles, use SR20. We identified that all utilities are above ground and would not be impacted by bridge/road abandonment. Ensley Road, a county road, was previously abandoned between Lyman-Hamilton Highway and SR20. However, it is noted that once infrastructure is removed it is extremely costly to reinstall it and bridge removal may not currently be a viable option from the County's perspective since the bridge currently serves over 150 vehicle trips per day, has a rating of 94.88 out of 100, and replacement is not scheduled for 2030.

4A. Cabin Creek Road Abandonment

4B. Lyman-Hamilton Highway Abandonment

5) Infrastructure Improvements

The Lyman-Hamilton Bridge currently has about 0.5 to 3 ft freeboard above the bed following the 2010 sediment removal and winter season. It is anticipated that the bridge would not currently convey more than an estimated 2-year return period flood. Since one of the sediment management activities in the creek is driven by a need to manage flooding caused by Muddy Creek, one option is to raise the existing bridge in order to improve flow conveyance.

5A. Bridge Modification – increase height: The anticipated year for replacement is 2030 with a an estimated projected cost of $3 million (estimated for 2030 dollars using the 1997 replacement costs of $1.1 M and adjusted for inflation using the past 10-year CPI average of 4.3%). To modify the bridge to make it higher, it would need to be re-designed to the appropriate return period flood profile, and would include an allowance for sedimentation in addition to freeboard.

The costs of raising the existing bridge and putting it on new footings would cost nearly as much as purchasing a new bridge since much of the total bridge costs are in the handling.

5B. Bridge Replacement – resize and raise: An increased bridge height and additional conveyance would also address some of the Skagit River flooding impacts and damages by allowing more Skagit River discharge to pass beneath the bridge rather than over the top of it. Increasing both width and height would add considerably to the benefits, but would require a new bridge, which is very expensive and anticipated to be beyond the financial ability of Skagit County; however, by adding both width and height, maintenance needs, and therefore costs, are anticipated to reduce over time. A potential negative consequence of raising the bridge and approaches could be that it redirects flooding and damages to other areas. These impacts would have to be assessed.

5C. Cabin Creek Road Culvert Replacement: Another infrastructure improvement would be to increase the diameter of the culvert under Cabin Creek Road. This improvement would not be a stand-alone improvement, but would be done in conjunction with project objectives to increase connectivity between the Skagit River, Muddy Creek and Davis Slough. The benefits would be to reduce some road damages resulting from Skagit River and Muddy Creek flooding and improve fish habitat passage if a permanent Davis Slough – Muddy Creek connection is made.

5D. Shoulder Improvements: Shoulder redesign to increase backslope and armor the shoulder in overflow areas is a passive infrastructure improvement that will lower the long-term and chronic repair costs resulting from flooding on the Skagit River. The armor can consist of concrete, grouted riprap, or appropriately sized riprap. A regrade of the road shoulder on the downstream side of overflow (north side at the bridge, south side at Jims Slough) to a 5H:1V slope to allow for passage of water without road shoulder and pavement damage. The costs are relatively low when compared to the other alternatives and can be implemented when the next repairs are needed. This alternative can be combined with 5E for increased benefits (damage reduction).

5E. Road Overflow Design (lowering): Lowering the road at historic overflow sites would allow for flood flows to move without obstruction and damage to the road resulting from headcutting. Flooding may occur more frequently on the lowered roads, but the repair damage is anticipated to go down immensely.

5F. Cockreham Levee Modifications (lowering): Reducing the frequency of overtopping can reduce the frequency of damages, and thus lower repair costs over the long-term. The hydraulics of the Cockreham Levee and the amount of this benefit would be realized are beyond the scope of this project. The costs of this investment are likely large based on previous analysis (GeoEngineers, 2007). Assessment of this alternative in greater detail and within a reach context could help assess the comprehensive costs and benefits of this alternative.

6) **Create Setback Levees**

The sedimentation in Muddy Creek at the Lyman-Hamilton Highway Bridge is aggravated by the fact that the creek is constrained within narrow levees, which do not allow for natural alluvial fan processes (primarily deposition) to occur. By confining deposition to within the existing creek channel, the rate of aggradation is increased artificially and translated downstream to the bridge area. By setting back the levees, the creek would be allowed to overflow its banks and deposit material on the alluvial fan floodplain. This would provide a much larger area for storage of material, as well as dramatically increasing the flood conveyance. This option has been implemented at nearby Hansen Creek.

The primary disadvantage to this option is that a very large amount of private property is required in order to be able to set back the levees from the creek. It might be possible to apply this concept in a limited fashion in the reach immediately downstream of SR 20 on the left bank (east of the creek) where impacts do not include structures. Skagit County Staff and the property owner met to discuss a potential alignment. Maintenance of levees would be necessary over time, and in addition to constructing new setback levees, improvements to crossings and road prisms may be needed. Maintenance of the existing stockpiles levees are, in theory, necessary under the existing management and yet the levees have not required much maintenance in the past years, therefore maintenance of new or improved levees could be infrequent.

The benefits of this project would be to increase and encourage sediment storage opportunities in an area upstream of the bridge, thus reducing sedimentation at the bridge, and simultaneously provide for the opportunity to improve the most impaired fish habitat reach. The addition of habitat enhancement features, such as large woody debris and riparian cover, can add to habitat diversity and conditions, which is currently lacking from the reach. In addition, trees could be planted within this area as flood hazard reduction benefits (from debris flows).

7) **Rerouting Muddy Creek**

Muddy Creek in the reach downstream of SR20 has been modified throughout the past century. Returning Muddy Creek to one of its former alignments could have some potential benefits. The alternative to re-route Muddy Creek into Careys Slough, Jims Slough and Davis Slough was considered.

Anecdotal accounts suggest that Muddy Creek used to flow into Careys Slough in historic times. Rerouting Muddy Creek to Careys Slough is only feasible from a fish habitat standpoint if there is a permanent connection to the Skagit River and flood impacts to the town of Hamilton do not increase. We evaluated Careys Slough outlet and the connectivity and felt that this connection likely exists. A 6-foot diameter culvert that goes underneath the Lyman-Hamilton Highway it was discharging approximately 15 cfs from Careys Slough in June 2011. We estimate that the culvert could likely pass lower flows from the combined Careys Creek and Muddy Creek, but a hydraulic analysis should be done to evaluate the capacity for higher flows. Results from that model may indicate that an improved crossing may be needed. The bedload sediment that is transported by Muddy Creek will deposit into Careys Slough. Given time, this will ultimately affect the morphology of the slough and transform it into a low gradient gravel bed stream. Additional modeling of the potential long-term impacts of this transformation should be done to ensure that this alternative is not merely a transfer maintenance needs and flood hazards to another location. We met with property owners and determined that rerouting into Careys Slough was not feasible from their perspective given the proposed use of the property, existing infrastructure, and potential flooding and maintenance they would incur. Therefore we do not feel that this alternative is feasible.

Rerouting Muddy Creek into Davis Slough and Jims Slough were also determined to be not feasible at this time because they do not currently meet the primary project objectives of decreasing sediment management and infrastructure damages given existing conditions. In particular, rerouting Muddy Creek to Davis Slough creates a problem of fish stranding. Both reroutes would require the relocation of recently constructed private infrastructure and construction of road crossings, and therefore would be very expensive. If and when the Middle Skagit initiatives are implemented, these alternatives should be reconsidered, as there could be fish and hydraulic benefits by connecting Muddy Creek to Jims Slough and Davis Slough with increased Skagit River connectivity.

8) Forestry Land Use Management

The upper watershed consists of commercial forestry properties. Forest practices are regulated by the Department of Natural Resources. Forestry harvests in the watershed appear to have peaked in the 1960’s through 1980’s. In recent years, the Timber Fish and Wildlife program has led to forest practice rules which are much more stringent than past rules and forest practices in areas with unstable slopes now require more scrutiny (Class IV Specials). As such, the County has the ability to provide comment to forest applications.

Much of the watershed has not been harvested within the past few decades, so in theory, basin stability and hydrology is recovering when compared to the post 1970’s watershed conditions. The recent harvests we did observe had been replanted per regulatory prescription. Areas we observed that were unvegetated and had exposed soils adjacent to the creek would be challenging to stabilize with plantings due to the rate of creek and slope movement and the depth at which movements were occurring. We observed many older established trees tipped or disturbed by recent slope movements. Tree root strength takes years to establish and typically extends only to depths of 6 feet (2 meters) or less; therefore it is less effective at stabilizing larger mass wasting occurrences, and scientific literature has not definitively linked deep-seated landslide activity to logging activities.

3.2 Alternatives Analysis

The purpose of the alternatives analysis is to determine which alternative(s) best meet the stated objectives and are implementable given the resources and abilities of Skagit County. Projects or actions that meet the objects provide benefits, but projects have costs or other conditions that may limit the ability of Skagit County to implement them; therefore, to determine which management alternatives are most feasible, we conducted a cost-benefit analysis.

3.2.1 Project Costs

Understanding project costs, both for the initial investment, and how the investment affects project costs over time is essential to provide rationale for making certain investment choices. To understand future costs, we assessed the pattern of historic project costs. The management of the infrastructure at Hamilton Junction has not been part of a formal plan; rather it has been handled by traditional management strategies that center around fixing things that are broken and not considering how these costs and commitments accumulate over time or what can be done to manage these assets differently to decrease financial obligations or maximize existing resources.

3.2.1.1 Historic and Future Costs

The assessment of future management costs is based on observed historic patterns and expects that the conditions experienced in the past will occur similarly into the future. These assumptions include flood frequency, project costs, and inflation, amongst other variables. The historic costs are presented in Table 11 below and the projected future costs assuming the same management strategy and similar conditions are presented in Table 12.

Table 11: Historic (1990-2010) observed and estimated damage costs

Damage Event	***Repair cost****	***Inflation Adjustment ($2010)***	***CPI***
1990 damages	*$100,000*	$166,837	130.7
1995 damages	*$1,050,000*	$1,426,534	152.4
1996 damages	*$20,000*	$27,795	156.9
1997 damages	*$20,000*	$27,172	160.5
2003 damages	*$20,000*	$23,701	184
2006 damages	*$10,000*	$10,816	201.6
2009 damages	*$10,000*	$10,164	214.5
	TOTAL (1990-2010)	**~$1,700,000**	*($2010)*

Average Annual Damages: $85,000 (2010 dollars)

Table 12: Future Repair Cost Estimate

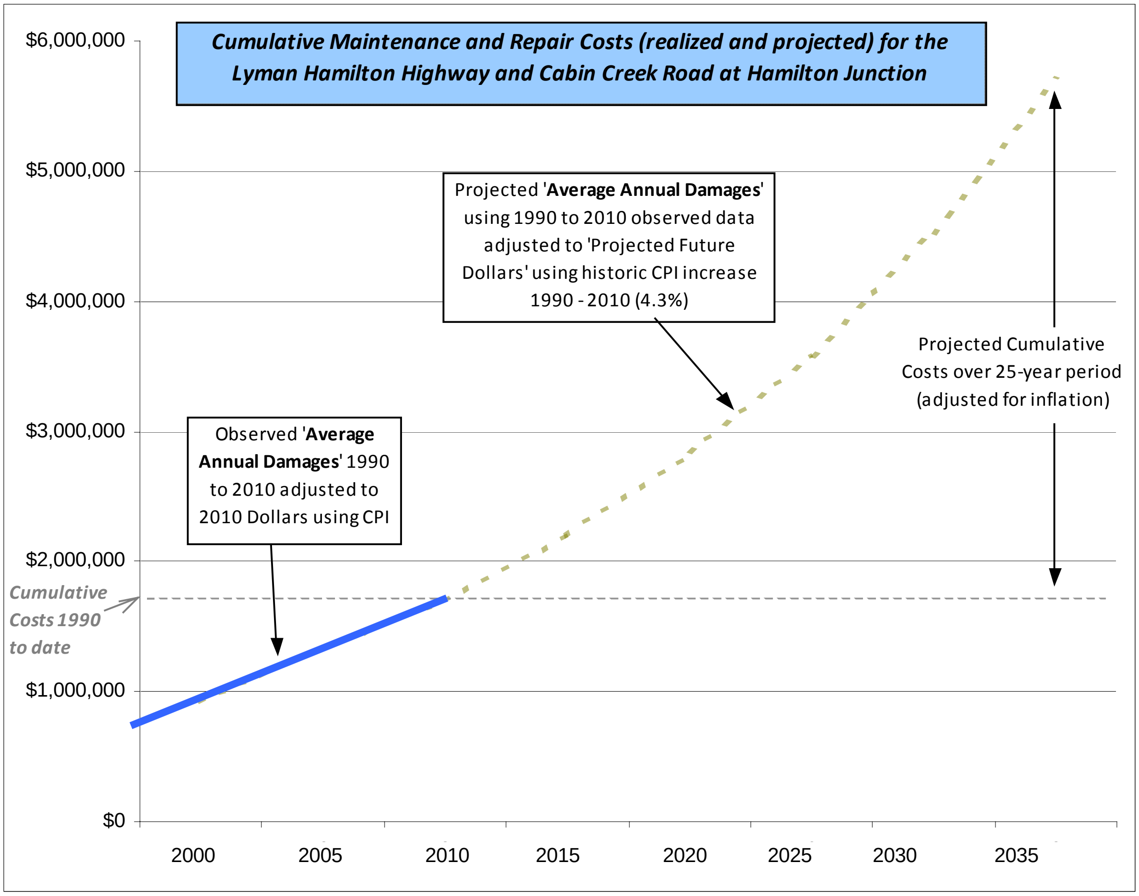
This method used "average annual damages" adjusted for future inflation using 4.4%/year and presented at 5 year increments (~$425,000/5-years in $2010 dollars)

Year	*Estimated 25-year Cumulative Repair Costs***
2015	$2.2 M
2020	$3.8 M
2025	$3.5 M
2030	$4.5 M
2035	$5.7 M

*Repair costs shown in italics are estimates. Records for repair types and damages were incomplete. Photo records show damages to shoulder, roadbed and pavement and field evidence shows significant riprap armoring. These costs estimates are considered low and actual repair costs could be higher.

**This estimate includes the replacement of Lyman-Hamilton Bridge at Muddy Creek, which is scheduled to occur within the 25-year projection

The 25-year forecasted project costs are presented graphically as a plot below.



Note: These costs do not include annual dredging.

3.2.1.2 Estimated Implementation Costs for Identified Alternatives

Table 13: Estimated Implementation Costs for Alternatives

Alternative	*Title*	*Planning-Level Cost to Implement*
1	No Action	$0
2	Upper Watershed Sediment Source Control	Scale Variable ($200,000 to < $1M)
3	Instream Sediment Removal (historic management practice)	$20,000 annually
4	Infrastructure Abandonment	
4A	Cabin Creek Road Abandonment	$100,000
4B	Lyman-Hamilton Road Abandonment	$150,000
5	Infrastructure Modifications	NA
5A	Lyman-Hamilton Bridge Raising (using existing structure w/ new footings)	$1 M
5B	Lyman-Hamilton Bridge Replacement (Raising/Widening)	$2.5 M
5C	Cabin Creek Road Davis Crossing Improvement (culvert re-size)	$150,000
5D	Shoulder Improvements (armoring and resloping)	$150,000
5E	Road lowering at overflow locations	$200,000
5F	Lower or remove the Cockerham Levee	$750,000
6	Levee Setback (between SR20 and L.H.Hwy Bridge)	$750,000
7	Muddy Creek Channel Relocation	$1 M
8	Forest Practices Management	$0

3.2.1.3 Projected long-term costs

Table 14: Projected Long-term Costs (25-year)

Alt	*Title*	*Planning-Level Cumulative Cost to Maintain Projects for 25-years (2010 – 2035, adjusted for inflation)*
1	No Action	\$3.8 M
2	Upper Watershed Sediment Source Control	< \$1M
3	Instream Sediment Removal (historic management practice)	\$850,000
4	Infrastructure Abandonment	NA
4A	Cabin Creek Road Abandonment	\$0
4B	Lyman-Hamilton Road Abandonment	\$0
5	Infrastructure Modifications	
5A	Lyman-Hamilton Bridge Raising	\$200,000
5B	Lyman-Hamilton Bridge Replacement	\$200,000
5C	Cabin Creek Road Davis Crossing Improvement	\$100,000
5D	Shoulder Improvements	\$100,000
5E	Road lowering at overflow locations	\$100,000
5F	Lower or remove the Cockerham Levee	Not assessed
6	Levee Setback	\$100,000
7	Muddy Creek Channel Relocation	\$500,000
8	Forest Practices Management	\$0

3.2.1.4 Total Project Costs (implementation plus 25-years maintenance and repairs)

Table 15: Total Project Costs (implementation plus 25-years maintenance and repairs)

Alternative	***Title***	***Total Project Cost***
1	No Action (repairs only)	$3.8 M
2	Upper Watershed Sediment Source Control	Scale Variable ($1 M plus)
3	Instream Sediment Removal (historic management practice)	$850,000
4	Infrastructure Abandonment	
4A	Cabin Creek Road Abandonment	$100,000
4B	Lyman-Hamilton Road Abandonment	$150,000
5	Infrastructure Modifications	
5A	Lyman-Hamilton Bridge Raising (using existing structure w/ new footings)	$1.2 M
5B	Lyman-Hamilton Bridge Replacement (Raising/Widening)	$2.7 M
5C	Cabin Creek Road Davis Crossing Improvement (culvert re-size)	$250,000
5D	Shoulder Improvements (armoring and re-sloping)	$250,000
5E	Road lowering at overflow locations	$300,000
5F	Lower or remove the Cockerham Levee	$750,000*
6	Levee Setback (between SR20 and L.H.Hwy Bridge)	$850,000
7	Muddy Creek Channel Relocation	$1.5 M
8	Forest Practices Management	$0

**More information needed to estimate project costs*

3.2.2 Summary of Project Benefits

Table 16: Alternatives Benefit Summary

Alt	***Title***	***Benefits***
1	No Action	Low upfront investment
2	Upper Watershed Sediment Source Control	Can reduce sediment volume, therefore extend project longevity
3	Instream Sediment Removal (historic management practice)	Maintains Davis Slough connection and hydraulic conveyance under bridge
4	Infrastructure Abandonment	Eliminates future maintenance needs
5	Infrastructure Modifications	Reduces future maintenance needs
6	Levee Setback	Improves habitat and decreases maintenance needs
7	Muddy Creek Channel Relocation	Reduces the management needs at the L.H. Hwy Bridge
8	Forest Practices Management	Decreases sediment delivery to the system

3.2.3 Cost-Benefit Analysis

The cost-benefit analysis consisted of the integration of project costs, both initial investment and long-term commitments, with benefits. The outcomes of the analysis resulted in a “score” derived at by dividing the costs by the benefits. The scores represent relative cost-benefit merits and in general showed that alternatives with multiple objectives and greater benefits and lower overall costs were favored. We present the relative values and the decision matrix in Table 17. The matrix, in Excel format, was provided to Skagit County to allow assessment of different alternatives for potential changes in costs or benefit.

Table 17: Cost-Benefit Analysis (decision matrix)

		BENEFITS		*PUBLIC IMPACTS*		*COSTS*	*SCORE*
Alternative	Reducing Infrastructure repair cost (25-year)*	Habitat benefits	Flood benefits		Estimated project costs (year 0)	Estimated 25-year maintenance costs (running total)	Benefits / Costs
	-5 = increase repair costs	-5 = negative impacts	-3 = negative impacts	0 = No Impacts	0 = No cost	0 = No cost	
	0 = no change	0 = no benefits	0 = no benefits	-3 = negative impacts	1 = < $200,000	1 = < $200,000	Poor
	5 = great reduction of costs	5 = great benefits	3 = great benefits		2 = < $500,000	2 = < $500,000	Fair
					3 = < $1M	3 = < $1M	Good
					4 = > $1M	4 = > $1M	
1 - No Action	0	-1	-1	-1	0	4	-0.5
2 - Upper Watershed	1	1	0	0	4	3	0.3
3 - Sediment Removal	1	-2	2	0	1	2	0.3
4A Cabin Ck Road	3	1	0	-1	1	0	4.0
4B - L.H. Hwy	5	0	0	-2	2	0	2.5
5A (bridge raise)	1	0	1	0	4	1	0.4
5B (bridge replace)	2	0	1	0	4	1	0.6
5C (Cabin Ck. Rd. culvert)	2	1	1	0	1	1	2.0
5D (backslope)	3	0	0	0	1	1	1.5
5E (road overflow)	4	0	0	0	1	0	4.0
5F (Cockreham Levee)	3	4	2	-1	4	3	1.3
6 - Setback Levee	1	4	1	0	3	1	1.5
7 - Relocation	1	3	1	0	3	2	1.0
8 - FP Management	0	3	0	0	0	1	3.0
Combined Alternatives							
4A, 5D, 5E, 6	4	3	2	-1	3	2	1.8
3, 4A, 4B, 5C, 5D, 5E, 6	5	5	2	-2	4	2	2.0
3, 6, 5D, 5E	4	3	2	0	4	2	1.5

* Note: Reduction of damages from Muddy Creek can have a maximum score of 1
Reduction of damages from the Skagit River can have a score of up to 5

3.2.4 Proposed Conceptual Project

We observed that by integrating certain combinations of alternatives, we could create an aggregate project with greater comprehensive benefits. Stakeholders may also better support these collective projects since they meet multiple objectives. We evaluated several collective projects and developed a conceptual project that meets all of the project objectives and we feel could be supported by most, if not all, of the stakeholders and Skagit County. Through this process, the following “suite” of alternatives can be combined to generate a single project that has good benefits to cost ratios and address all the objectives of the project and appear feasible within the means of Skagit County:

- Setback Levee
- Infrastructure Modifications (shoulder armoring and road lowering)
- Channel engineering and limited sediment removal to maintain Davis Slough connection
- Re-convey the Cabin Creek Road Right-of-Way over to private ownership so it can be maintained as a private crossing; resize the Davis Slough crossing
- Consider plans to ultimately abandon the Lyman-Hamilton Highway or lower the Cockerham Levee.

3.2.4.1 Conceptual Project Description

Through the process of exploring conceptual collective projects, we found that the alternatives analysis was effective as a template to address the general approach and costs of a project alternative, but that there are many variables, modifications, and details that can be adopted or incorporated into each alternative to tailor a specific design to create a project that “works” for the given conditions and constraints. Our proposal for a conceptual “collective” project is composed of the following project elements:

1. Continue to work with the private landowner between Lyman-Hamilton Hwy and SR20 to develop a possible setback levee alignment. Coordinate resources from stakeholders and develop partnerships for grant funding. Develop setback levees that can reduce the landowners flooding issues, allow for sediment storage, and improve habitat conditions in the most impaired reach of Muddy Creek. Chinook rearing is documented in the lower reaches of Muddy Creek and therefore this project could be combined with other Chinook habitat improvement alternatives for this priority reach to develop a successful habitat restoration project. This design concept is consistent with a process-based management approach by allowing natural process (sediment deposition, flooding, and channel migration) to occur. A conceptual levee alignment, riparian plan, and stream design has been developed as a sketch for discussion purposes only (Appendix F).

2. Work with stakeholders and agencies to develop an engineering design to help to maintain a surface water connection between Muddy Creek and Davis Slough. Conceptually, this design could be a hydraulic constriction and grade control to create a transport reach rather than a depositional reach at the bridge. It is possible that occasional dredging at this site may be needed to manage certain hydraulic events that deposit sediment and re-isolate the Davis

Slough habitat. This design concept also has Chinook habitat benefits and is ranked number 7 in the PHPR (2011) and is consistent with recovery goals by restoring freshwater floodplain rearing habitat. A possible design “typical” is shown in Appendix F.

3. Abandon the public right-of-way for Cabin Creek Road and re-convey this easement to private use. The alignment could be maintained by the private landowner for agricultural use. Replacing the existing undersized culvert with an agricultural crossing has reduced engineering standards than for redeveloping a public crossing, thus a crossing that was larger and more habitat friendly could be pursued at a lesser cost. The access route would be maintained by the private landholder, thus alleviating Skagit County’s future maintenance needs for this infrastructure.

4. Create engineered overflow sections of the Lyman-Hamilton Highway at the historically damaged sections (west and east of the bridge and at the culvert crossing west near Jims Slough)(concept presented in Appendix F). By lowering the roadway, hydraulic head differences will be minimized, thus decreasing the damaging effects of being overtopped by the Skagit River during flood events. If possible, make the road surface at grade with the existing adjacent grade and fill the roadside ditches along the north side of the Lyman-Hamilton Highway. The road would be inundated more often, but the damages would be considerably less. Combine the lowering of this roadway with the armoring and re-sloping of the shoulder in areas where the road is not at grade. An armored shoulder with 5H:1V backslopes will allow overtopping with reduced shoulder erosion damages, further reducing the repair costs resulting from flooding. Both of these strategies can be accomplished following the next road damage if designs were in place, therefore maximizing the use of the existing road surface for as long as possible. The implementation of this management strategy will greatly reduce the long-term management costs and could increase the longevity of the existing bridge by reducing the hydraulic forces that act upon it during larger flood events.

5. Consider alternatives to lower the Cockerham Levee since these alternatives increase the frequency and elevation of flood events that damage the infrastructure at Hamilton Junction, and thus Skagit County’s long-term investment costs. This effort should be coordinated with the greater overall Middle Skagit restoration effort.

6. If the Lyman-Hamilton Highway Bridge were to be damaged to a point where it needed to be replaced, consider ultimate abandonment of this infrastructure. This will eliminate all future management costs for Skagit County at this site.

3.2.4.2 Planning-level Implementation Costs and Sequencing for Conceptual Project Elements 1-4

1. Setback Levee: $750,000
    a. Build partnerships; summer-fall 2011
    b. Develop project design; fall – winter 2011
    c. Develop funding application for SRFB; early spring 2012
    d. Initiate permitting; spring 2012
    e. Refine and finalize design; fall 2012
    f. Initiate construction phases 2013

2. Davis Slough Reconnection: $200,000 (not including Cabin Creek Road work)
    a. Build partnerships; summer-fall 2011
    b. Develop project design; fall – winter 2011
    c. Develop funding application for SRFB; early spring 2012
    d. Initiate permitting; spring 2012
    e. Refine and finalize design; summer 2012
    f. Initiate construction phase; fish window 2012

3. Cabin Creek Road Modifications: $50,000 - $200,000 (varies with crossing type)
    a. ROW abandonment and agricultural crossing design and permitting; fall 2011
    b. Construction; fish window 2012

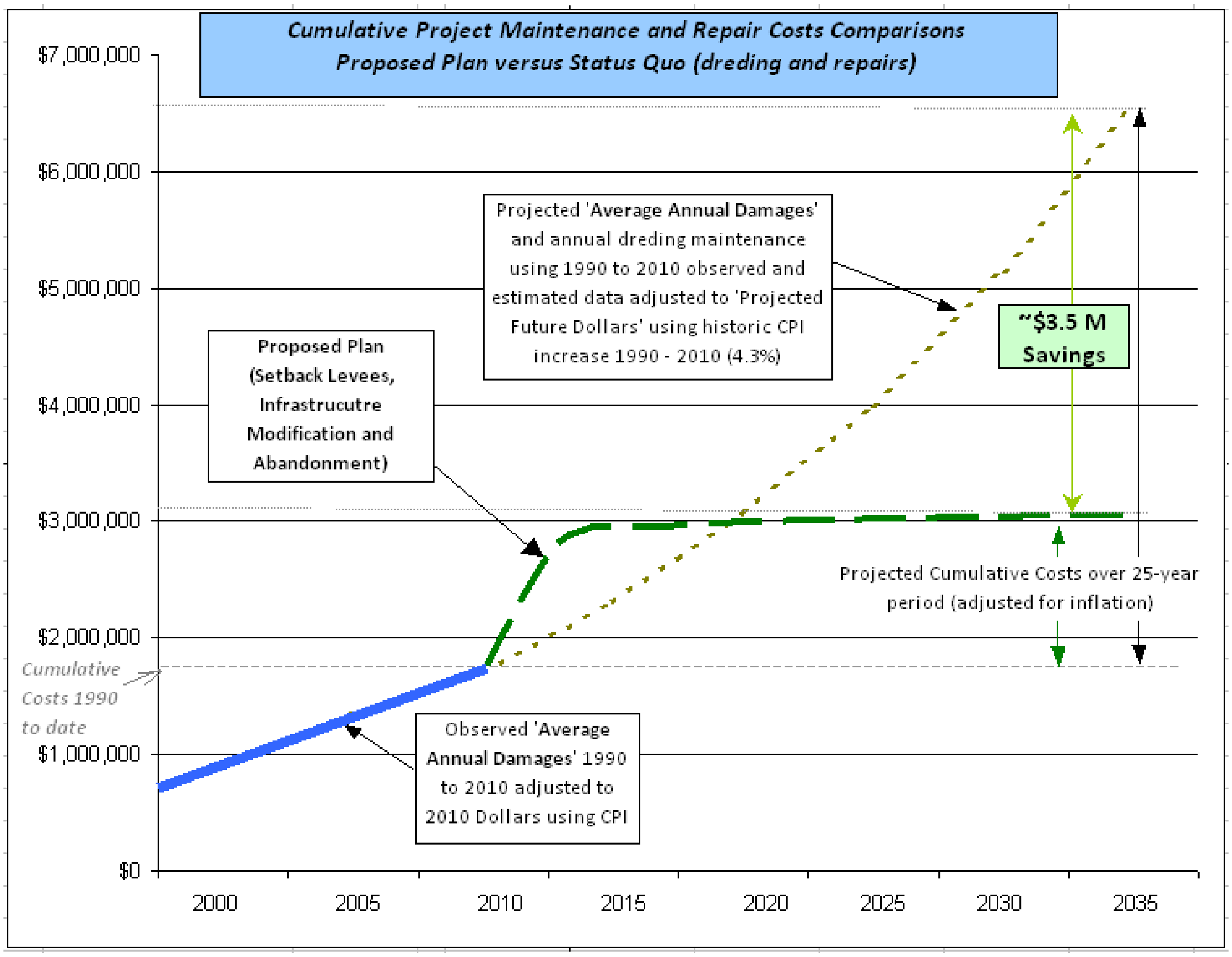
4. Engineered Road Overflow
    a. Design road modifications: $30,000; fall 2011
    b. Construct following flood damage using emergency resources: $200,000

Total Investment Costs (full implementation of elements 1-4 above): $1.2 M*

**Planning-level costs developed for this estimate are considered conservative.*

3.2.4.3 Cost Savings from Plan Implementation (25-year)

The current management activities (dredging and repairs), if projected into the future, are estimated to cost $5.5 M cumulatively over the next 25 years. The implementation of the proposed project elements will cost an estimated $1.2 M (elements 1-4, and element 6) and repairs and maintenance would drop off significantly, especially repairs from damages with the implementation of elements 3-6. The savings offered by full implementation if the plan over the 25-year period is estimated to be over $3 M, primarily because of the reduction in repair costs by elimination of infrastructure and a reduction in maintenance needs by allowing sediment deposition upstream of the bridge. The projected 25-year costs of the conceptual project versus current management are shown in the graph on the following page.


Cumulative Project Maintenance and Repair Costs Comparisons
Proposed Plan versus Status Quo (dreding and repairs)
$7,000,000
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$0
2000
2005
2010
2015
2020
2025
2030
2035
Projected 'Average Annual Damages' and annual dreding maintenance using 1990 to 2010 observed and estimated data adjusted to 'Projected Future Dollars' using historic CPI increase 1990 - 2010 (4.3%)
~$3.5 M Savings
Proposed Plan (Setback Levees, Infrastrucutre Modification and Abandonment)
Projected Cumulative Costs over 25-year period (adjusted for inflation)
Cumulative Costs 1990 to date
Observed 'Average Annual Damages' 1990 to 2010 adjusted to 2010 Dollars using CPI

4 Summary and Recommendations

4.1 Summary

The key points in this report are summarized as follows:

1. The primary damages to the infrastructure at Hamilton Junction (Lyman-Hamilton Highway and Muddy Creek Bridge, Cabin Creek Road) are caused by over bank flooding from the Skagit River
2. These damages cost approximately $85,000 per year (average annual costs 1990-2010) have cost approximately $1.7 M since 1990 and damages occur, on average, about every 3 to 5 years
3. Flooding from backwater conditions on the Skagit River caused by the Cockreham Island Levee may increase damage recurrence intervals at Hamilton Junction, and therefore cumulative repair costs
4. Muddy Creek sediment removals do not reduce the damages to the bridge and roads at Hamilton Junction
5. The most habitat impaired reach in the Muddy Creek watershed occurs between Lyman-Hamilton Highway and SR20
6. The Muddy Creek – Davis Slough connection no longer exists because of sedimentation in Muddy Creek and therefore Chinook rearing habitat offered by Davis Slough has been isolated (restoration of this connection ranks 7th in the PHPR (2011))
7. Landslide activity in the upper watershed and channel incision are the greatest contributors of sediment to the system and are anticipated to continue long into the future
8. The most feasible multi-objective Muddy Creek management alternatives to address existing bridge conveyance and habitat issues, based on cost-benefit analysis are: setback levees, restoring Davis connection with stream engineering and dredging, road modifications (shoulder improvements and lowering), and ultimate abandonment of infrastructure.
9. Implementation of the proposed conceptual plan will have an initial investment cost of approximately $1.2 M but will save over $3 M over the next 25-years
10. Implementation of the proposed conceptual plan has both fish and flood benefits in addition to reducing financial burdens on Skagit County over time
11. Potential partnerships exist to increase the potential for project funding.

4.2 Recommendations

It is recommended that the following alternatives be implemented to meet the Skagit County Public Works management objectives:

1. Work with private landowner(s) and stakeholders north of Lyman-Hamilton Highway to further develop, design and construct setback levees to allow for sediment and flood storage and improved habitat conditions
2. Work with WDFW and stakeholders to develop stream engineering techniques combined with low-impact sediment dredging methods to reconnect Muddy Creek to Davis Slough and provide for increased flood capacity beneath the Lyman-Hamilton Bridge

3. Develop partnerships with landowners and stakeholders to further develop projects and identify collaborative funding strategies to maximize collective resources
4. Design road lowering and shoulder improvements to allow for passive overflow during Skagit River flooding and implement concurrently with the next damage repairs
5. Plan for ultimate abandonment of infrastructure, specifically the Cabin Creek Road, Lyman-Hamilton Highway Bridge and potentially the Cockreham Levee.

5 Closure

This report was submitted by:

Paul D. Pittman, L.E.G.

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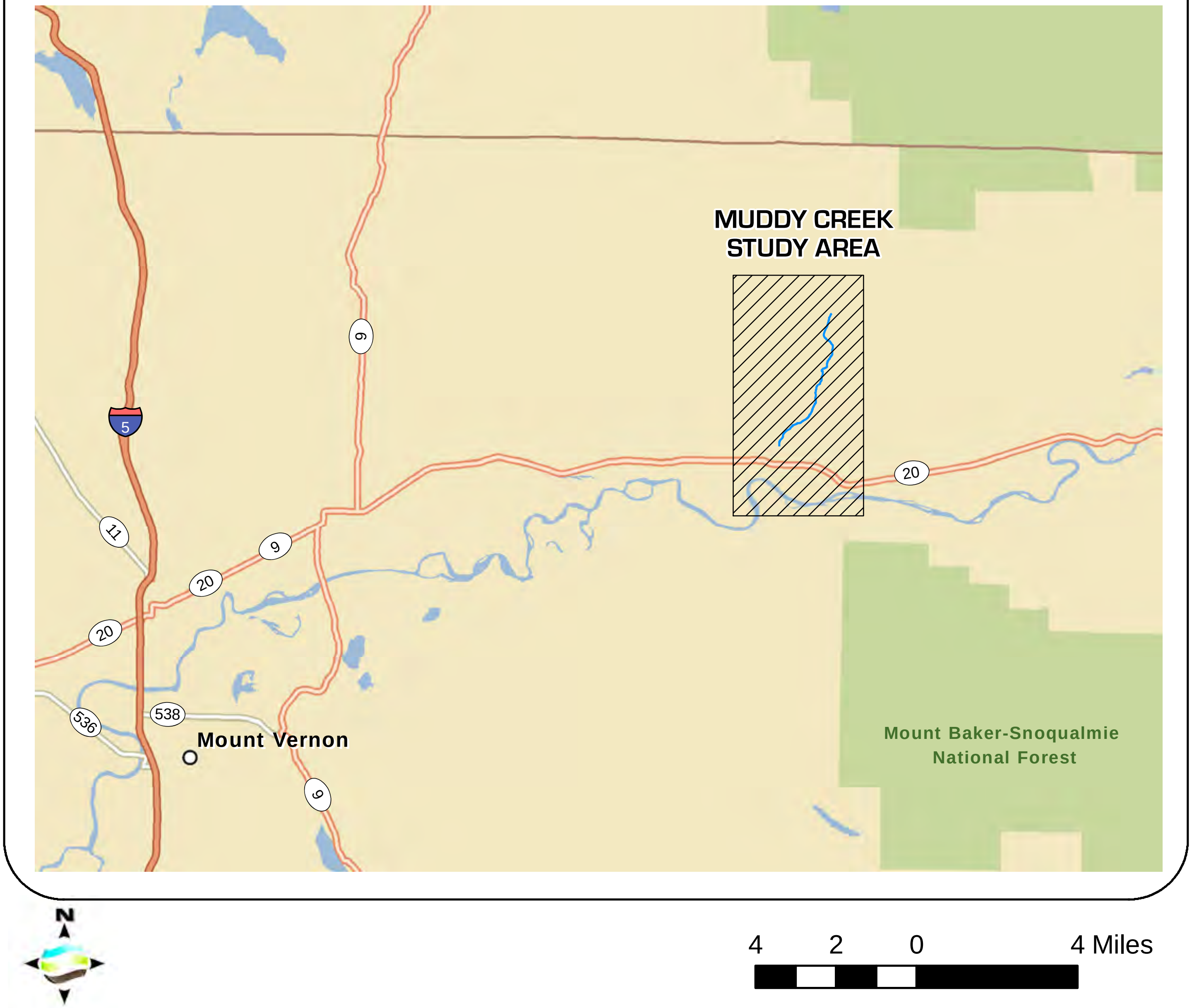
VICINITY MAP

SITUATE IN A PORTION OF
T35N R6E, W.M.
IN SKAGIT COUNTY, WASHINGTON



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w: ElementSolutions.org
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Muddy Creek Geomorphic Analysis

VICINITY MAP

Client: Skagit County Public Works

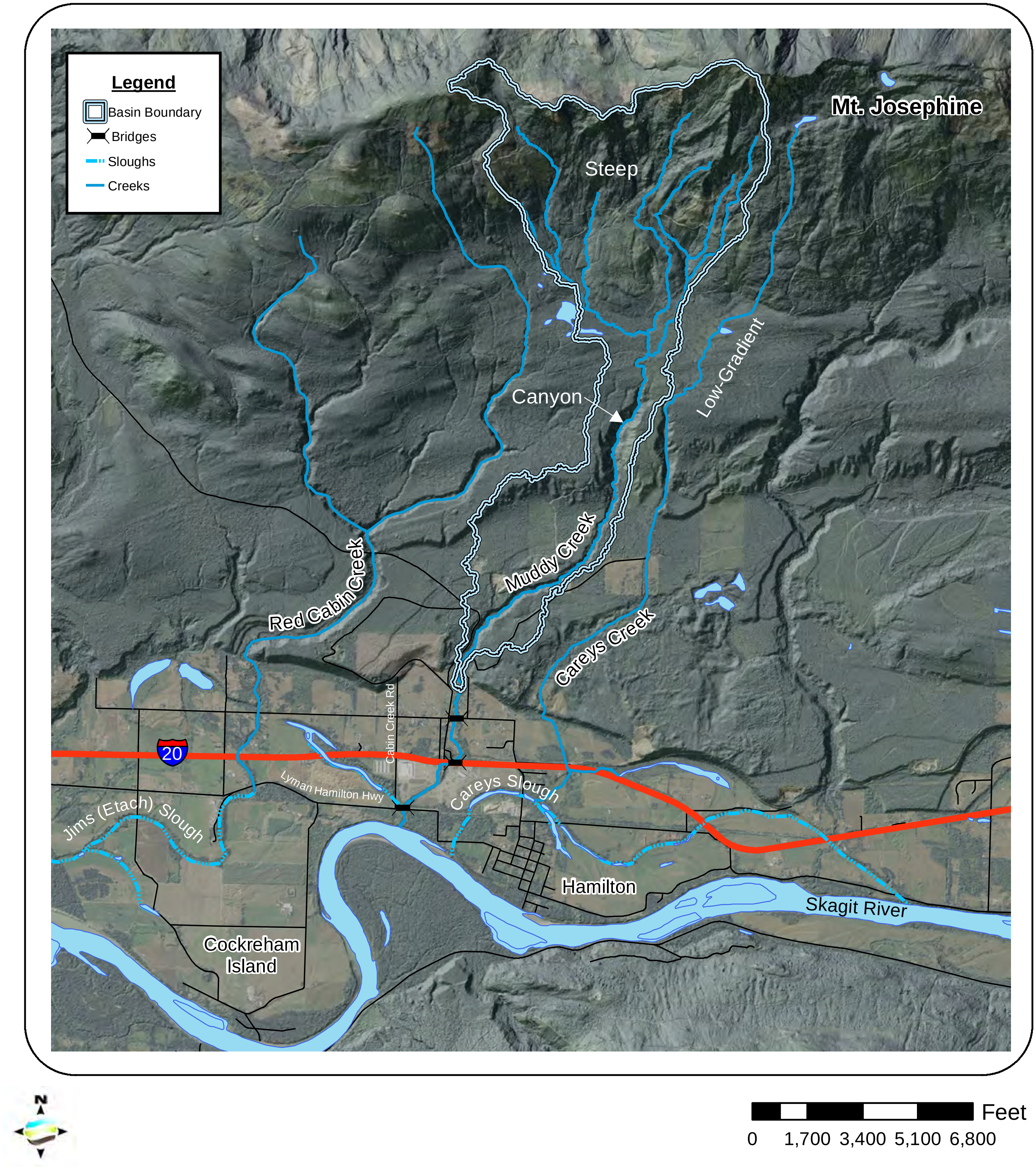
Skagit County, Washington

DATE: July 13, 2011

Figure 1

Project Number: 2010114

Path: I:\GIS\SkagitCounty_GIS\Muddy\MXD\Vmap.mxd



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Muddy Creek Geomorphic Analysis

SITE MAP

Client: Skagit County Public Works

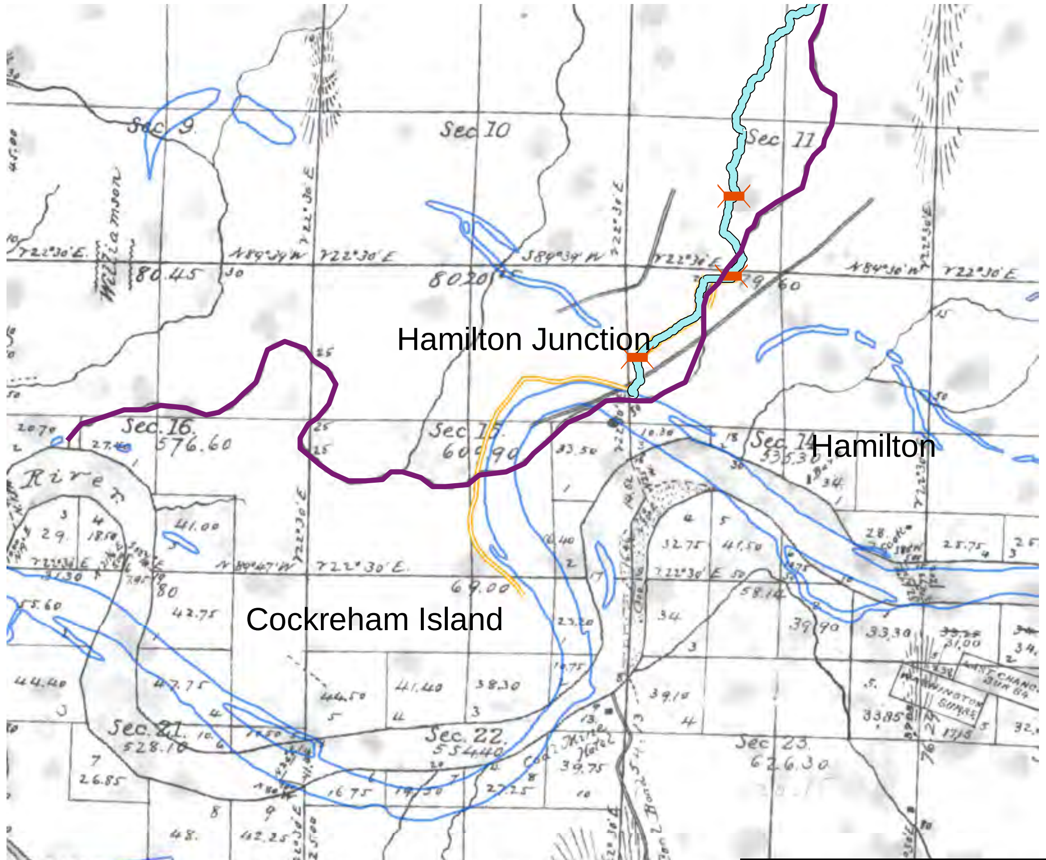
Location: Skagit County, WA

DATE: July 13, 2011

Figure 2

Project Number: 2010113

Path: I:\GIS\SkagitCounty_GIS\Muddy\MXD\sitemap.mxd



1879 Government Land Office (GLO) Map

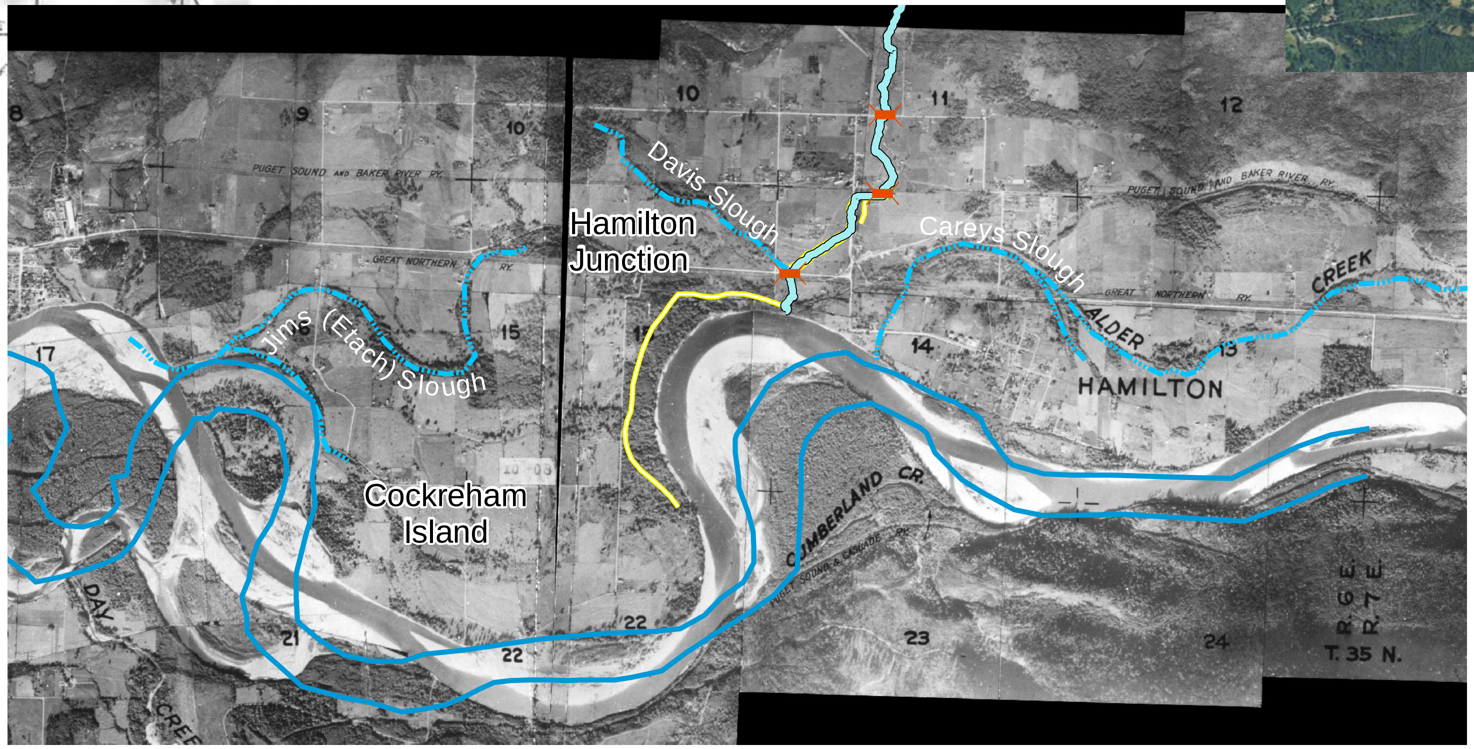
1879 GLO Legend

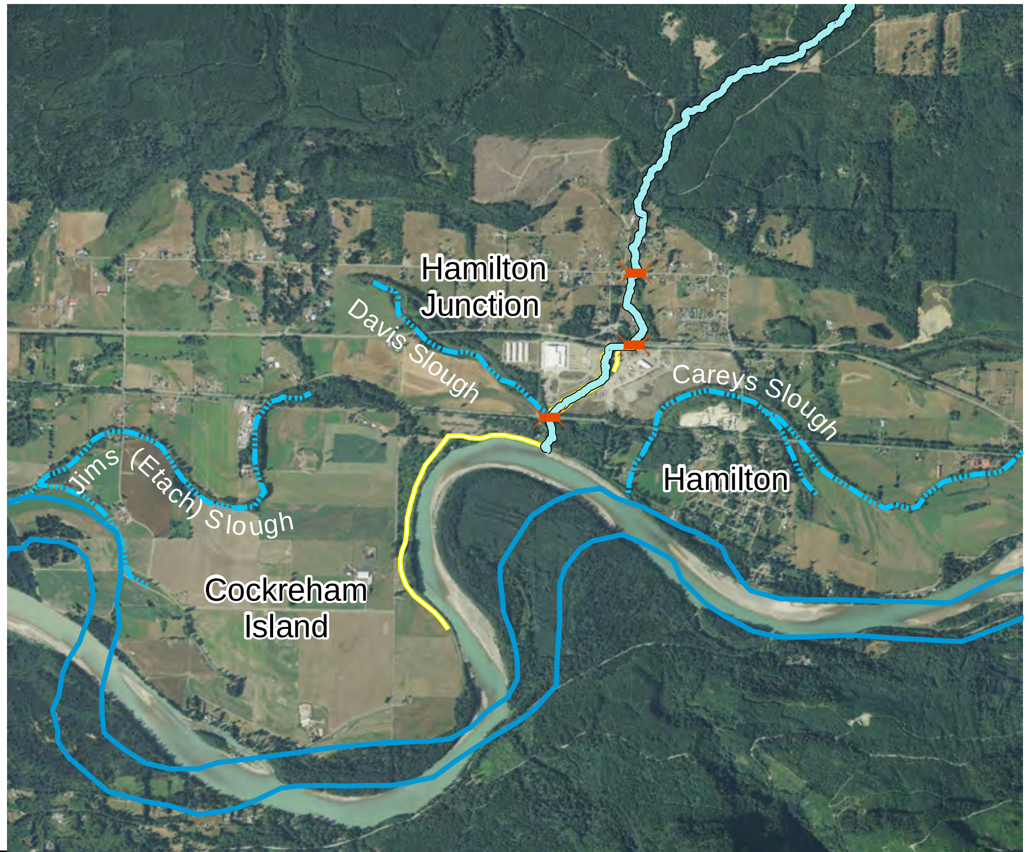
━	Muddy Creek (1879)
✕	Bridges (2011)
═	Muddy Creek (2011)
☐	Hydrology (2009)
═	Levees (2011)

1937 Skagit County Aerial Legend

━	Skagit River (1879)
✕	Bridges (2011)
═	Muddy Creek (2011)
┅	Sloughs
━	Levees (2011)

1937 Skagit County Historic Aerial





2009 USDA Imagery

2009 USDA Aerial Legend

━	Skagit River (1879)
✕	Bridges (2011)
═	Muddy Creek (2011)
━	Levees (2011)
┅	Sloughs

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Muddy Creek Geomorphic Analysis

Historical Comparison

Client: Skagit County Public Works

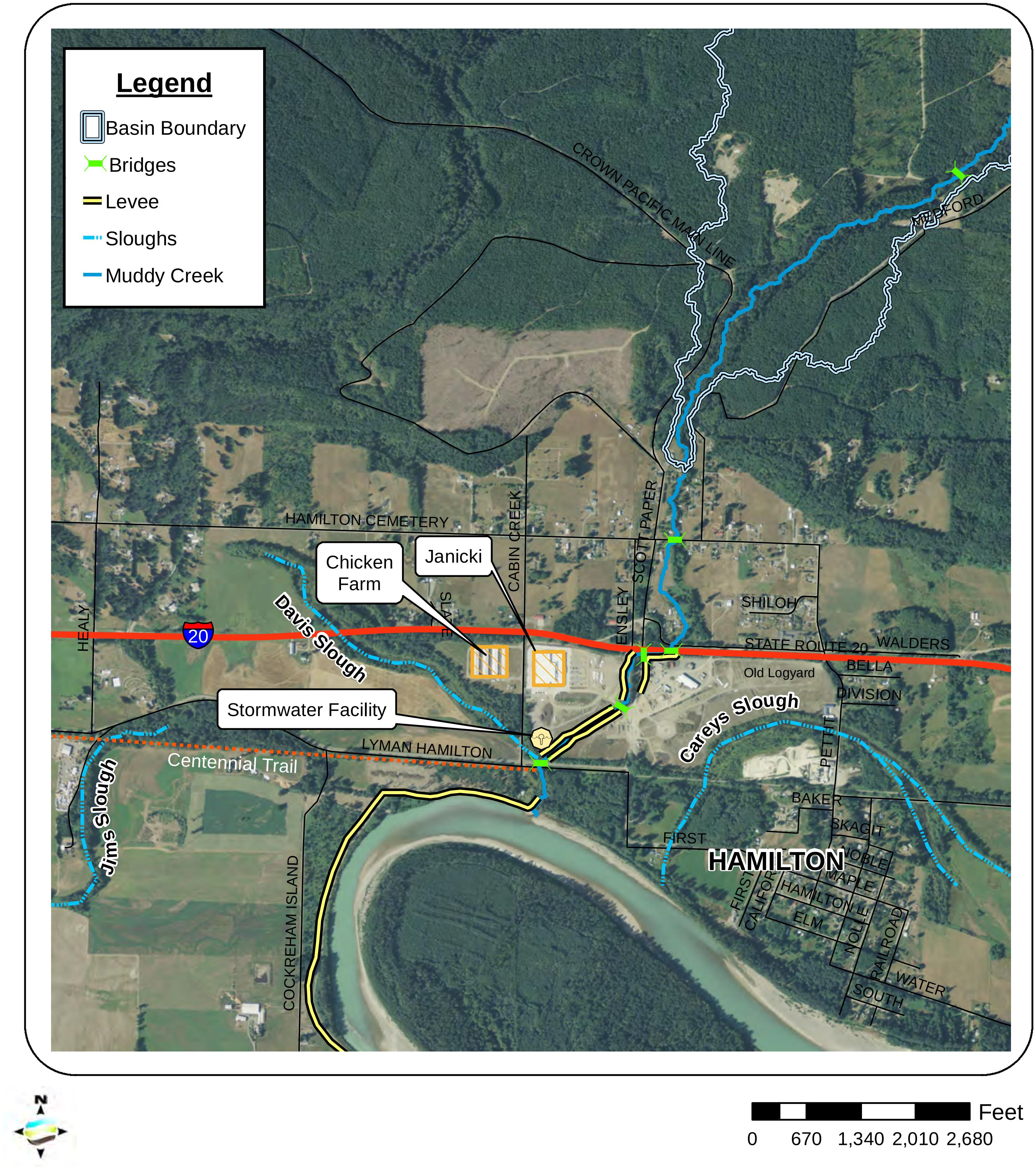
Location: Skagit County, Washington

DATE: July 13, 2011

Figure 3

Project Number: 2010113

Path: I:\GIS\SkagitCounty_GIS\Muddy\MXD\photos.mxd



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Muddy Creek Geomorphic Analysis

INFRASTRUCTURE MAP

Client: Skagit County Public Works

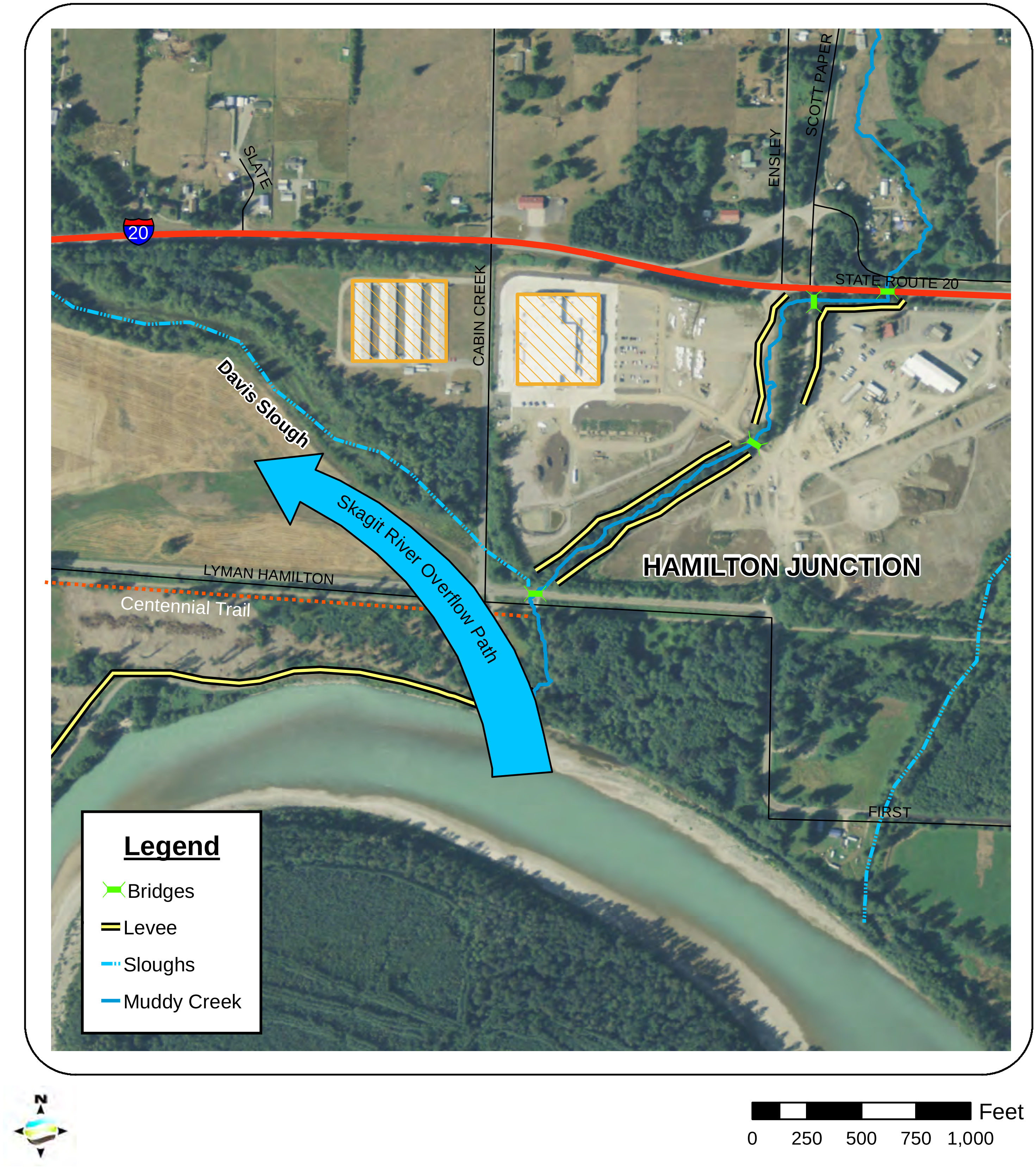
Location: Skagit County, WA

DATE: July 13, 2011

Figure 4

Project Number: 2010113

Path: I:\GIS\SkagitCounty_GIS\Muddy\MXD\infrastructure.mxd



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Muddy Creek Geomorphic Analysis

OVERFLOW PATH

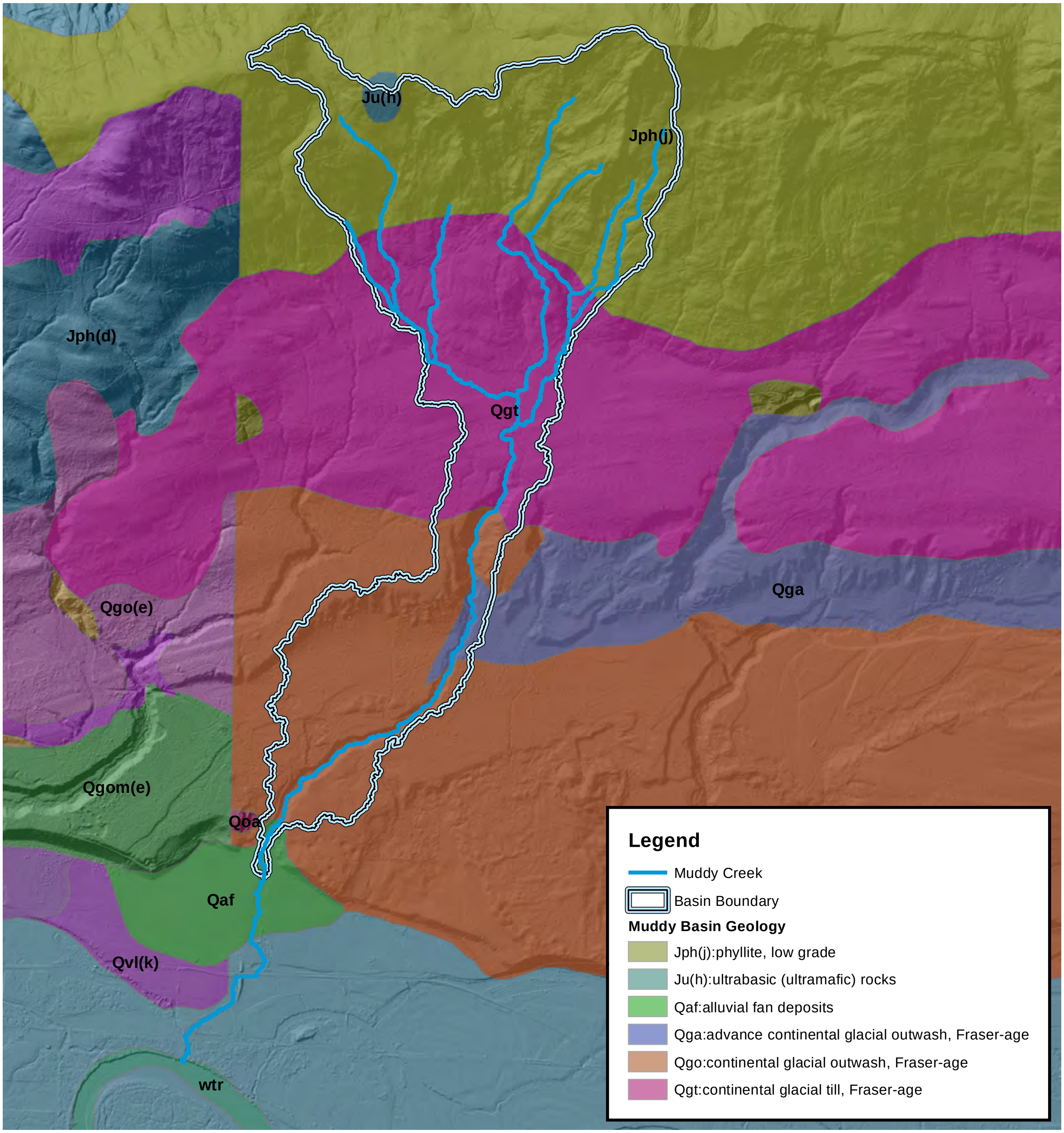
Client: Skagit County Public Works

Location: Skagit County, WA

DATE: July 13, 2011

Figure 5

Project Number: 2010113



Notes: From 1998-2000 DNR 1:100,000 Digital
Geology Shapefile

Feet
0 1,400 2,800 4,200 5,600

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Muddy Creek Geomorphic Analysis

Geology Map

Client: Skagit County Public Works

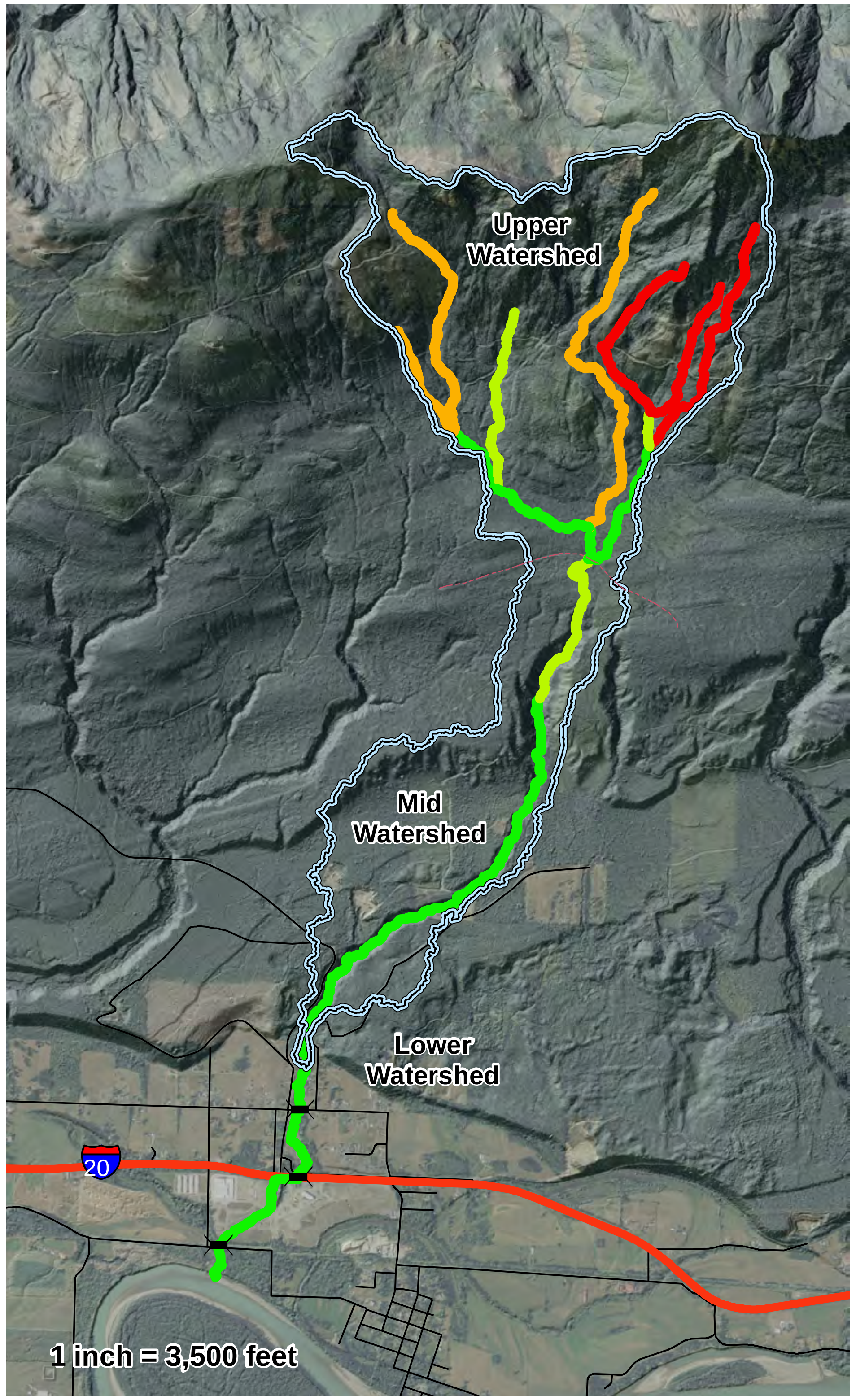
Location: Skagit County, WA

DATE: July 13, 2011

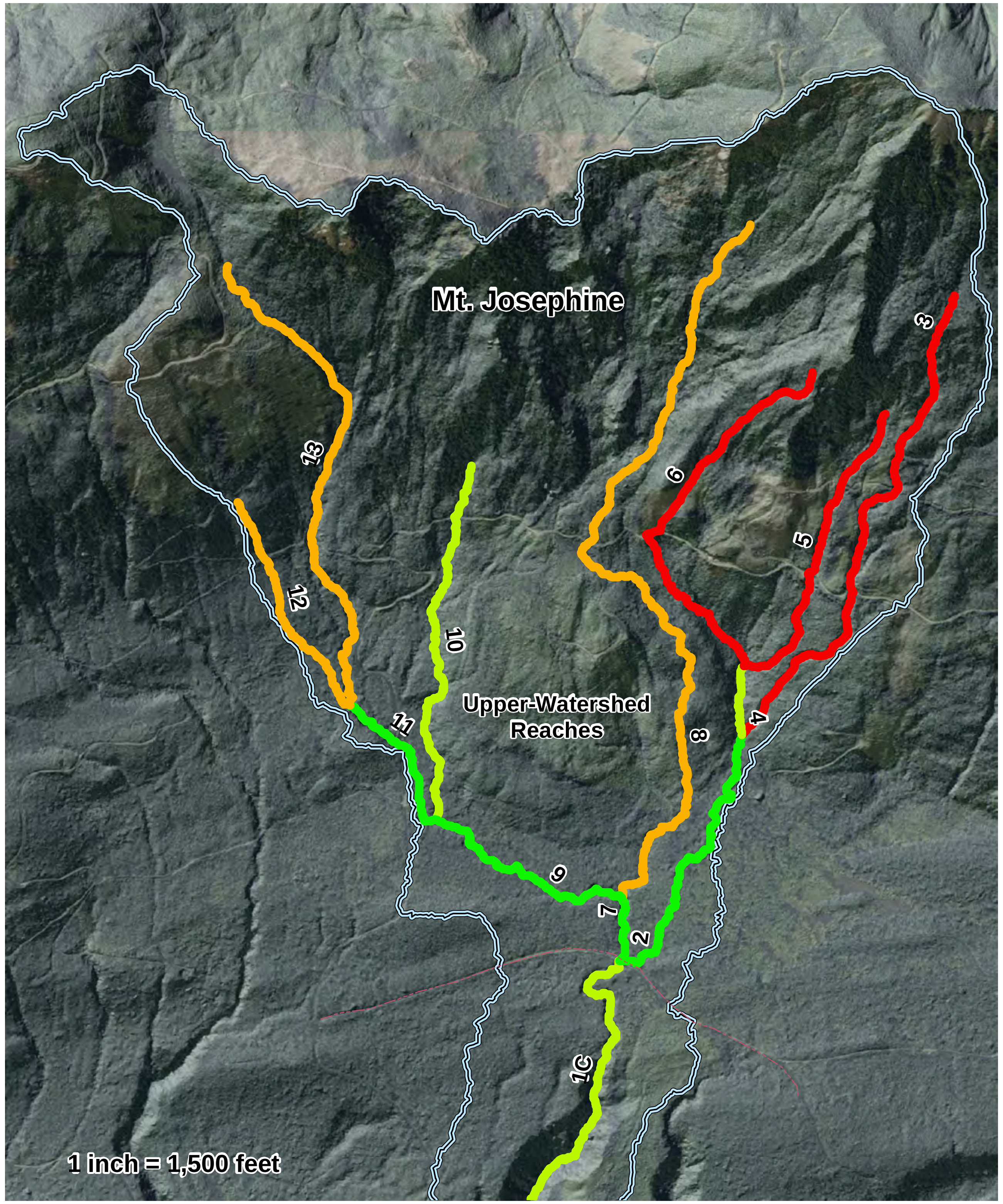
Figure 6

Project Number: 2010113

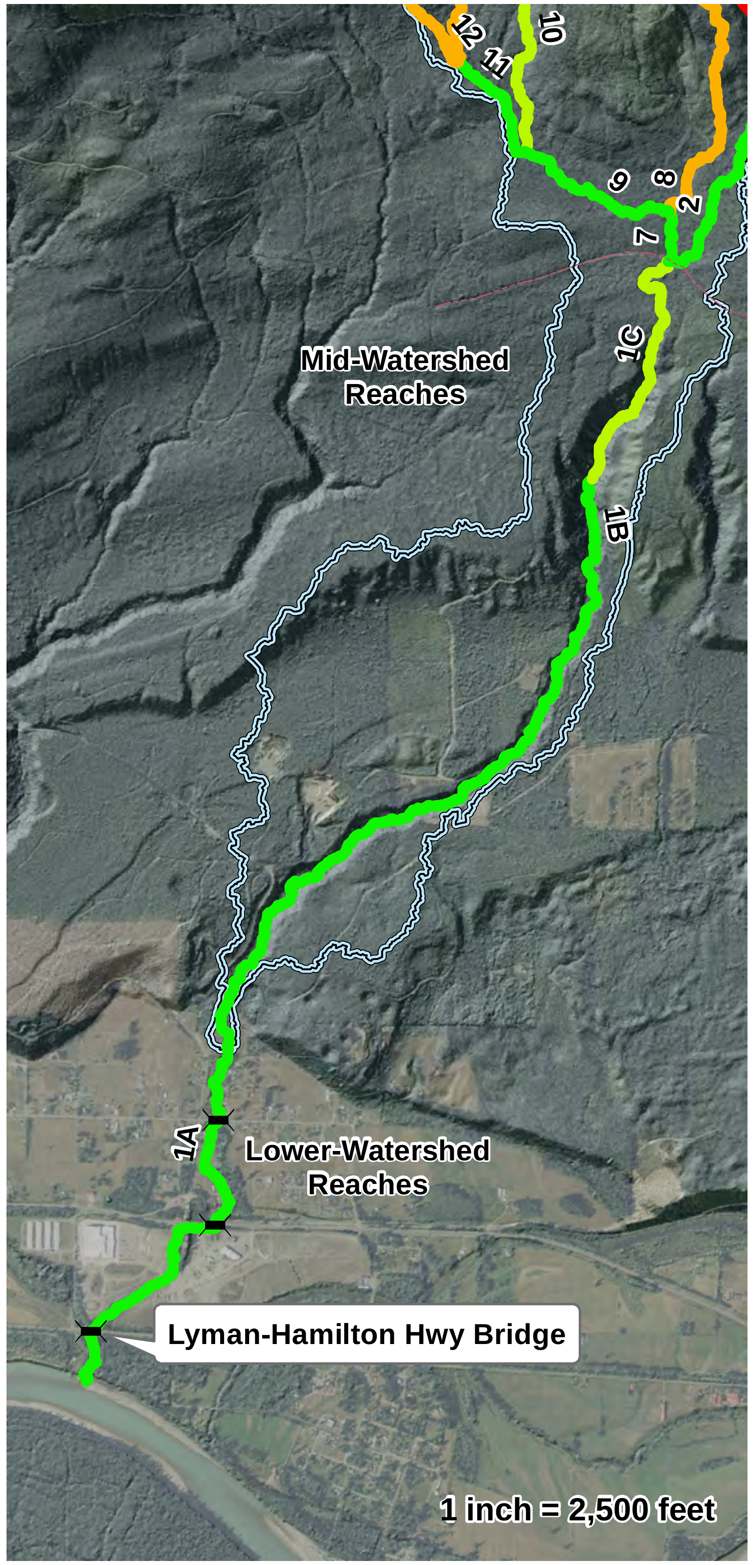
Path: I:\GIS\SkagitCounty_GIS\Muddy\MXD\geology.mxd



Muddy Creek Basin



Upper Basin



Lower Basin

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Legend

Muddy Creek Stream Gradient

- 🟥 0.2401 - 0.3100
- 🟧 0.1401 - 0.2400
- 🟩 0.0501 - 0.1400
- 🟩 0.0100 - 0.0500

- ⌶ Lyman-Hamiltong Hwy Bridge
- ☐ Watershed Boundary
- --- DNR Road (cross basin)

N

Muddy Creek Geomorphic Analysis

Sub-Basin and Reach Delineation

Client: Skagit County Public Works

Location: Skagit County, Washington

DATE: July 13, 2011

Figure 7

Project Number: 2010113

Path: I:\GIS\SkagitCounty_GIS\Muddy\MXD\Watershed1.mxd

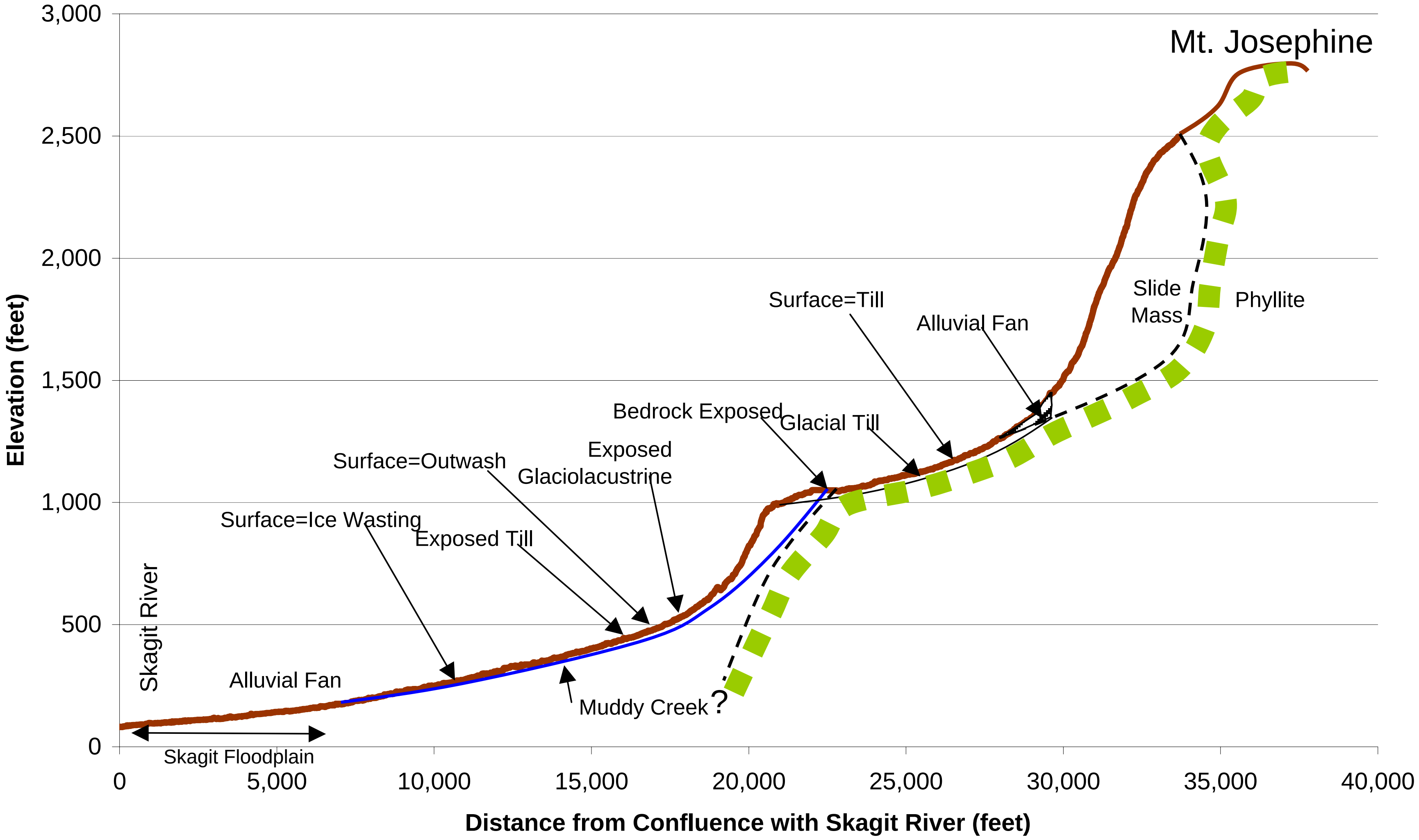


Figure 8. Muddy Creek Typical Profile

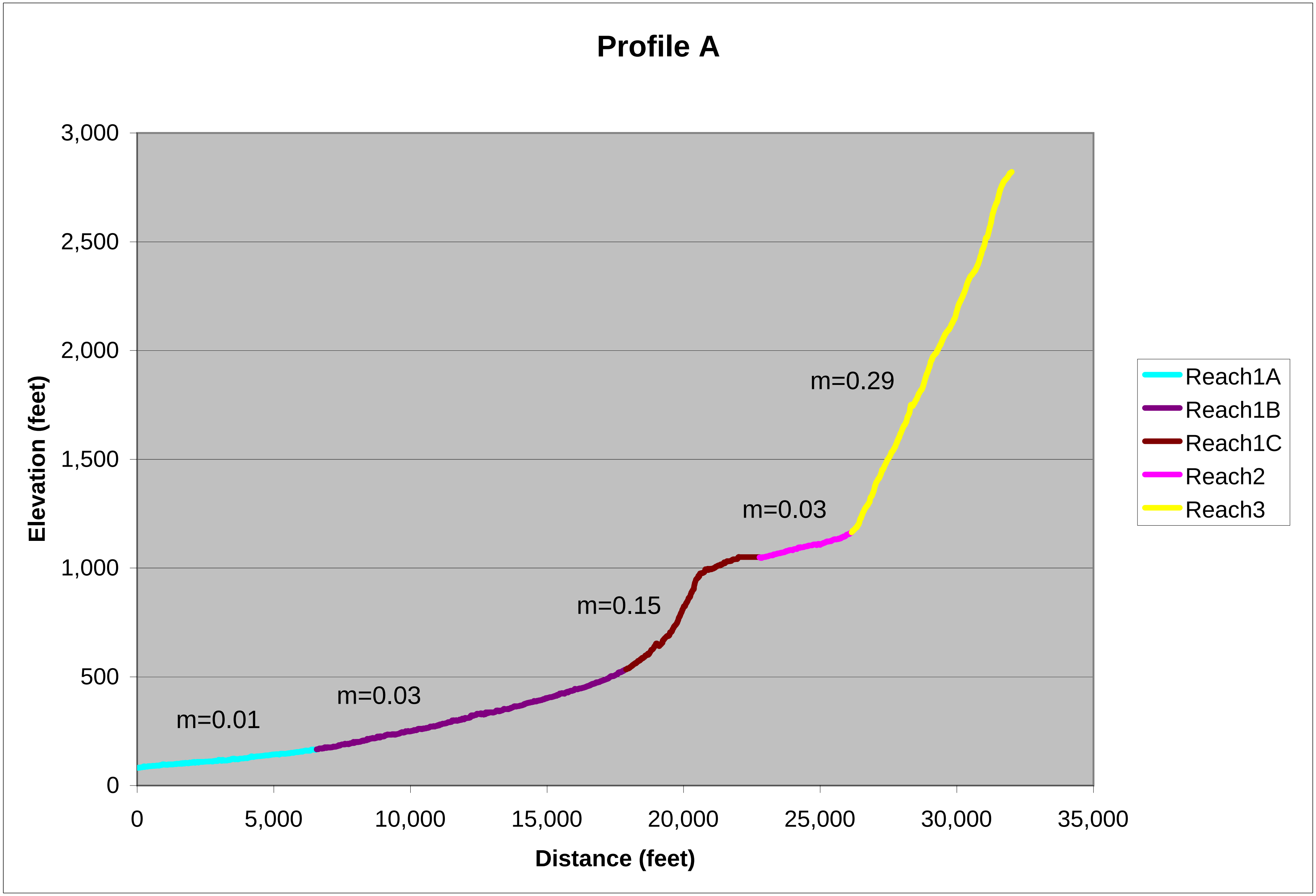


Figure 8a. Muddy Creek longitudinal profile. See Figure 10 for profile location.

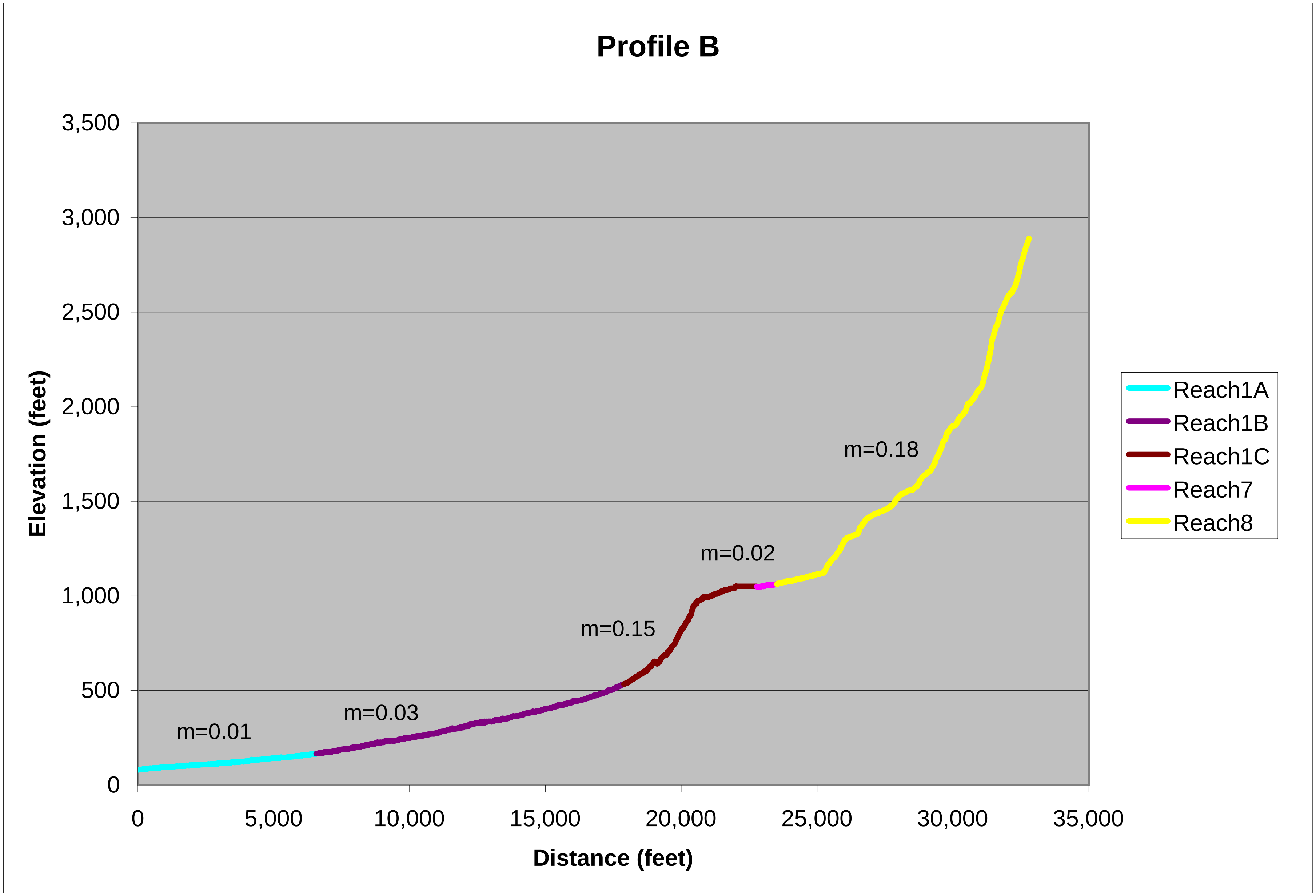


Figure 8a. Muddy Creek longitudinal profile. See Figure 10 for profile location.

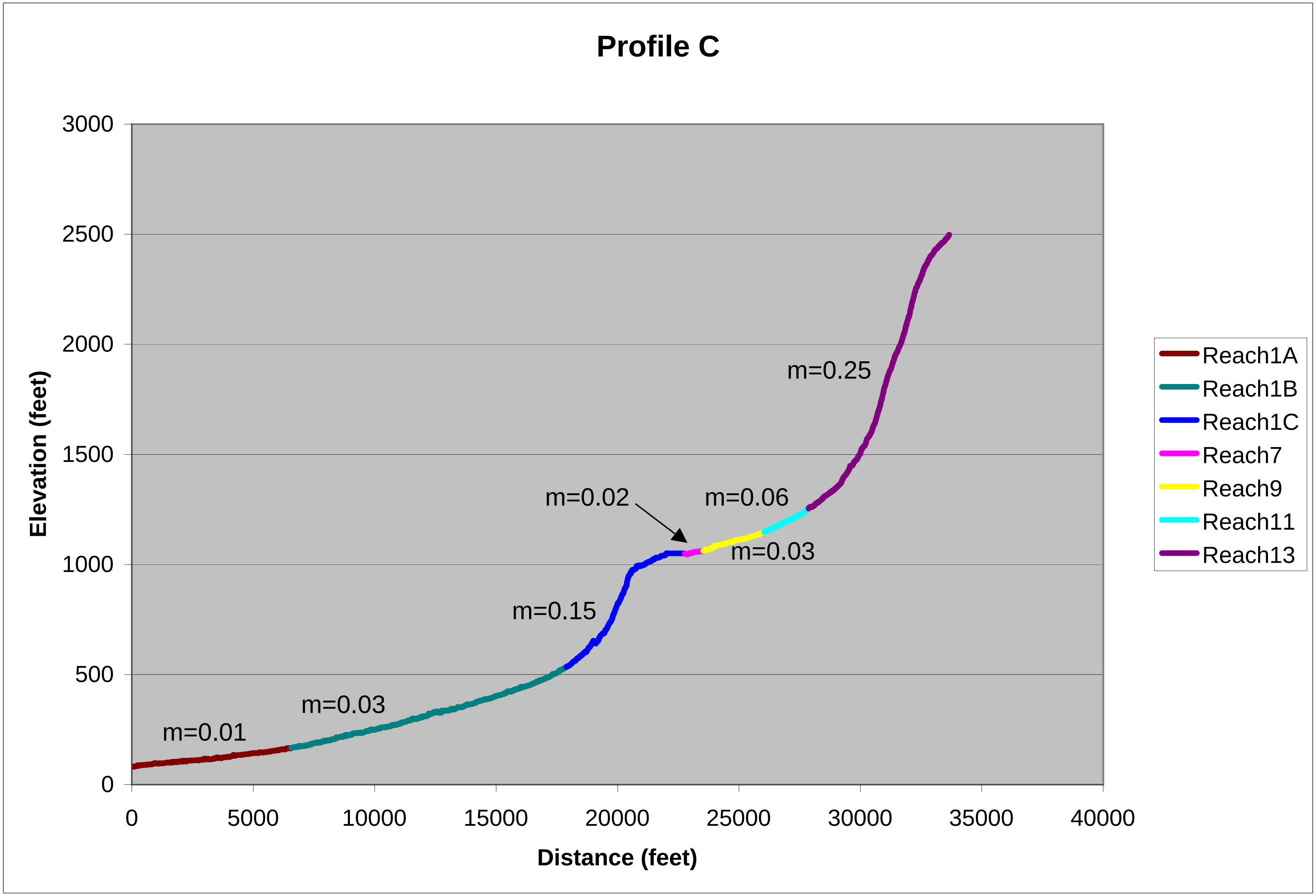
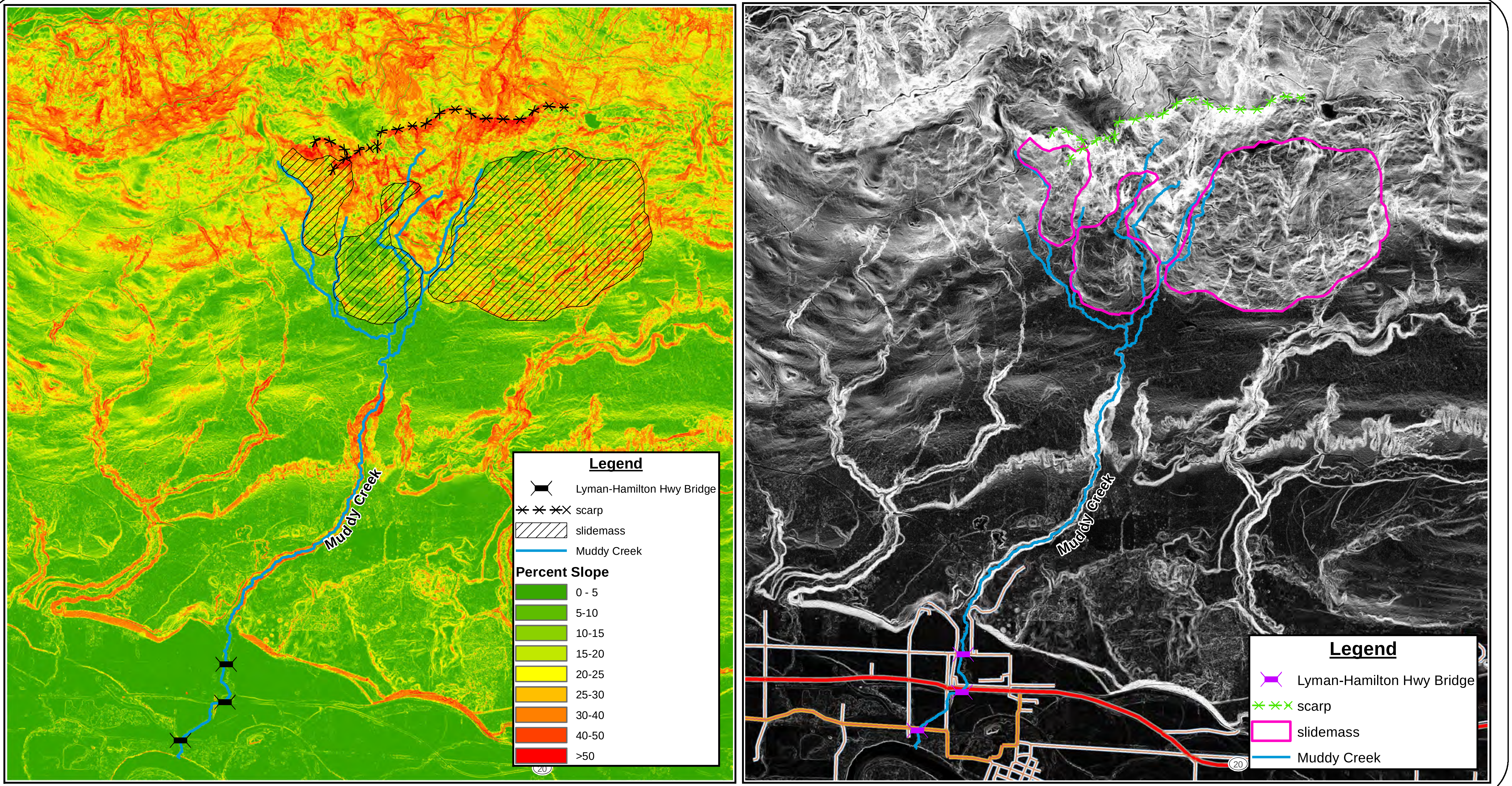


Figure 8a. Muddy Creek longitudinal profile. See Figure 10 for profile location.



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N

1 inch = 3,400 feet

0 1,700 3,400 6,800 Feet

Muddy Creek Geomorphic Analysis

Slope Map

Client: Skagit County Public Works

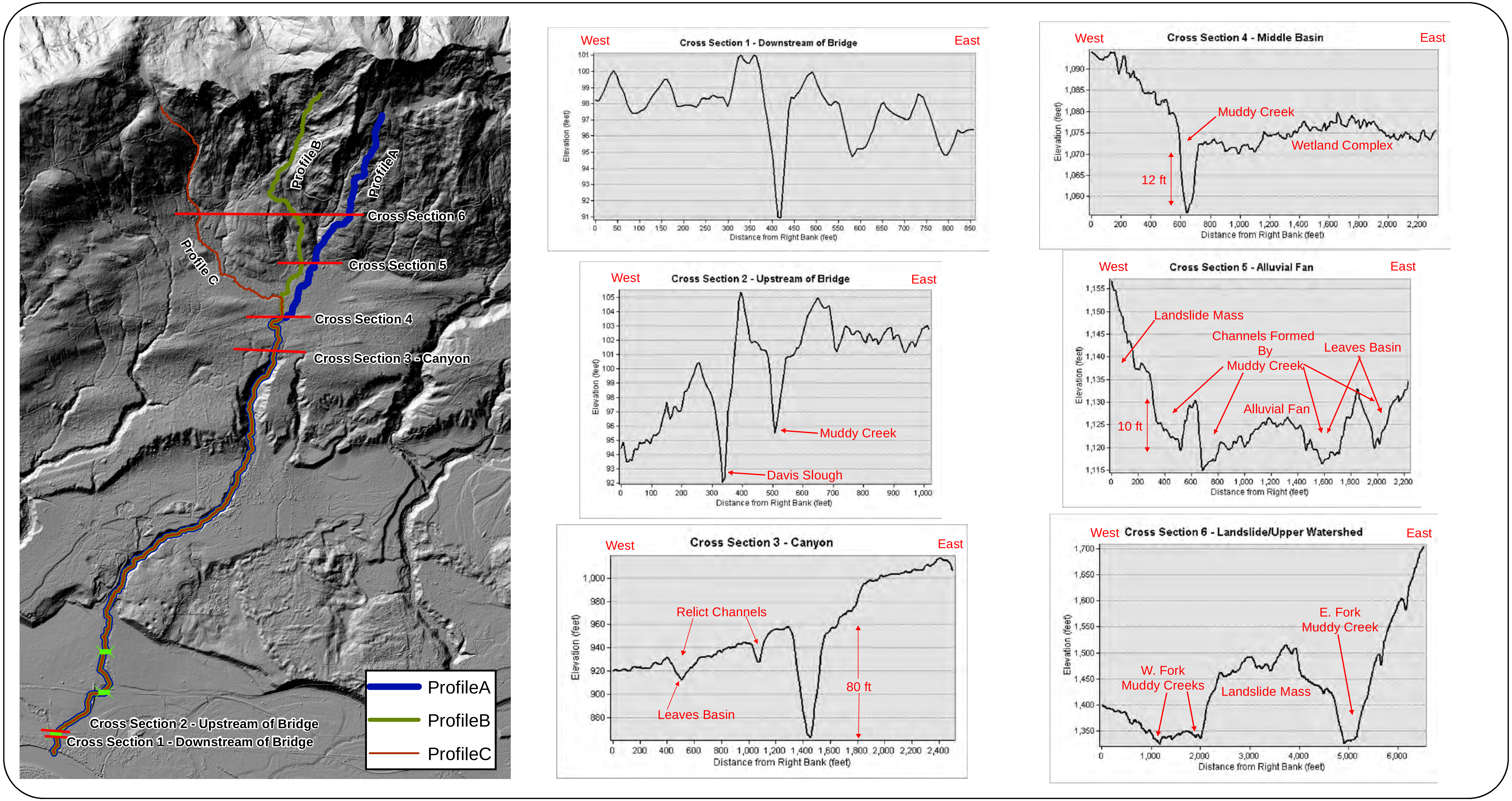
Location: Skagit County, Washington

DATE: July 13, 2011

Figure 9

Project Number: 2010113

Path: I:\GIS\SkagitCounty_GIS\Muddy\MXD\slope.mxd



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N

0 0.3 0.6 0.9 1.2 Miles

Note: Cross section are oriented north (looking upstream)

Muddy Creek Geomorphic Assesment

Profile and Cross Sectional Analysis

Client: Skagit County Public Works

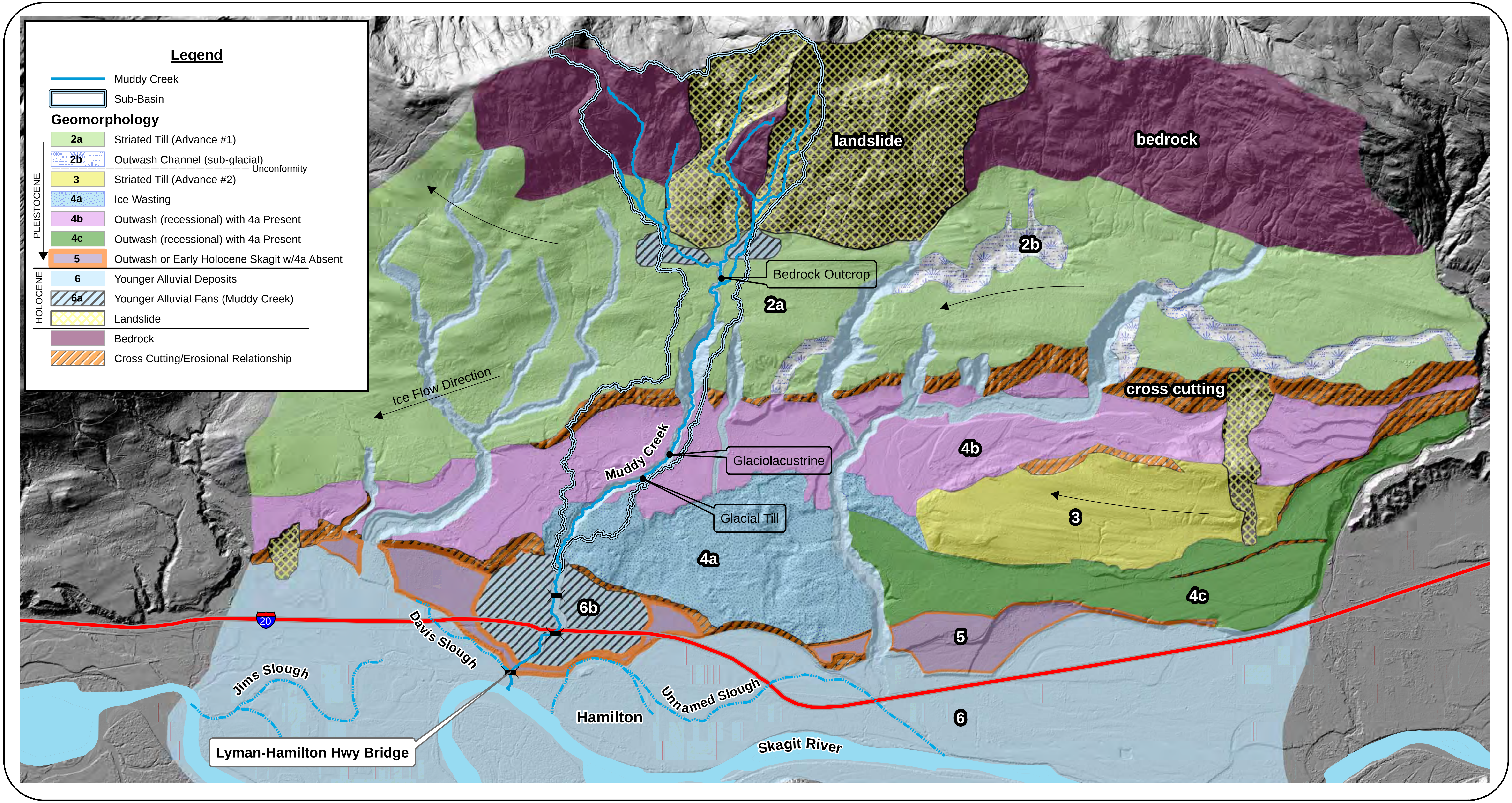
Location: Skagit County

DATE: July 13, 2011

Figure 10

Project Number: 2010113

Path: I:\GIS\SkagitCounty_GIS\Muddy\MXD\Cross Sections.mxd



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N

Miles
0 0.3 0.6 0.9 1.2

Muddy Creek Geomorphic Analysis

Interpreted Geomorphology

Client: Skagit County Public Works

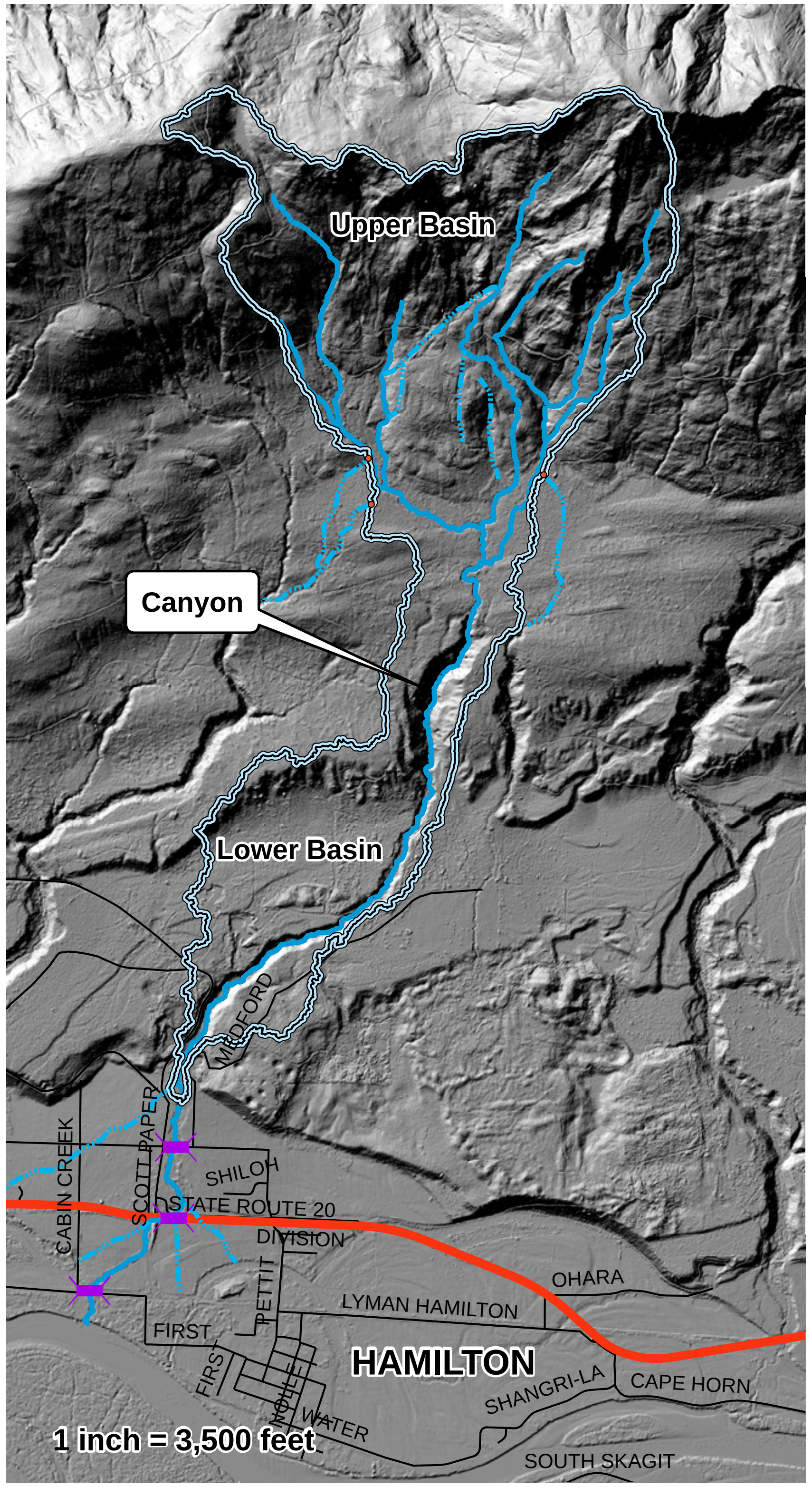
Location: Skagit County, Washington

DATE: July 13, 2011

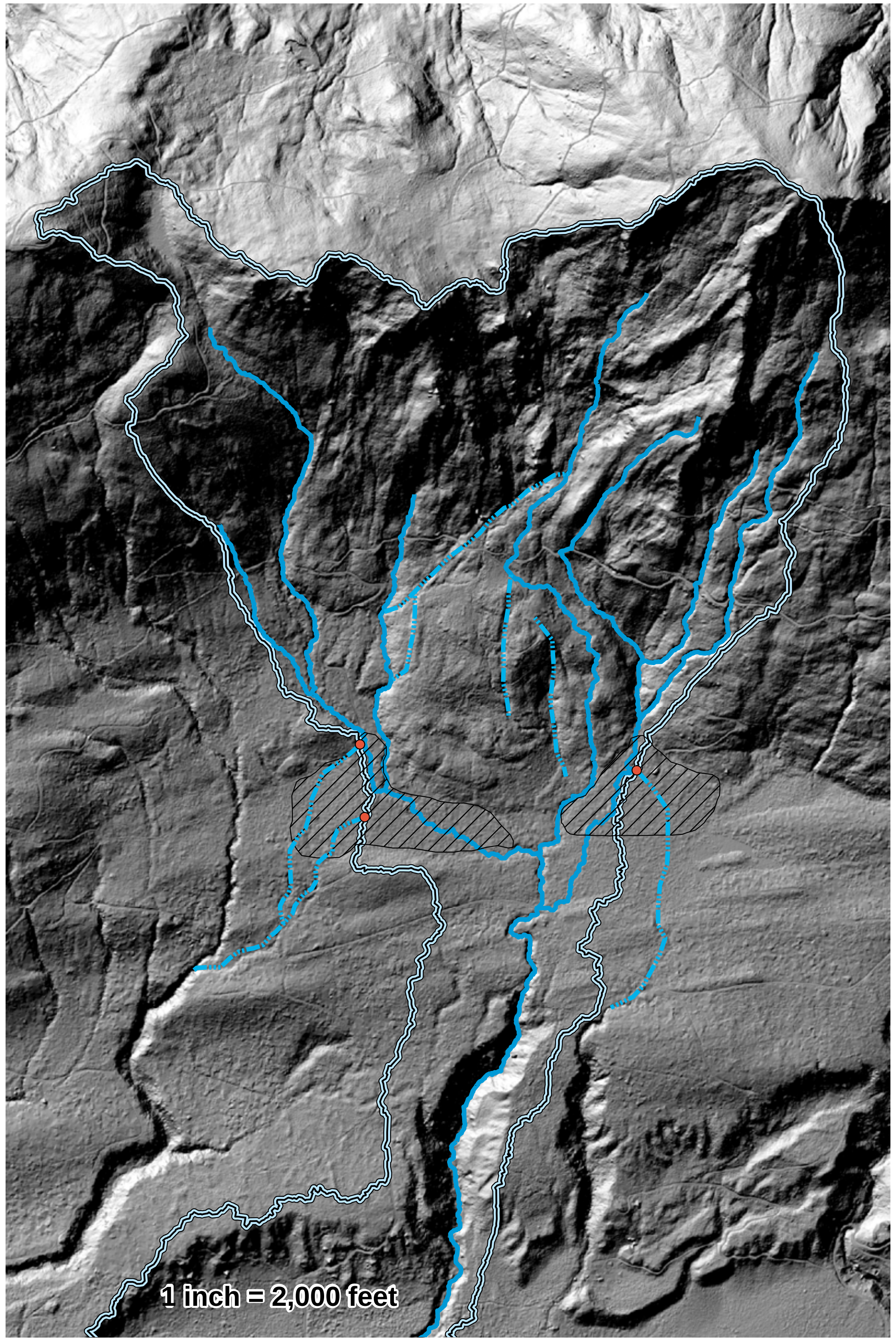
Figure 11

Project Number: 2010113

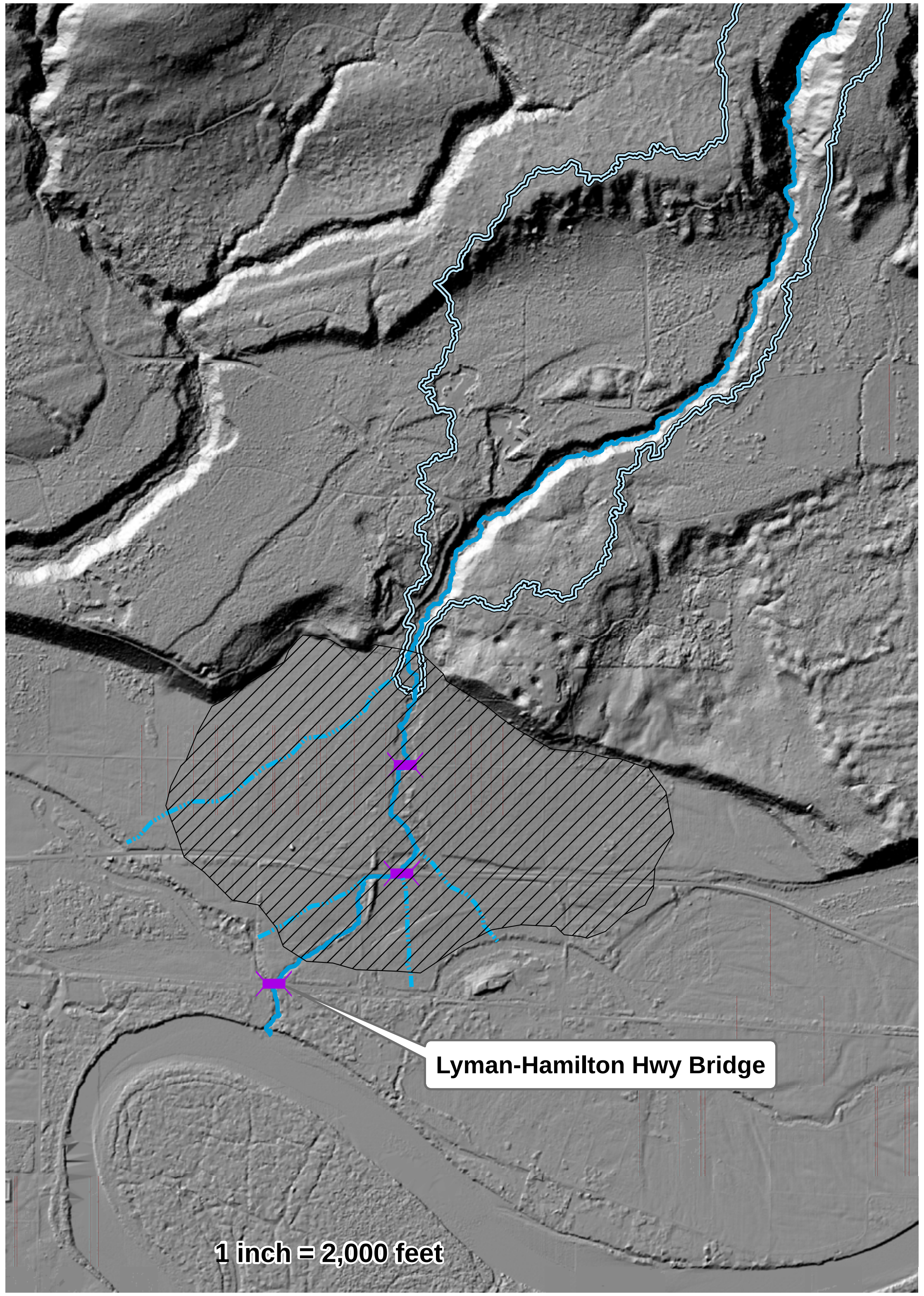
Path: I:\GIS\SkagitCounty_GIS\Muddy\MXD\geomorph.mxd



Muddy Creek Watershed



Upper Watershed



Lower Watershed

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Legend

- ⬮ Basin Exit
- ▨ alluvial_fan
- ▭ Basin Boundary
- ⋈ Lyman-Hamiltong Hwy Bridge
- -·-·- Relict Channel or Potential Avulsion Routes
- ― Muddy Creek

N

Muddy Creek Geomorphic Analysis

Hillshade Analysis

Client: Skagit County Public Works

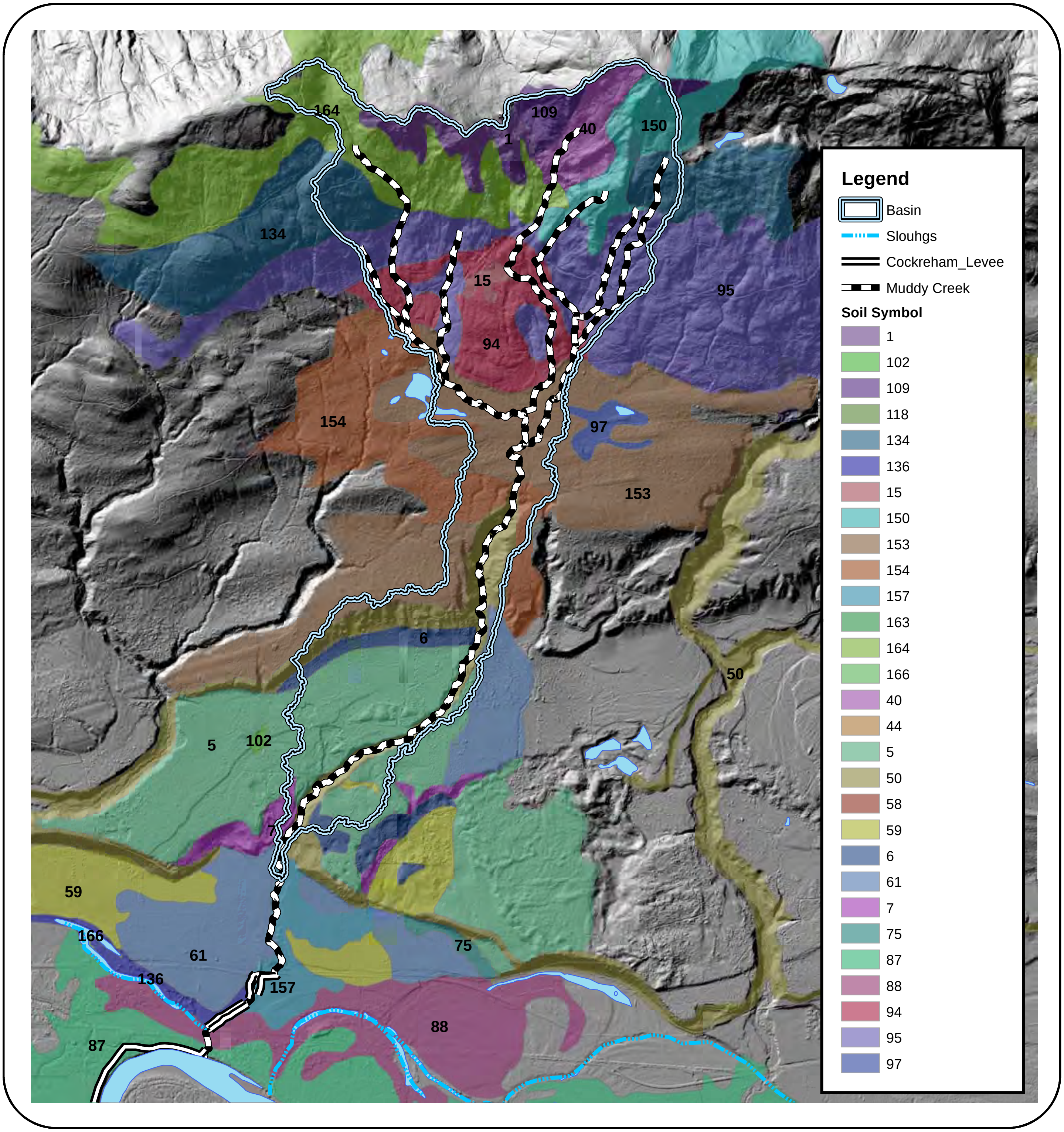
Location: Skagit County, Washington

DATE: July 13, 2011

Figure 12

Project Number: 2010113

Path: I:\GIS\SkagitCounty_GIS\Muddy\MXD\hillshade.mxd



Notes: See Figure 13b for Soil Unit
Descriptions. Soil data obtained online from

Feet
0 1,400 2,800 4,200 5,600

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Muddy Creek Geomorphic Analysis

Soils Maps

Client: Skagit County Public Works

Location: Skagit County, WA

DATE: July 13, 2011

Figure 13

Project Number: 2010113

Path: I:\GIS\SkagitCounty_GIS\Muddy\MXD\soil.mxd

Muddy Creek Basin Soil Units*

Symbol	Description
1	Andic Cryochrepts-Rock outcrop complex, 65 to 90 percent slopes
5	Barneston gravelly loam, 0 to 8 percent slopes
6	Barneston very gravelly sandy loam, 8 to 30 percent slopes
7	Barneston very gravelly sandy loam, 30 to 65 percent slopes
15	Borohemists, 0 to 3 percent slopes
40	Crinker-Rock outcrop complex, 30 to 65 percent slopes
44	Diobsud gravelly silt loam, 30 to 65 percent slopes
50	Dystric Xerorthents, 50 to 80 percent slopes
58	Getchell gravelly silt loam, 30 to 65 percent slopes
59	Giles silt loam
61	Gilligan silt loam
94	Montborne very gravelly silt loam, 3 to 30 percent slopes
95	Montborne-Rinker complex, 30 to 65 percent slopes
97	Mukilteo muck
102	Norma silt loam
109	Rock outcrop
134	Springsteen very gravelly loam, 30 to 65 percent slopes
150	Typic Cryorthods-Rock outcrop complex, 65 to 90 percent slopes
153	Vanzandt very gravelly loam, 0 to 15 percent slopes
154	Vanzandt very gravelly loam, 15 to 30 percent slopes
157	Wickersham silt loam, 0 to 8 percent slopes
163	Wollard-Springsteen complex, 3 to 30 percent slopes
164	Wollard-Springsteen complex, 30 to 65 percent slopes

*No soil description available for symbols not represented on list

Figure 8a. Muddy Creek longitudinal profile. See Figure 10

APPENDIX A

Hydraulic Permit Approval

Washington
Department of
FISH and
WILDLIFE

HYDRAULIC PROJECT APPROVAL

RCW 77.55.021 - See appeal process at end of HPA

North Puget Sound
16018 Mill Creek Boulevard
Mill Creek, WA 98012-1296
(425) 775-1311

Issue Date: September 20, 2010
Project Expiration Date: November 30, 2010
Control Number: 121577-1
FPA/Public Notice #: N/A

PERMITTEE	AUTHORIZED AGENT OR CONTRACTOR
Skagit County Public Works Department ATTENTION: Chris Kowitz 1800 Continental Place Mount Vernon, WA 98273 360-775-9531 Fax: 360-775-0950	

Project Name:	Muddy Creek Conveyance Improvement
Project Description:	Remove 50 cy of gravel and other debris from above, under and below bridge. Replant with willows and mow to eradicate weeds as much as possible. A consultant will be hired by Skagit County who will develop a draft set of alternatives and feasibility analysis available for stakeholder review by February 2011 at the latest, to determine the best possible long-term sediment management strategy for Muddy Creek, in order to avoid future dredging.

PROVISIONS

1. TIMING LIMITATIONS: The project may begin immediately and shall be completed by September 30, 2010, provided all instream work is completed by September 24, 2010.

2. If at any time, as a result of project activities, fish are observed in distress, a fish kill occurs, or water quality problems develop (including equipment leaks or spills), immediate notification shall be made to the Washington Military Department's Emergency Management Division at 1-800-258-5990, and to the Area Habitat Biologist listed below.

3. Work shall be accomplished per plans and specifications approved by the Washington Department of Fish and Wildlife entitled JARPA and dated September 18, 2010, except as modified by this Hydraulic Project Approval, and emails between Chris Kowitz and Wendy Cole. A copy of these plans and this HPA shall be available on site during construction.

DREDGING

4. No more than 50 cubic yards of material will be removed.

5. Dredging shall be accomplished in the dry.

6. Upon completion of the dredging, the streambed shall contain no pits, potholes, or large depressions to avoid stranding of fish.

7. Dredging shall be limited to deepening of the streambed. Banks shall not be disturbed.

8.Dredged streambed materials shall be disposed of at an approved upland site so it will not re-enter state waters.

9.Stockpiling of material waterward of the ordinary high water line is not approved.

10. If necessary to reposition woody material, it shall be placed or anchored to provide stable, functional fish habitat.

EQUIPMENT RELATED
11. Equipment used for this project shall be free of external petroleum-based products while working around the stream. Equipment shall be checked daily for leaks and any necessary repairs shall be completed prior to commencing work activities along the stream.

MTIGATION
12. WDFW requires mitigation for impacts to fish life. Dredging such as this project entails creates indirect impacts to fish life. Skagit Cpunty shall hire a consultant to analyze options and determine a long-term solution for sediment managment that does not involve dredging. A draft set of alternatives shall be distributed for review by February, 2011. A project application shall be submitted by May, 2011.

13. Willows shall be replanted by November 30, 2010, on both sides of the creek between Lyman Hamilton Highway and the Cascade Trail. Mowing as much as possible to eradicate weeds in the dredged reach shall be periodically conducted until a long-term solution is reached for sediment management.

PROJECT LOCATIONS

Location #1 Hamilton Wy and Muddy Creek

<table>
<tr><td colspan="4">WORK START: September 20, 2010</td><td colspan="3">WORK END: November 30, 2010</td></tr>
<tr><td colspan="2">WRIA:
03.0352</td><td colspan="3">Waterbody:
Muddy Creek (rb)</td><td colspan="2">Tributary to:
Skagit River</td></tr>
<tr><td>1/4 SEC:
NW 1/4</td><td>Section:
14</td><td>Township:
35 N</td><td>Range:
06 E</td><td>Latitude:
N 48.5259</td><td>Longitude:
W 122.0052</td><td>County:
Skagit</td></tr>
<tr><td colspan="7">Location #1 Driving Directions</td></tr>
</table>

APPLY TO ALL HYDRAULIC PROJECT APPROVALS

This Hydraulic Project Approval pertains only to those requirements of the Washington State Hydraulic Code, specifically Chapter 77.55 RCW (formerly RCW 77.20). Additional authorization from other public agencies may be necessary for this project. The person(s) to whom this Hydraulic Project Approval is issued is responsible for applying for and obtaining any additional authorization from other public agencies (local, state and/or federal) that may be necessary for this project.

This Hydraulic Project Approval shall be available on the job site at all times and all its provisions followed by the person(s) to whom this Hydraulic Project Approval is issued and operator(s) performing the work.

This Hydraulic Project Approval does not authorize trespass.

The person(s) to whom this Hydraulic Project Approval is issued and operator(s) performing the work may be held liable for any loss or damage to fish life or fish habitat that results from failure to comply with the provisions of this Hydraulic Project Approval.

Failure to comply with the provisions of this Hydraulic Project Approval could result in a civil penalty of up to one hundred dollars per day and/or a gross misdemeanor charge, possibly punishable by fine and/or imprisonment.

All Hydraulic Project Approvals issued under RCW 77.55.021 are subject to additional restrictions, conditions, or revocation if the Department of Fish and Wildlife determines that changed conditions require such action. The person(s) to whom this Hydraulic Project Approval is issued has the right to appeal those decisions. Procedures for filing appeals are listed below.

Requests for any change to an unexpired HPA must be made in writing. Requests for new HPAs must be made by submitting a new complete application. Send your requests to the department by: mail to the Washington Department of Fish and Wildlife, Habitat Program, 600 Capitol Way North, Olympia, Washington 98501-1091; e-mail to HPAapplications@dfw.wa.gov; fax to (360) 902-2946; or hand-delivery to the Natural Resources Building, 1111 Washington St SE, Habitat Program, Fifth floor.

APPEALS INFORMATION

If you wish to appeal the issuance, denial, conditioning, or modification of a Hydraulic Project Approval (HPA), you may request an informal or formal appeal.

A. INFORMAL APPEALS: WAC 220-110-340 is the rule describing how to request an informal appeal of Washington Department of Fish and Wildlife (WDFW) actions taken under Chapter 77.55 RCW. Please refer to that rule for complete informal appeal procedures. The following information summarizes that rule.

A person who is aggrieved by the issuance, denial, conditioning, or modification of an HPA may request an informal appeal of that action. You must send your request to WDFW by: mail to the Washington Department of Fish and Wildlife HPA Appeals Coordinator, 600 Capitol Way North, Olympia, Washington 98501-1091; e-mail to HPAapplications@dfw.wa.gov; fax to (360) 902-2946; or hand-delivery to the Natural Resources Building, 1111 Washington St SE, Habitat Program, Fifth floor. WDFW must receive your request within 30 days from the date you receive notice of the decision. If you agree, and you applied for the HPA, resolution of the appeal may be facilitated through an informal conference with the WDFW employee responsible for the decision and a supervisor. If a resolution is not reached through the informal conference, or you are not the person who applied for the HPA, the HPA Appeals Coordinator or designee will conduct an informal hearing and recommend a decision to the Director or designee. If you are not satisfied with the results of the informal appeal, you may file a request for a formal appeal.

B. FORMAL APPEALS: WAC 220-110-350 is the rule describing how to request a formal appeal of WDFW actions taken under Chapter 77.55 RCW. Please refer to that rule for complete formal appeal procedures. The following information summarizes that rule.

A person who is aggrieved by the issuance, denial, conditioning, or modification of an HPA may request a formal appeal of that action. You must send your request for a formal appeal to the clerk of the Pollution Control Hearings Boards and serve a copy on WDFW within 30 days from the date you receive notice of the decision. You may serve

WDFW by mail to the Washington Department of Fish and Wildlife HPA Appeals Coordinator, 600 Capitol Way North, Olympia, Washington 98501-1091; e-mail to HPAapplications@dfw.wa.gov; fax to (360) 902-2946; or hand-delivery to the Natural Resources Building, 1111 Washington St SE, Habitat Program, Fifth floor. The time period for requesting a formal appeal is suspended during consideration of a timely informal appeal. If there has been an informal appeal, you may request a formal appeal within 30 days from the date you receive the Director's or designee's written decision in response to the informal appeal.

C. FAILURE TO APPEAL WITHIN THE REQUIRED TIME PERIODS: If there is no timely request for an appeal, the WDFW action shall be final and unappealable.

ENFORCEMENT: Sergeant Lambert (41) P3

Habitat Biologist Wendy Cole	colewdc@dfw.wa.gov 360-466-4345	Wendy Cole	for Director WDFW

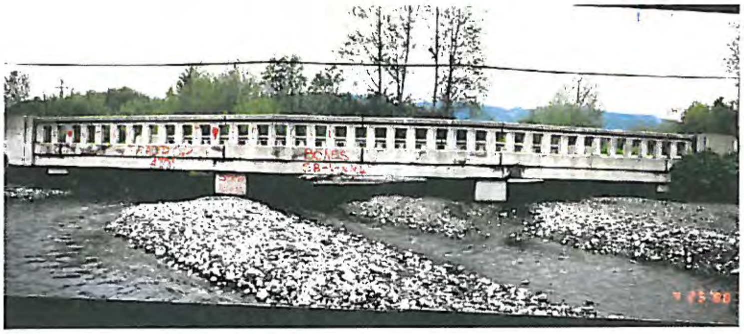
CC:

APPENDIX B

Historic Documentation of Conditions and Damages

121

APR • 72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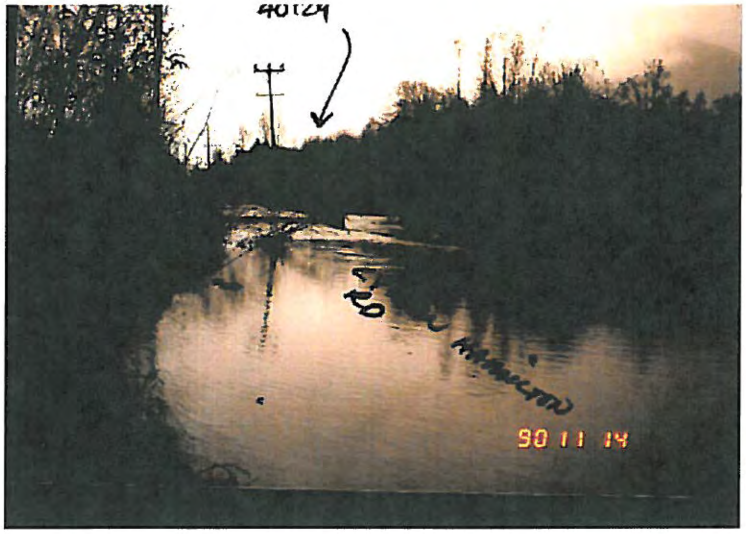
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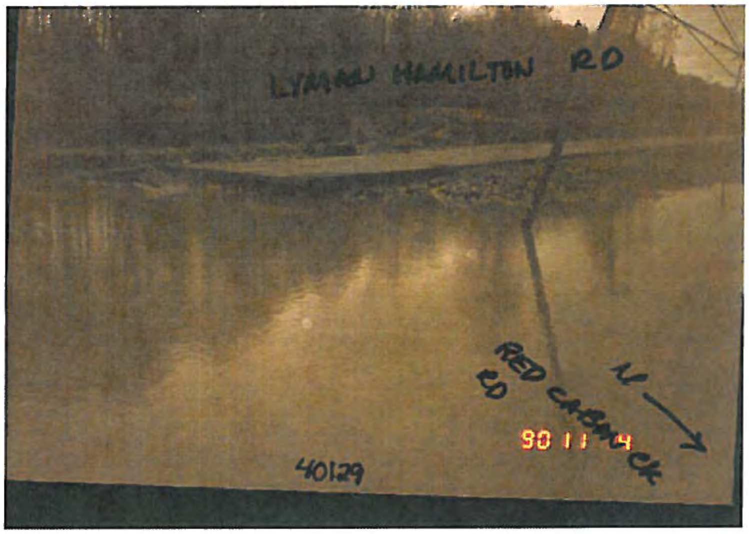
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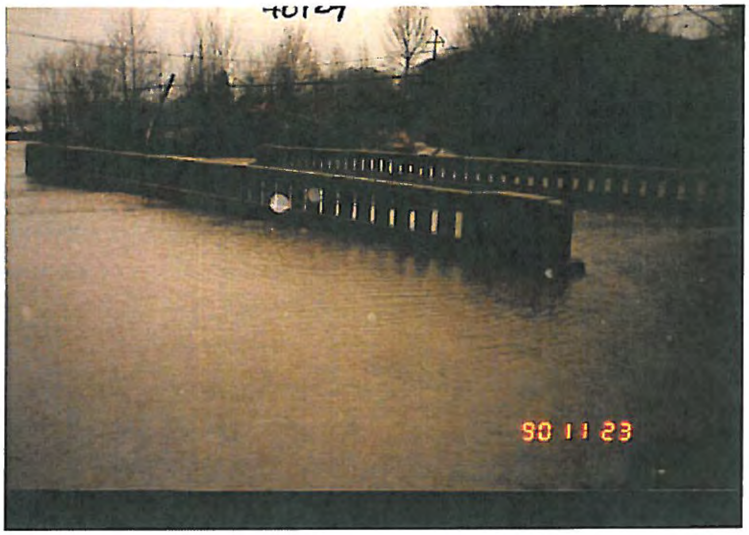
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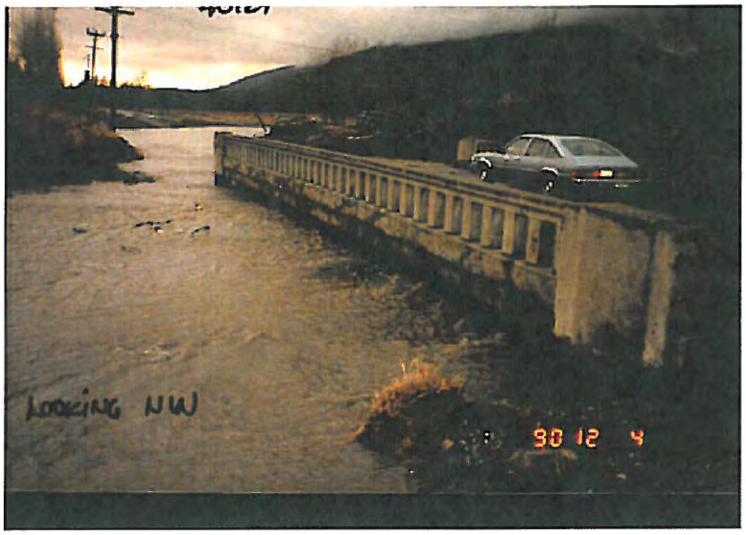
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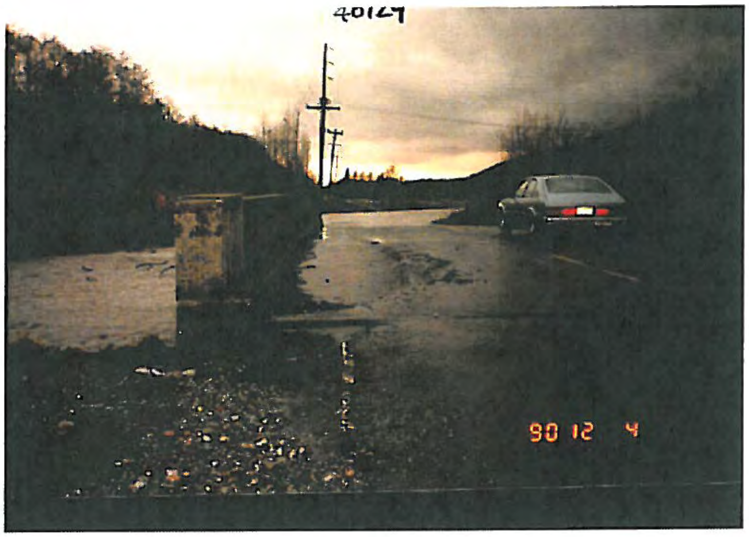
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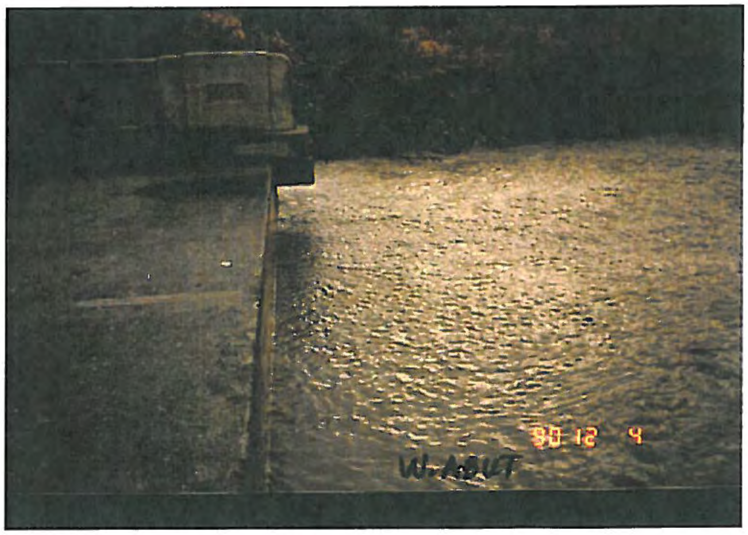
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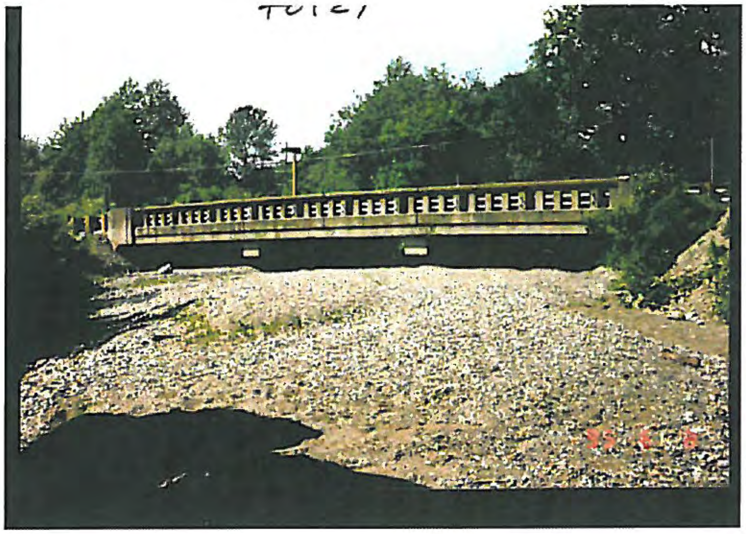

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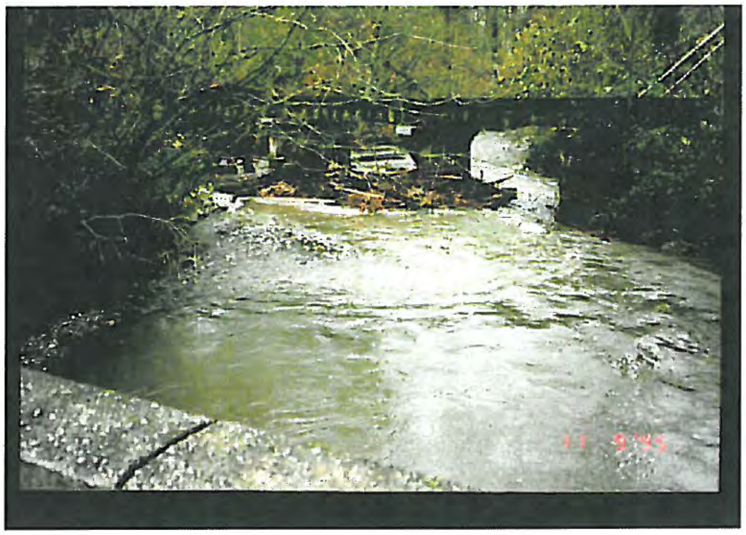
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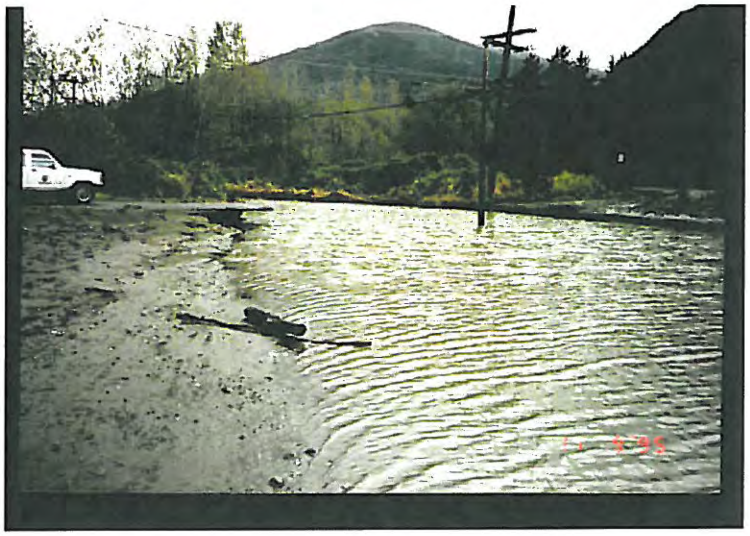
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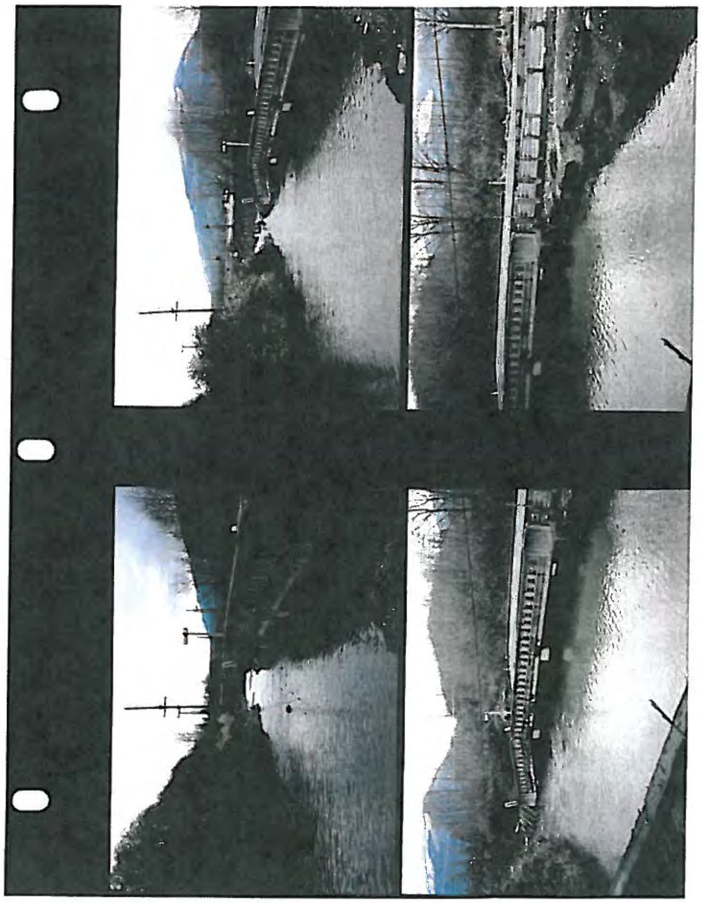
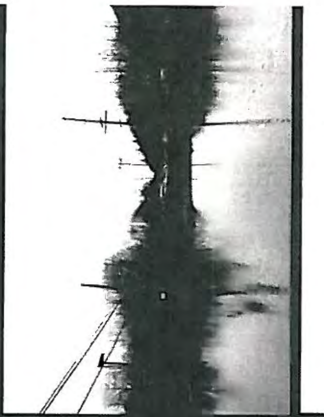
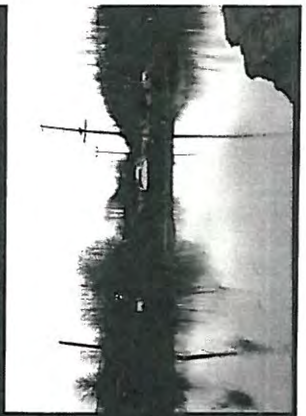
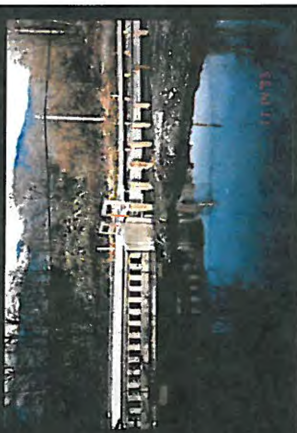
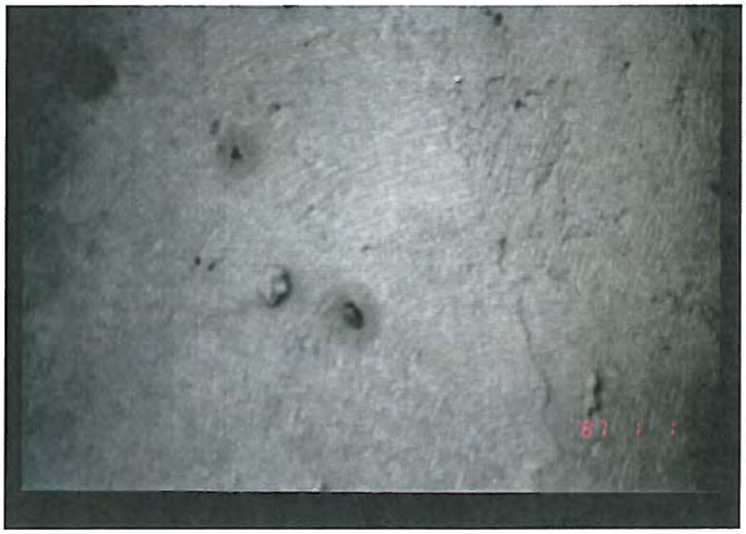
Hoh: [illegible] Sept.
approach road damaged & undermined
by the [illegible] during the flood
in November (again pics 5)

Another [illegible] undermined abutment
[illegible] soft [illegible] the deck [illegible]
[illegible] see pictures.



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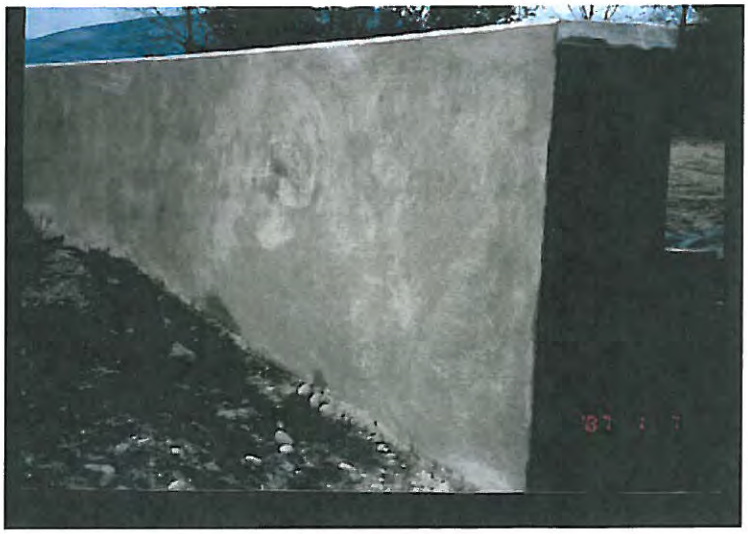
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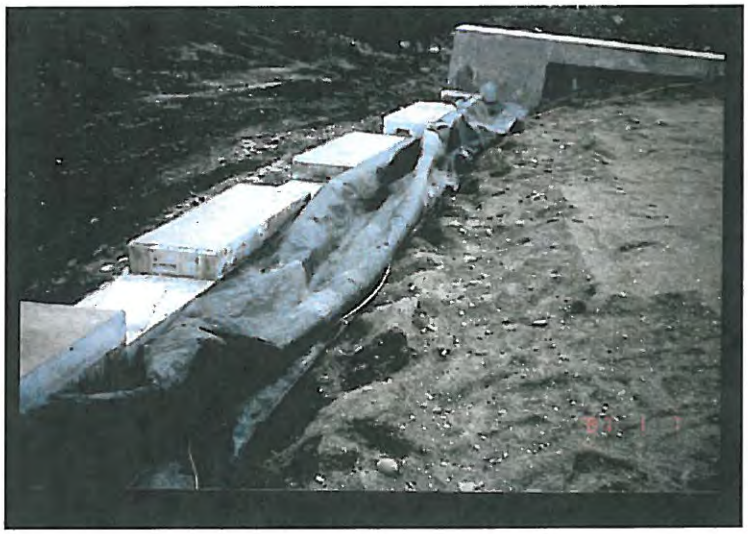

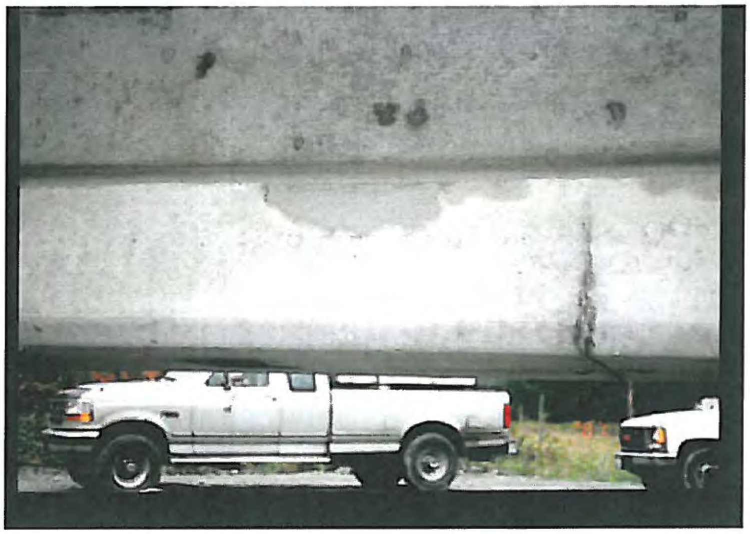


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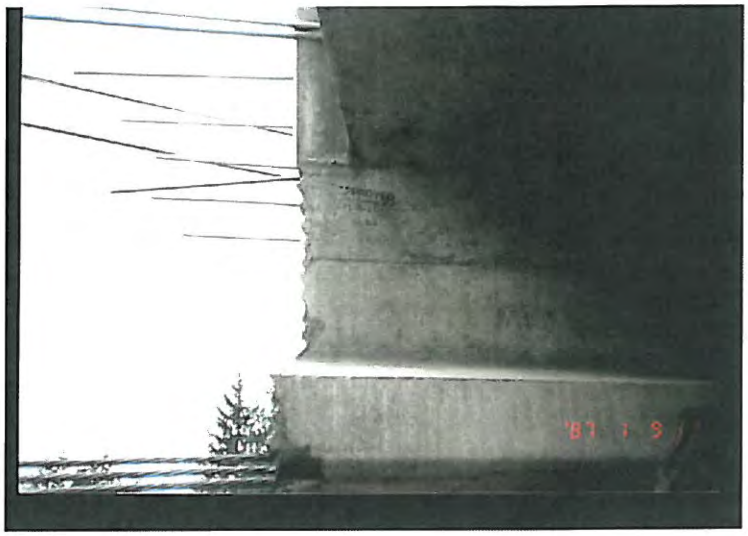
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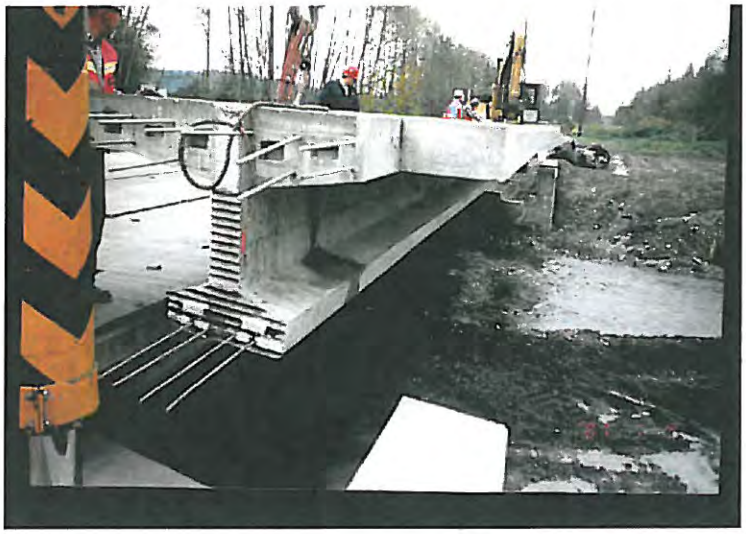

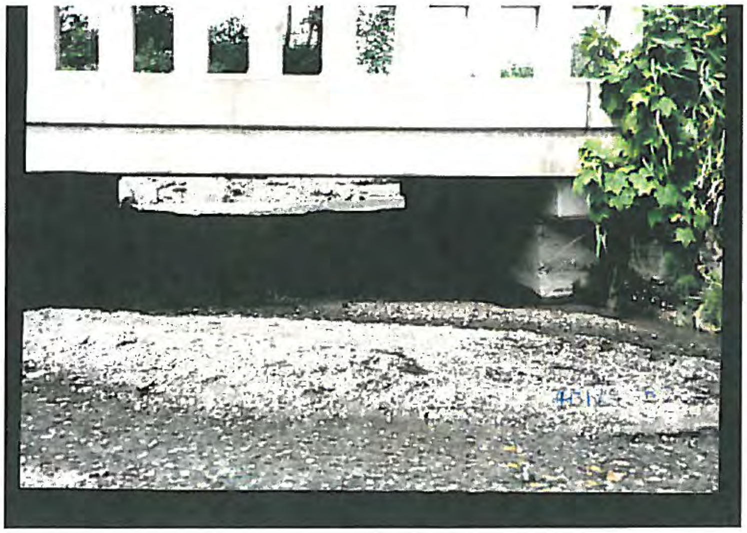


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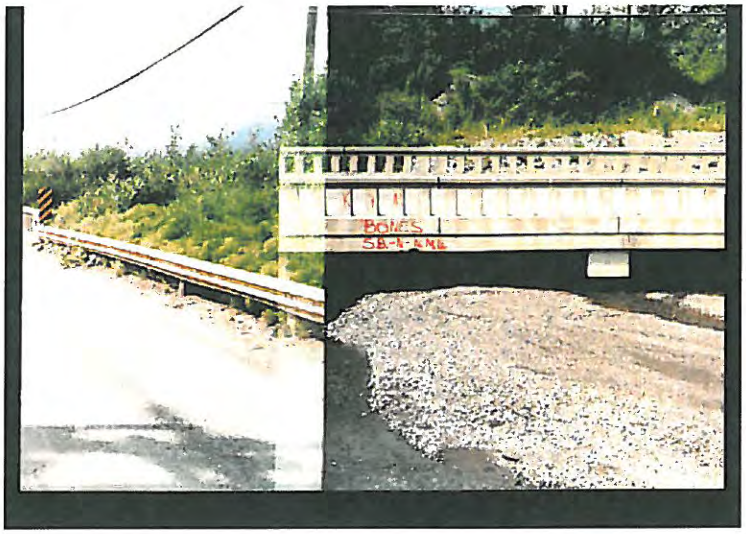
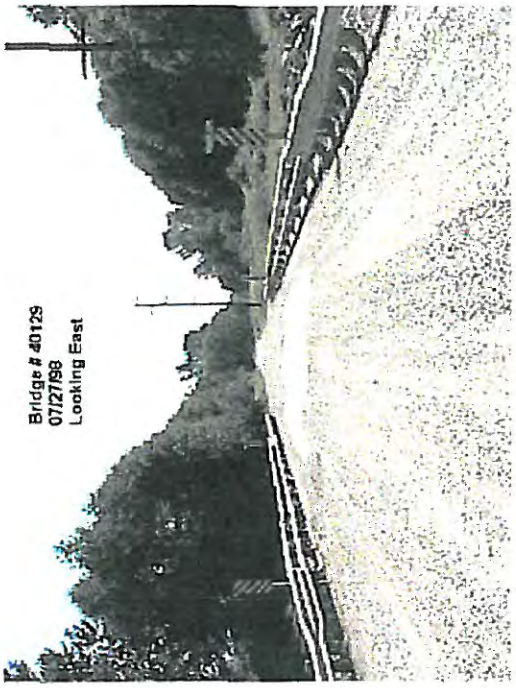

BONES

Bridge # 40129
Muddy Creek
07/27/98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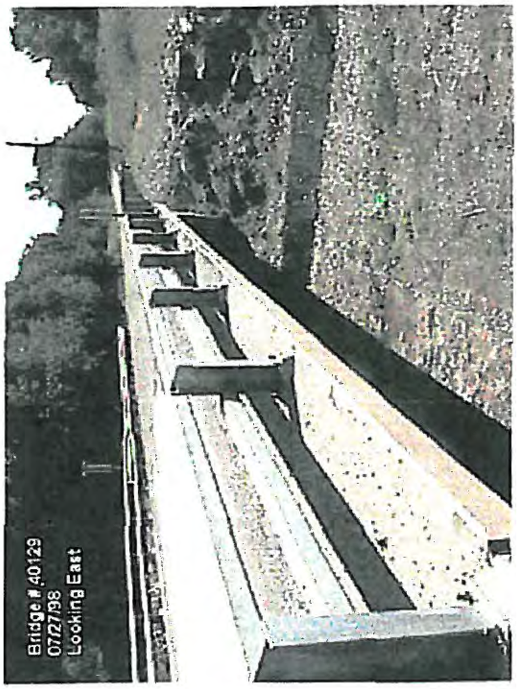
07/27/98
Looking East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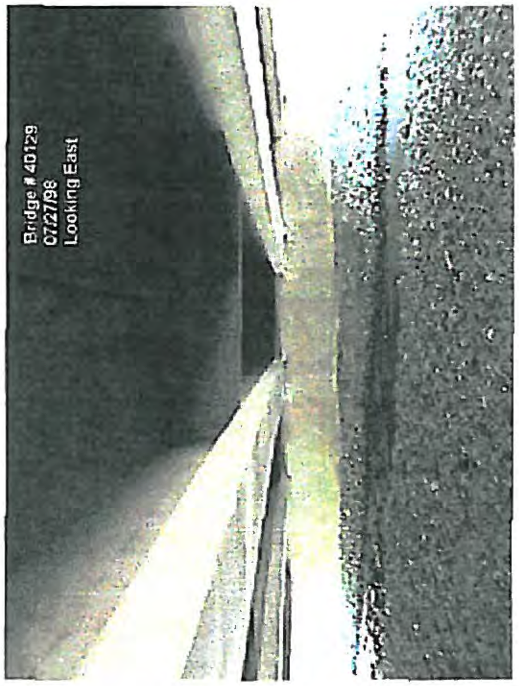
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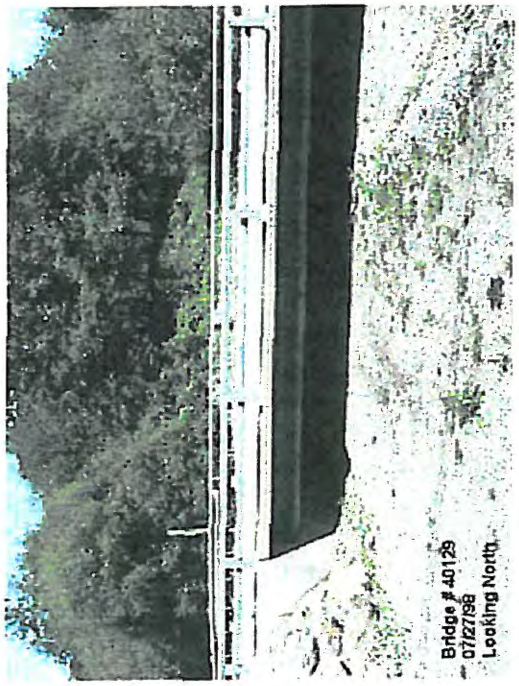
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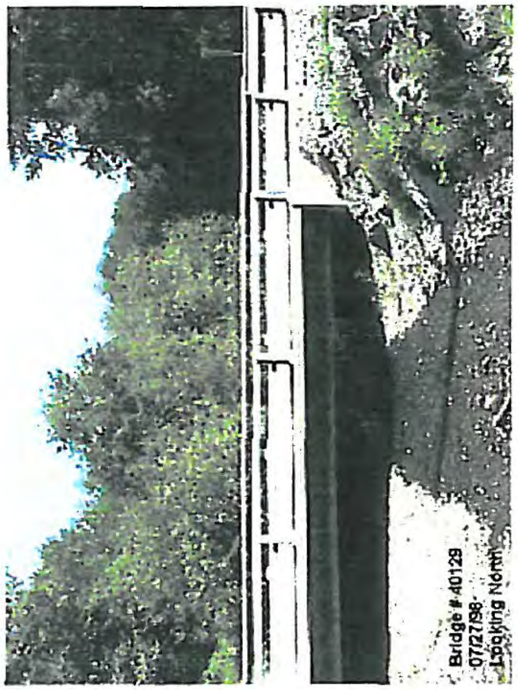

Bridge # 40129
07/27/98
Looking North




APPENDIX C
Background on Geologic Hazards - Flooding and Debris Flow Risks

Many natural hazards exist within the Muddy Creek study area. These hazards include, but are not limited to:

- landslide hazards (including debris flows);
- flooding hazards;
- volcanic hazards (including lahars) from Mount Baker and Glacier Peak; and
- seismic hazards.

The purpose of the Muddy Creek Alternatives Feasibility Study was not to assess the natural hazards (the source of danger) or the risks (the probability of occurrence and the consequences) for proposed or existing private developments within the study area. However, it should be noted that many of these hazards could impact the infrastructure and community located on the alluvial fans and floodplain of the Skagit Valley, and that in some cases the combined high recurrence interval and potential consequences of some hazards create potentially high risk.

In particular, we learned through field observations that debris flows from the upper watershed occur with fairly high frequency and we saw evidence of debris flows occurring within the watershed, especially in the upper watershed. Some of these debris flows have the potential to reach the inhabited portions of the alluvial fan. Large debris flows have the potential to carry significant debris (rocks, logs, sediment) long distances with velocities that can damage or destroy infrastructure and property (homes, cars). Debris impact and burial can create potentially lethal conditions to those caught in the path of a debris flow.

Typically, discharges from debris flows are significantly larger than clear-water or even rain-on-snow flood flows. Debris flows include not only water but also a large portion of sediment adding to the volume and therefore discharge. The empirical equation:

$$Q_P = (V_{max}/50)^{0.87} \quad \text{[where } Q_P \text{ is the peak discharge (m}^3\text{/s) and V is the total debris flow volume (m}^3\text{)]}$$

was derived for bouldery to muddy debris flows in southwestern British Columbia (Jakob, 1996). Applying this equation to a small Muddy Creek debris flow delivering a sediment volume of 3000 yd^3 (2200 m^3) in a single event would result in a debris flow peak discharge of 1000 cfs (30 m^3/s). This figure is 3 times higher than the estimated 100-year return period flood flow of 350 cfs. Debris flow volumes much larger than this are possible.

A detailed debris flow analysis was completed on the Jones Creek alluvial fan near the town of Acme in Whatcom County, northwest of Muddy Creek. The basin geology, elevation and size is comparable to that of Muddy Creek and the geology is similar. A debris flow in 1983 delivered 33,000 cubic yards of sediment and resulted in a peak discharge of 7,800 cfs where the 100-year return period clear water flood is calculated to be 310 cfs. Analysis of the alluvial fan stratigraphy revealed that much larger debris flows had occurred frequently throughout the past 7,000 years and indicated that the 1983 event was approximately a 50 to 100 year return interval event. Therefore, debris flows, while infrequent, create substantially higher peak discharges and can deliver large quantities of sediment.

Frequency of debris flows and magnitude is controlled by watershed characteristics and hydroclimatic conditions. Watersheds with abundant amounts of stored sediment and debris are more responsive to hydroclimatic events, especially high intensity rainfall, long periods of antecedent moisture, and rain-on-snow, and these watersheds can respond with a wide range of debris flow magnitudes.   These basins do not need the recharge period between large events because a single, massive event is not capable of removing all of the stored sediment, therefore the frequency of large events can be higher. Muddy Creek has a virtually limitless amount of sediment stored in its upper watershed which is unstable. Previous regionally proximate studies by Orme (1989, 1990), deLaChapelle (2000), and Jakob et al (2004) have measured return periods in the Late Holocene. Generally, those analyses found that very large, regionally significant debris flows had a recurrence interval of approximately 500 years and that major events had a recurrence interval of approximately 50 years.

Development on alluvial fans is particularly susceptible to debris flow hazards and loss of life and property damage from debris flows occurs frequently in a global scale. In Japan, an estimated 90 people per year die from debris flow events (VanDine, 1985), and several catastrophic events in South America have killed several tens of thousands of people (1985 Armero, Columbia, about 21,000 deaths; 1999 Vargas Venezuela, about 30,000 deaths).

Under state legislation enacted in 1990, alluvial fans fall under the critical areas classification of the Washington State Growth Management Act (GMA) as geologically hazardous areas [WAC 365-190-080(4)(d)(viii)]. Alluvial fan development is regulated by ordinance (Chapter 14.24) in Skagit County.

APPENDIX D

Vasak Biodynamics Habitat Assessment And Historic Fish Habitat Assessment Data

Habitat Assessment of Muddy Creek
Skagit County, Washington

May 2011

Prepared for Element Solutions by Vasak Biodynamics LLC

Ryan Vasak M.Sc.
Michael LeMoine M.Sc.

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Habitat Assessment

Muddy Creek, a small perenial stream in western Skagit County, Washington, is a tributary to the Skagit River. The stream flows through mixed land uses, including forested lands, rresidential, and forest products extraction. Sediment aggrades within the stream channel under the Hamilton-Lyman Hwy Bridge and threatens to impact the use of the bridge in the future. To inform future sediment management and possible restoration efforts along Muddy Creek, we performed a stream habitat and large woody debris assessment of a section of Coal Creek using the Timber-Fish-Wildlife (TFW) monitoring protocol (Pleus et al. 1999; Schuett-Hames et al. 1999) and Environmental Monitoring and Assessment Program (EMAP) Rapid Visual Assessment mehtods (Lazorchak et al. 1998).

On May 9th, 10th, and 11th, 2011, we conducted habitat assessments in two phases: 1) intensive habitat assessment, including: an upstream identification and measurements of all habitat unitis and downstream survey of large woody debris (LWD), spawning habitat, and stream slope, and 2) rapid visual assessment describing general characteristics of entire reaches. To better describe the habitat conditions within Muddy Creek, we identified habitat units starting at the mouth of Muddy Creek where it meets the Skagit River. Working upstream, we measured several instream characteristics for each habitat unit including: type, length, width, pool depths, bank vegetation, canopy cover, and sediment type. Every twenty habtat units we identified transects for channel cross sections where we recorded: bankfull width and depth, wetted width and depth, Wolman Pebble Counts, and latitude/longitude. The results of the survey are separated according to reaches delinated at the upper and lower margins by each transect.

We intensively surveyed approximatly 5480 ft of Muddy Creek, from the mouth of Muddy Creek to 584 feet above the property line of the most upstream residence (Figure 1). Along the entire distance, we omited only a short reach due to electrified fencing over the creek. The instream conditions above and below the reach not surveyed were similarly chanelized with cattle observed in the creek and major habitat changes within the unknown reach were unlikely. We conducted EMAP rapid visual assessments and documented major sediment sources across all reaches intensively surveyed and across an additional two reaches within the forest lands (Figure 2).

Data Summary

Over the length of our survey, we identified diverse instream and riparian conditions in Muddy Creek. Instream and riparian condition of Muddy Creek relates closely to land use. Industrial and residential areas tended to have degraded instream habitat and reduced riparian zones. The forest lands had good instream habitat and intact and mature riparian zones. The forest lands supported fish, which were consistently observed.

Canopy and riparian vegetation varied along the stream. Forest lands had largely intact and healthy riparian corridors with large decidous and coniferous trees and well developed understory. Riparian condition declined through residential areas and at the Janicki Industries property. Instream habitat in the forest lands were optimal for fish and aquatic life, even considering the high sediment load potential of Muddy Creek. The developed reaches, including residential areas and the Janicki Industries property have suitable gravels for spawning. However, the homogenous habitat and lack of complexity within these areas would limit rearing of juvenile salmonids. The forest lands have less spawning gravels than the lower reaches, but provide excellent rearing for salmon and trout. Active sediment recruitment to Muddy Creek was evident at many locations on the forest lands and along some parts of the channelized/straightened reaches through the Janicki Industry property.

Instream Conditions

Instream substrate below the Hamilton-Lyman highway, along Reach-A, is primarily composed of gravels and small cobbles with a high percent of embededness. Some wood recruitment is occuring in this reach and Muddy Creek follows an unconstrained sinous path. Above the Hamilton-Lyman Highway to Washington State Highway 20, Muddy Creek flows through the Janicki Industries property where larger gravels and cobbles were observed and probably associated with the increases in stream slope through the property. Muddy creek is straightened and channelized through the Janicki Industries property, resulting in low habitat diversity (Picture 2). Based on visual assessment, instream flows appeared less compared to reaches on forest lands, suggesting surface water loss to groundwater.

Upstream of Washington State Highway 20 to forest lands along Reaches G-K, the stream was imtermitently channelized and composed mostly of riffle habitats. Limited pools and former channel alterations were not as prevelant as in the reachs through the Janicki property. However, the habitat diversity is still depressed through these areas. Sediment size is similar to downstream reaches but less fines were observed. Some young of the year salmon and/or trout were observed in these reaches, compared to zero fish observed below Washington State Highway 20.

On forest lands that we surveyed, the sediment size, number of pieces of LWD, and the number of habitat units per meter increased throughout reaches G - K. The instream habitats included diverse habitat sub-units including riffles, pools, cascades and plunge pools. Although the sediment size increased and included boulders and bedrock, the sediment was still influenced by fines and was 10% - 40% embedded in these reaches. The bankfull channel was often wider than the current stream channel and contained piles of available gravels and cobbles. Young of the year salmon and/or trout were observed in every pool and along the sides of riffles.

Sediment Sources

We identified many notable sediment sources on the forest lands that are actively contributing semdiment (Figure 2). Most of the sediment sources observed have no evidence to be anthropogenically caused. Slope incision is the most common source of sediment where Muddy Creek is cutting at the base of the hill slope (Picture 7). One major landslide was observed contributing significant amounts of sediment to Muddy Creek (Picture 9). Large benches of sand, gravel, and cobble many feet above the bankful depth were observed (Picture 6). These large benches were probably formed by historic sediment flows down the valley and are allowing for areas of sediment recruitment over a large expanse of Muddy creek.

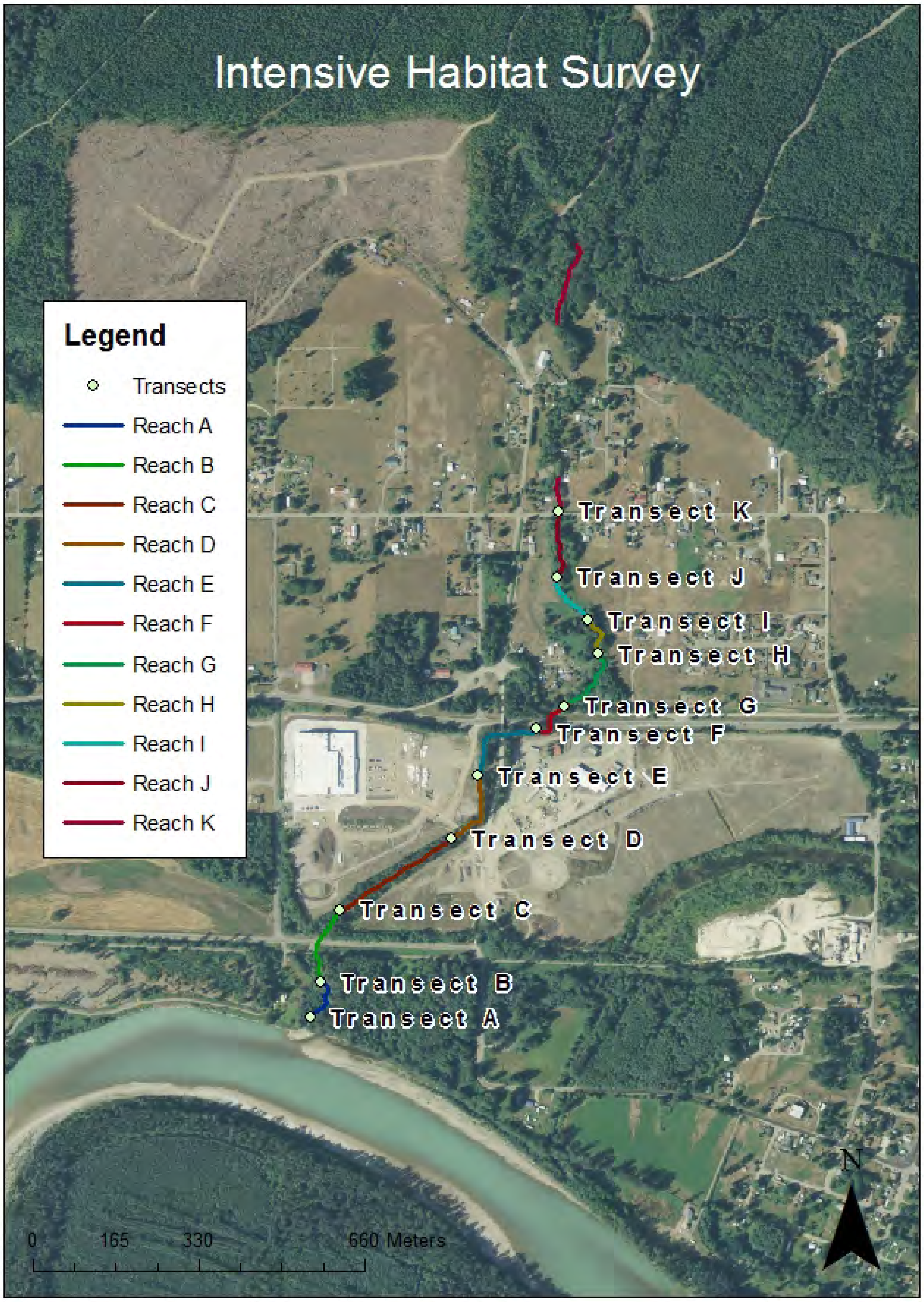


Figure 1. Transect and reach locations for the intensive habitat survey.

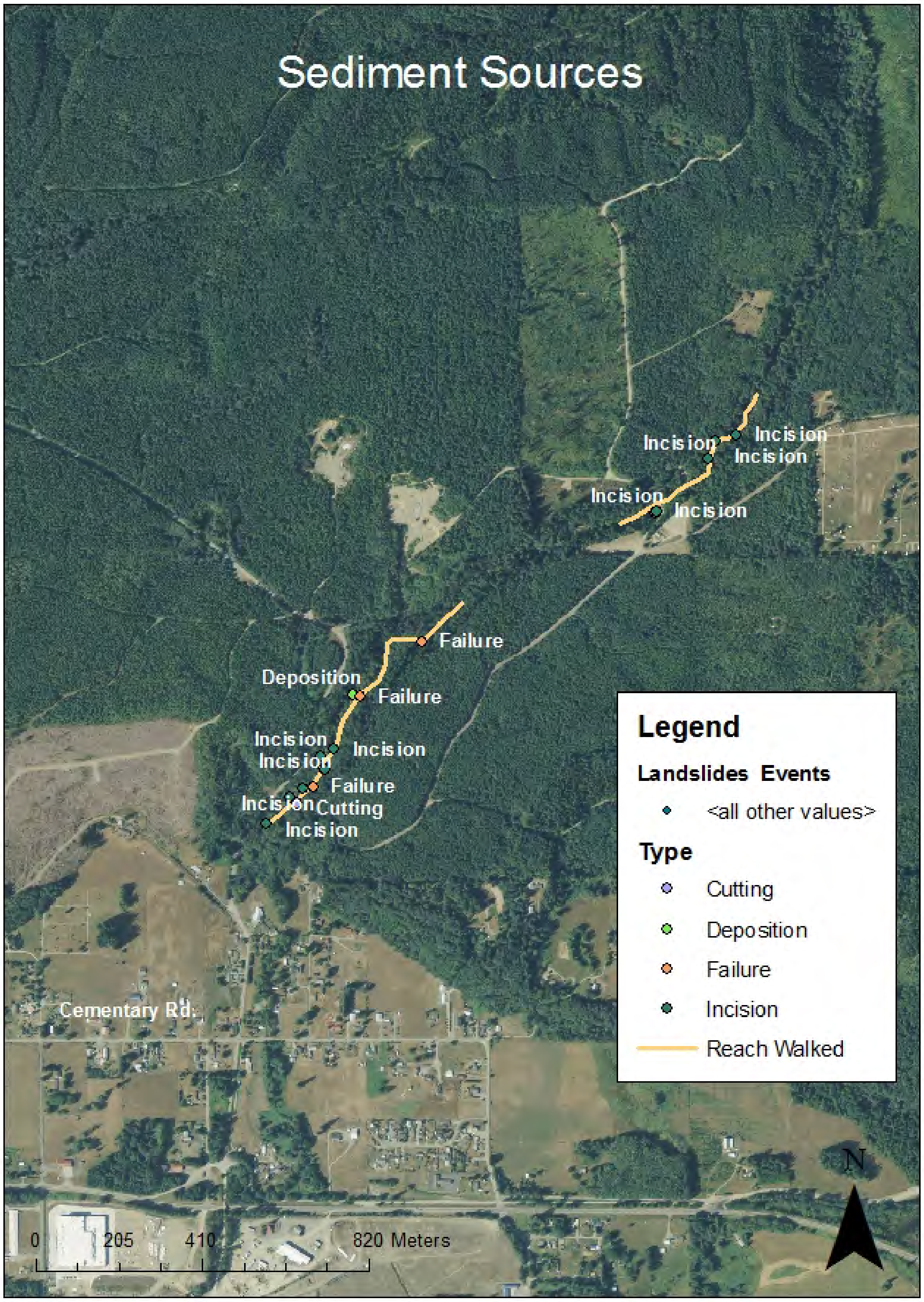

Sediment Sources
Incision
Incision
Incision
Incision
Incision
Failure
Deposition
Failure
Incision
Incision
Incision
Failure
Incision
Cutting
Incision
Cementary Rd.
Legend
Landslides Events
<all other values>
Type
Cutting
Deposition
Failure
Incision
Reach Walked
0
205
410
820 Meters
N

Figure 2. Sediment sources and addition stream walked.

Pictures

Picture 1. Muddy Creek near mouth to Skagit River in western Skagit County, Washington.

Picture 2. Muddy Creek through Janicki Industries property.

Picture 3. Small restoration project on the Janicki Industries property.

Picture 4. Muddy Creek on Janicki Industries property, WA State Hwy 20 on right.

Picture 5. Large eroded bank on righ-bank near end of intensive habitat survey (Reach K). Active erosion and sediment recruitment including several recently fallen trees with green leaves. Bank is approximately 30 feet high and 100 feet long, with undercutting of alder trees at the top of the bank.

Picture 6. Large sediment berm from historic deposition and now eroding.

Picture 7. Incised bank on the left-bank of channel and the creek actively recruiting sediment.

Picture 8. Another historic gravel bench being incised by Muddy Creek.

Picture 9. Hillslope failure into the creek.

Picture 10. Gravel bench that recruits sediment at bankful discharge.

Picture 12. High embeddeness from a hill slope failure, just upstream.

Picture 13. Currently failing slope with indication of historic failure.

Picture 14. Active erosion that is possilby human caused, near horse campe bridge.

Picture 15. Large, 75 meter high, incision on right-bank just below horse camp bridge.

References

Lazorchak, J.M., Klemm, D.J. , and D.V. Peck (editors). 1998. Environmental Monitoring and Assessment Program -Surface Waters: Field Operations and Methods for Measuring the Ecological Condition of Wadeable Streams. EPA/620/R94/004F. U.S. Environmental Protection Agency, Washington, D.C.

Pleues, A.E., D. Schuett-Hames, and L. Bullchild. 1999. TFW monitoring protocol method manual for the habitat unit survey. Prepared for the Washington State Department of Natural Rersources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-99-003. DNR # 105. June.

Schuett- Hames, D., A.E. Pleus, J. Ward, M. Fox, and J. Light. 1999. TFW monitoring protocol method manual for the large woody debris survey. Prepared for the Washington State Department of Natural Rersources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-99-004. DNR # 106. June.

Sub-basin	Stream name	Section #	Low River mile	High River mile	Low River Km	High River km	Section landmarks	additional Comments
Middle-Skagit	Muddy Cr.	03.0352	0.0	0.9	0.0	1.44	mouth to Ham.Cem.Rd	

SECTION NUMBER	SURVEY DATE	SPECIES	LIVE	TOTAL DEAD	UNSAMPLED DEAD	PRE-CUT DEAD	SPECIES NUMBER	TOTAL VISIBLE REDDS	REDDS FLAGGED ON SURVEY	JAW TAGS FOUND ON SURVEY	JAW TAG SAMPLE SIZE	NUMBER OF AD CLIPS	AD CLIP CARCASS SAMPLE SIZE	BAG LABEL NUMBER	TYPE COUNT	TYPE SURVEY	OTHER SPECIES	COMMENTS	NOTE
03.0352	1/13/88	Coho	NA	NA	NA	NA	4	NA	NA	2	33	0	33	–	supp	foot	–	21	

MIDDLE SKAGIT

Muddy Cr. 0352

SPOT
Supp

1. mouth to Hwy 20
2. 0.0 – 0.6 (WDF green card)
3. 0.0 - 0.95Km (RM index)

Jones & Red Cabin as Index

DATE	SPECIES	LIVE	DEAD	TOTAL	TOTAL REDDS	NEW REDDS	EXPLANATION
86-01-03	Coho	1	0	1	1	—	2.25 x 1 = 2 est redds
	Chum	1	0	0	–	–	chum observed at mouth of creek

MIDDLE-SKAGIT

Muddy Cr. #0352.2 (352.1) (SPOT OF 352.1)

1. Hwy 20 to Unnamed No# RB trib
2. 0.6 - 1.5 (WDF green card)
3. 0.95 - 2.40 Km (RM index)

Jones & Redcabin as Indexes

DATE	SPECIES	LIVE	DEAD	TOTAL	TOTAL REDDS	NEW REDDS	EXPLANATION
86-01-03	Coho	0	0	0	5	—	2.25 x 5 = 11 est redds

SUB - BASIN	STREAM NAME	SECTION#	Low River Mile	High River Mile	Low River KM	High River KM	SECTION LANDMARKS	ADDITIONAL COMMENTS
MID-SKAGIT	MUDDY CRK	03.0352.1	0.0	2.1	0.0	3.43	MOUTH TO LOGGING RD	BRIDGE

12/29/89 - DEAD COHO FOUND IN LOWER SECTION NEAR LOG YARD BELOW HWY 20

REDDS - 12 FRESH REDDS SEEN IN THE LOWER SECTION BELOW HWY. 20

4 OLDER REDDS SEEN IN THE UPPER SECTION FROM HWY 20 TO SCOTT PAPER RD.

1/5/90 - NO FISH SEEN, THE SECTION WHERE THE FISH & REDDS HAD BEEN SEEN AT (IE. ALONG THE LOG YARD SECTION) WAS COVERED WITH A FILM OF GAS/OIL SO VISIBILITY WAS MINIMAL.

Section Number	Survey Date	Species	Live	Total Dead	Unsampled Dead	Pre-cut Dead	Species Number	Total Visible Redds	Redds Flagged on Survey	Type Count	Type Survey	Other Species	COMMENTS	NOTES
03.0352.1	12/29/89	COHO	1	9	0	0	4	16		SUPP	FOOT		20	
	1/5/90		0	0	0	0	4	0					24	
	1/18/90		0	0	0	0	4	0					21	
	1/22/90													

SDATE = 90/01/22

sm

SUB - BASIN	STREAM NAME	SECTION#	Low River Mile	High River Mile	Low River KM	High River KM	SECTION LANDMARKS	ADDITIONAL COMMENTS
MIDDLE-SKAGIT	MUDDY CRK	03 0352.1	0.0	2.1	0.0	3.43	MOUTH TO LOGGING RD	

AREA SURVEYED IS MOUTH TO RB TRIB
LRM 0.0 TO HRM 1.5
LRKm 0.0 to HRKm 2.4

Section Number	Survey Date	Species	Live	Total Dead	Unsampled Dead	Pre-cut Dead	Species Number	Total Visible Redds	Redds Flagged on Survey	Type Count	Type Survey	Other Species	COMMENTS	NOTES
03 0352.1	86-01-03	COHO	1	0	0	0	4	6	—	SPOT	FOOT	2	—	
↓	↓	CHUM	1	0	0	0	2	—	—			4		

		River Mile		River KM		
Stream name	section#	Low	High	Low	High	Section Landmarks/Low to high
Muddy Creek	03.0352.1	0.0	2.1	0.0	3.43	mouth to Logging Road

comments:

Date	Species	live	Total DEAD	unsampled DEAD	Pre-cut Dead	Total Redds	New Redds	Jaw tag sample	Ad Clip sample	Bag Label#	Survey Comments
87-01-28	COHO	2	6	-	-	-	-	0/6	0/0		

SITE INFORMATION

Site Identifier : MU1RB1
Site Name :
WRIA : 03.0352X
Region : NS
Trib to : Muddy Cr
River Mile : 1.60
River System : Muddy Cr
Legal Description : NE1/4S11T35NR6E
County : Skagit
Habitat Type :

Landowner Type : Private
Landowner Name :
Address :
Address2 :
City :
State :
Zipcode :
Phone :

Directions :

From Sedro Woolley, head east on highway 20 for approximately 9.8 miles to Red Cabin road. Turn left and go 0.1 miles to the Hamilton Cemetary road. Turn right and go 0.1 miles to Crown mainline on the left. Drive approximately 100 yards to the attended gate where they ususally wave you through. From the gate go approximately 0.4 miles to a sharp curve to the left and a spur road on the right. Take spur road for 0.1 miles to a gate. Park here, hike down slope to Muddy Cr and the site.

Area Overview :

This is a short, wall-based trib that probably dries up during summer months, has no spawning habitat and offers a small amount of good over-winter rearing habitat.

Field Survey Information

Date : 02/03/1997 **Observer :** Olis **Survey Type :** initial

HABITAT INFORMATION

Water Source: ( ) Spring (X) Groundwater (X) Surface runoff

Flow: (X) Intermitent ( ) Year-round

Estimated Flows (cfs): Lower end: 0.2
Upper end: none

Water Temperature(C): Lower end: 8.8
Upper end: 8.8

Receiving Water Temperature (C): 5.5

Other Observations:

Site Area Measurements: ( )Indirect (X) Direct ( ) Combination
Widths: Channel: 1.5m Ponds: Wetlands:
Depths: Channel: 15cm Ponds: Wetlands:
Total length (includes ponds and wetlands): 82m

Total existing habitat area (est. m2): 116

Spawning area:	Mainstem:	Tribs:	Total:
Impounded area:	Mainstem:	Tribs:	Total:
Other rearing area:	Mainstem: 116	Tribs:	Total:

Unaccessible habitat: Mainstem: Tribs: Total:

Spawning habitat conditions: (X) None ( ) Poor ( ) Fair ( ) Good ( ) Exellent

Describe spawning habitat:

Rearing habitat conditions: ( ) None ( ) Poor ( ) Fair (X) Good ( ) Exellent

Describe pond and other rearing habitat: This site has slow-moving and pool habitat; substrate is silty with occasional p-gravel; good cover from berry brush and woody debris; and stream depth averages 5".

Describe unaccessible habitat:

Wetland type: ( ) Bog ( ) Marsh ( ) Scrub-shrub ( ) Forested

Describe:

Flooding potential: ( ) Low (X) Medium ( ) High

Describe: During a major flood event, water may flow over the bank and into the head end of this site. However, there is no evidence that this occured within the last year.

FISH INFORMATION

Site entry condition: ( ) Poor (X) Fair ( ) Good

Describe: There is a pool area at entry, but a fish has to negotiate a 5m glide/riff section at the mouth of this site to access.

Coho access and use: Juvenile (X) Unknown ( ) None ( ) Poor ( ) Fair ( ) Good
Adult ( ) Unknown (X) None ( ) Poor ( ) Fair ( ) Good

Describe: Because of the shallowness of the site and lack of spawning gravel, there is no adult access or use. Juvenile coho can access the site and probably do use it.

Other species acces and use: ( ) Chum ( ) Pink ( ) Sockeye ( ) Chinook (X) Trout

Describe: There were several juvenile trout observed using the pool area at the head end of the site.

ENHANCEMENT OPPORTUNITIES: None

Project type:

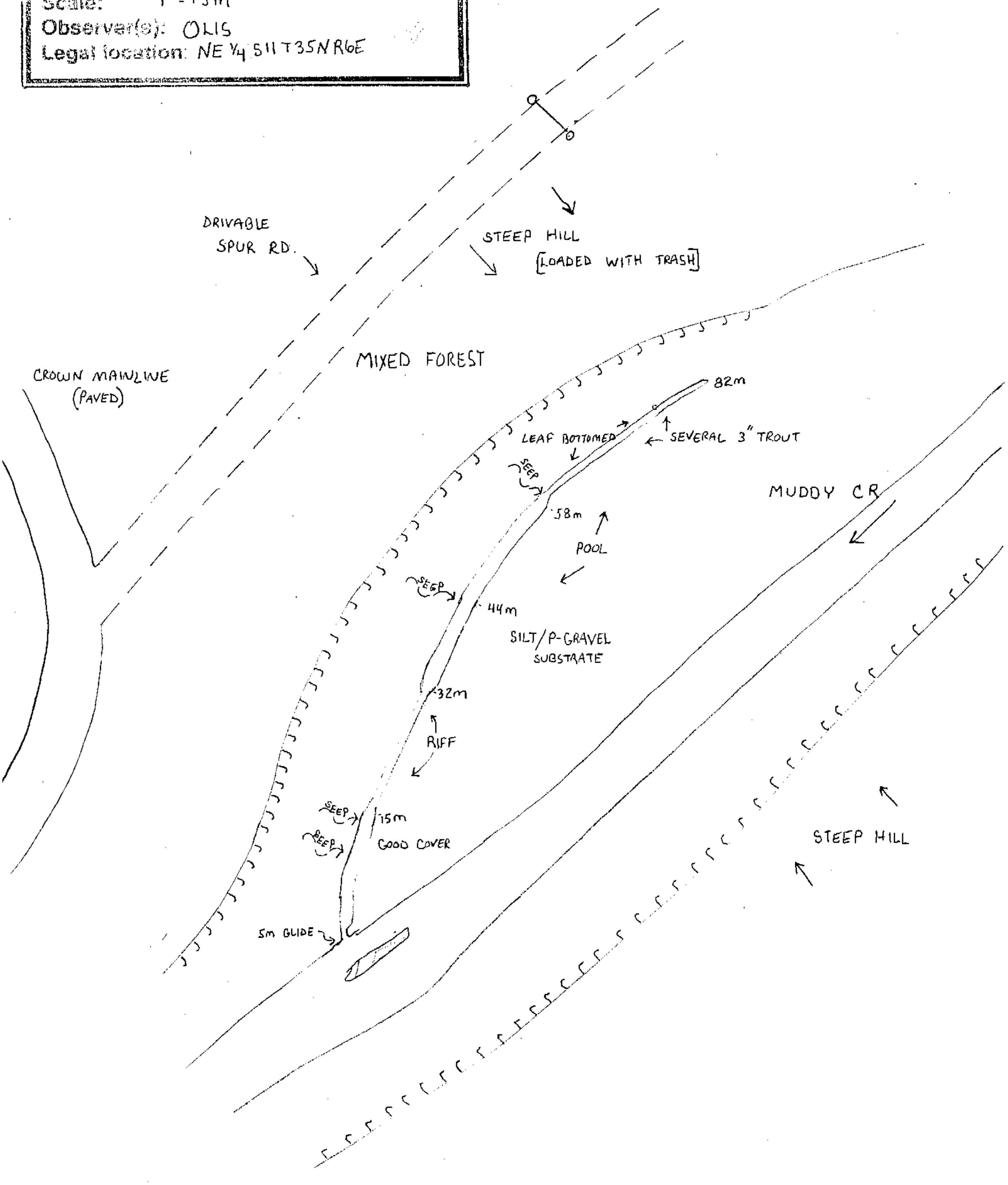
Equipment access:

ADDITIONAL COMMENTS: The steep slope just above this site is loaded with trash and litter from people dumping their garbage from the spur road above.

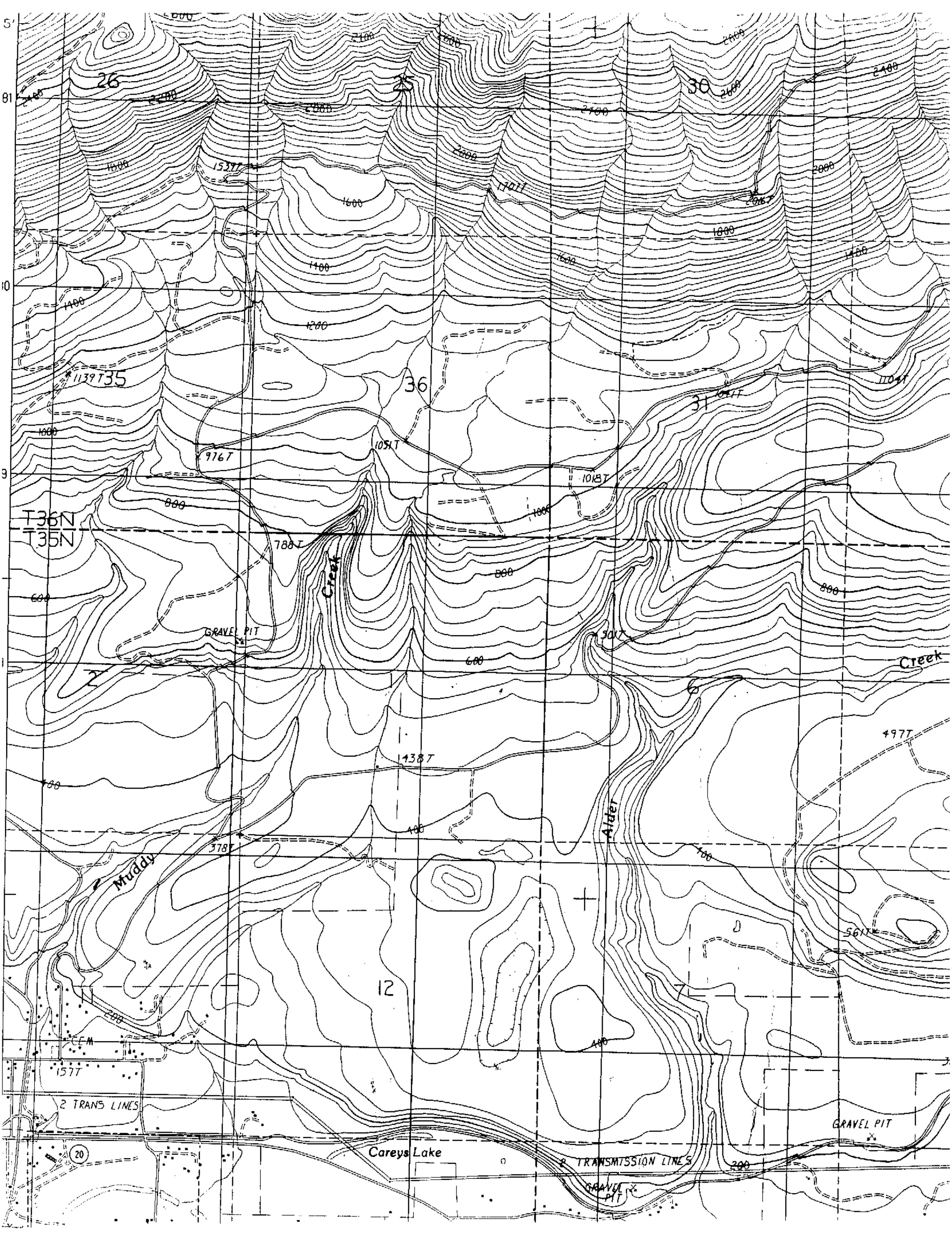
ATTACHMENTS AVAILABLE

( ) Aerials (X) Sketch (X) Maps ( ) Spawning Surveys ( ) Juvenile Trapping
( ) Other References

Site id code: MUIRB1
Site name:
Scale: 1"=15m
Observer(s): OLIS
Legal location: NE ¼ S11 T35N R6E



1"=15m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1041T
1104T
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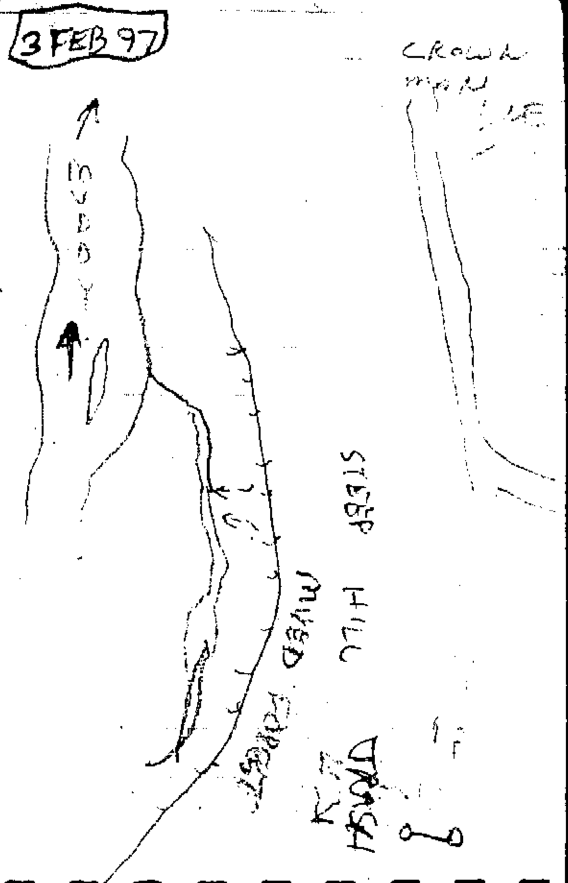
976T
1051T
1018T
800
T36N
T35N
788T
Creek
600
GRAVEL PIT
501T
Creek
2
6
497T
438T
400
Alder
378T
Muddy
561T
12
7
1
200
CEM
157T
2 TRANS LINES
20
Careys Lake
TRANSMISSION LINES
GRAVEL PIT
GRAVEL PIT
200

MU1RB1

RM7.6

NE 1/4 S11 T35N R6E

3 FEB 97



0.0 ENTRY
FLOW - 0.2 CFS
WTR TEMP - 48°
REC WTR - 42°
ACCESS - POOL @ ENTRY
BUT FIRST 5m IS GLIDE
RIFF AREA.
5m WW ≈0.5m
- GLIDE- RIFF AREA
15m WW 2m - SLOW-MOVING
≈ 5" DEEP
- SILTY SUBSTRATE w/
P-GRAVEL
- GOOD COVER FROM BERRIES
- SKUNK CABBAGE PRESENT
- 2 SEEPS ON RB

32m WW 1m
- MOSTLY RIFF
44m WW 2m
- MOSTLY POOL
- SEEP ON RB
58m WW 2m
- MOSTLY POOL
- STRM COVERD w/
WOODY DEBRIS
- ANOTHER SEEP ON
RB
82m WW 1m POOL
- END OF WTR
- JUVENILE TROUT
SEEN IN THIS SECTION
WTR TEMP - 48°
- LEAVE BOTTOMED

COMMENTS

- NO SPAWNING
HABITAT
- SMALL AMOUNTS OF
OVER WINTER REARING
- MOD. FLOODING
- GRNDWTR SOURCE - SEEPS
COMING OFF HILL
- PROB. DRIES UP IN
SUMMER

Region Reference Number – DNR Use Only			
Region	WRIA	Year	Number
NW	013	08	0238

Comment Due Date
1-9-09

Reviewer Comments
Water Type Modification

Attention Reviewers: DNR will make a decision by the Comment Due Date. Your comments only will be considered if they are received on or before the Comment Due Date. Return this completed form by mail, fax, or e-mail to the appropriate DNR Region office.

Reviewer's Name: ______________________ Reviewer's Affiliation: ______________________

Reviewer's Phone Number: ______________________ **Reviewer's E-Mail:** ______________________

☐ **Agree** with proposed **change(s)** ☐ Disagree with proposed **change(s)**

Reasons for Agreement or **Disagreement** (add ***attachments if necessary):***

Signature ______________________ **Date** ______________________
(Signatures are not necessary for e-mailed responses)

DNR Office Summary and Decision

WRIA 3 Name of Reviewers	Agree	Disagree	Date Comment Received	No Reply
DNR: Lancaster/clark				
WDFW: Rockwell				
DOE: Penhale				
Tribe: USIT				
Other: SRSC				
Other: Skagit Co				

☐ Approve change ☐ Disapprove change

Reasons for disapproval

Signature ______________________ Date ______________________

Proponent and reviewers notified of decision by ______________________ on ______________________
(Name) (Date)

E-mailed 12/9/08 cw

WASHINGTON STATE DEPARTMENT OF
Natural Resources

Water Type **Modification** Form

(For changes to the Water Type Map)

Check all that apply
[ ] *Adding streams/lakes
[ ] "Removing streams/lakes
[ ] "Changing location of streams/lakes
[ ] Changing water type based on physical Characteristics
[x] Changing water type based on protocol survey
[ ] Other. Describe ——

Region Reference Number – DNR Use Only			
Region	WRIA	Year	Number
NW	03	08	0238

1. Water Reference Id A	2. Name of Water	3. Tributary To	4. 'Legal Description (Section, Township, Range, E/W) **Sec. 36 T36N R6E**

5. 'County **Skagit**	6. Water Type Shawn on Map **N, 4**	7. Proposed Water Type **F, 3**	8. 'Date of Field Visit **April 16,2008**

9. 'Forest Practices Application Number(s) (if applicable)

10. Change is based on the following (check all that apply).
[x] Fish found
[ ] No fish found
[ ] Physical characteristics
[ ] Public water diversion
[ ] Fish hatchery diversion
[ ] Water feature exists, but does not meet WAC 222-16-031 definition.
See Additional Block Text for Water Reference ID A on attached sheet.

11. Water levels in the survey area *were:* [ ] Above Normal [x] Normal [ ] Below Normal
Description:
Based on stream flow predictions developed by the United States Dept. of Agriculture, Natural Resources Conservation Service, *the* Washington Dept. of Natural Resources determined that stream flows would be "normal" during the 2008 survey season. Field estimates of discharge were taken for surveyed channel segments. Flow conditions encountered during the survey were within the normal range.

12. The water type break was determined by:
[ ] Stopping at last observed fish
[x] Stopping at upper extent of fish habitat
[ ] Stopping at end of harvest or property boundary
[ ] Other – Describe:
See Additional Block Text for Water Reference ID A on attached sheet.

13. Are there any fish passage barriers downstream of the surveyed stream segment(s):
[ ] Natural barriers: [ ] Falls [ ] Cascades [ ] Bedrock chutes If yes, what is the height ______
[ ] Temporary barriers (log jams)
[ ] Man-made barriers (culverts)

Fish passage barriers were Identified by: [ ] Maps [ ] Field observation [ ] Other – describe:
n/a

14. Is there evidence of mass wasting or scouring events?
[ ] Yes. Describe how these affected current stream channel conditions and fish distribution in the stream.
[x] No

'Proponent name and signature Jason Stuart Print Name: **Jason Stuart**	Organization name and address WA Dept. of Natural Resources 919 North Township Sedro-Woolly, WA 98284	Telephone number **(360) 866-3600**
Surveyor name Kyle B. Meier	Organization name and address Forest & Channel Metrics, Inc. 1013A 85th Ave. SE Olympia, Washington 98501	Telephone number **(360) 753-0485**

AS 12/8/08

WASHINGTON STATE DEPARTMENT OF
Natural Resources

Water Type Modification Form
(For changes to the Water Type Map)

Check all that apply
- [ ] *Adding streams/lakes
- [ ] *Removing streams/lakes
- [ ] *Changing location of streams/lakes
- [ ] Changing water type based on physical characteristics
- [ ] Changing water type based on protocol survey
- [x] Other. Describe Verifying current water type

Region Reference Number – DNR Use Only			
Region	WRIA	Year	Number
NW	03	08	0238

1. Water Reference Id	2. Name of Water	3. Tributary To	4. *Legal Description (Section, Township, Range, E/W)
B			Sec. 36 T36N R6E

5. *County	6. Water Type Shown on Map	7. Proposed Water Type	8. *Date of Field Visit
Skagit	N, 4	N, 4	April 15, 2008

9. *Forest Practices Application Number(s) (if applicable)

10. Change is based on the following (check all that apply).
- [ ] Fish found
- [x] No fish found
- [ ] Physical characteristics
- [ ] Public water diversion
- [ ] Fish hatchery diversion
- [ ] Water feature exists, but does not meet WAC 222-16-031 definition.

No fish were detected within this segment, which lies upstream from the proposed type break described for Water Reference ID A.

11. Water levels in the survey area were: [ ] Above Normal [x] Normal [ ] Below Normal

Description:

Based on stream flow predictions developed by the United States Dept. of Agriculture, Natural Resources Conservation Service, the Washington Dept. of Natural Resources determined that stream flows would be 'normal" during the 2008 survey season. Field estimates of discharge were taken for surveyed channel segments. Flow conditions encountered during the survey were within the normal range.

12. The water type break was determined by:
- [ ] Stopping at last observed fish
- [x] Stopping at upper extent of fish habitat
- [ ] Stopping at end of harvest or property boundary
- [ ] Other – Describe:

No fish were detected within this segment, which lies upstream from the proposed type break described for Water Reference ID A.

13. Are there any fish passage barriers downstream of the surveyed stream segment(s):
- [ ] Natural barriers: [ ] Falls [ ] Cascades [ ] Bedrock chutes If yes, what is the height ______
- [ ] Temporary barriers (log jams)
- [ ] Man-made barriers (culverts)

Fish passage barriers were identified by: [ ] Maps [ ] Field observation [ ] Other – describe:

n/a

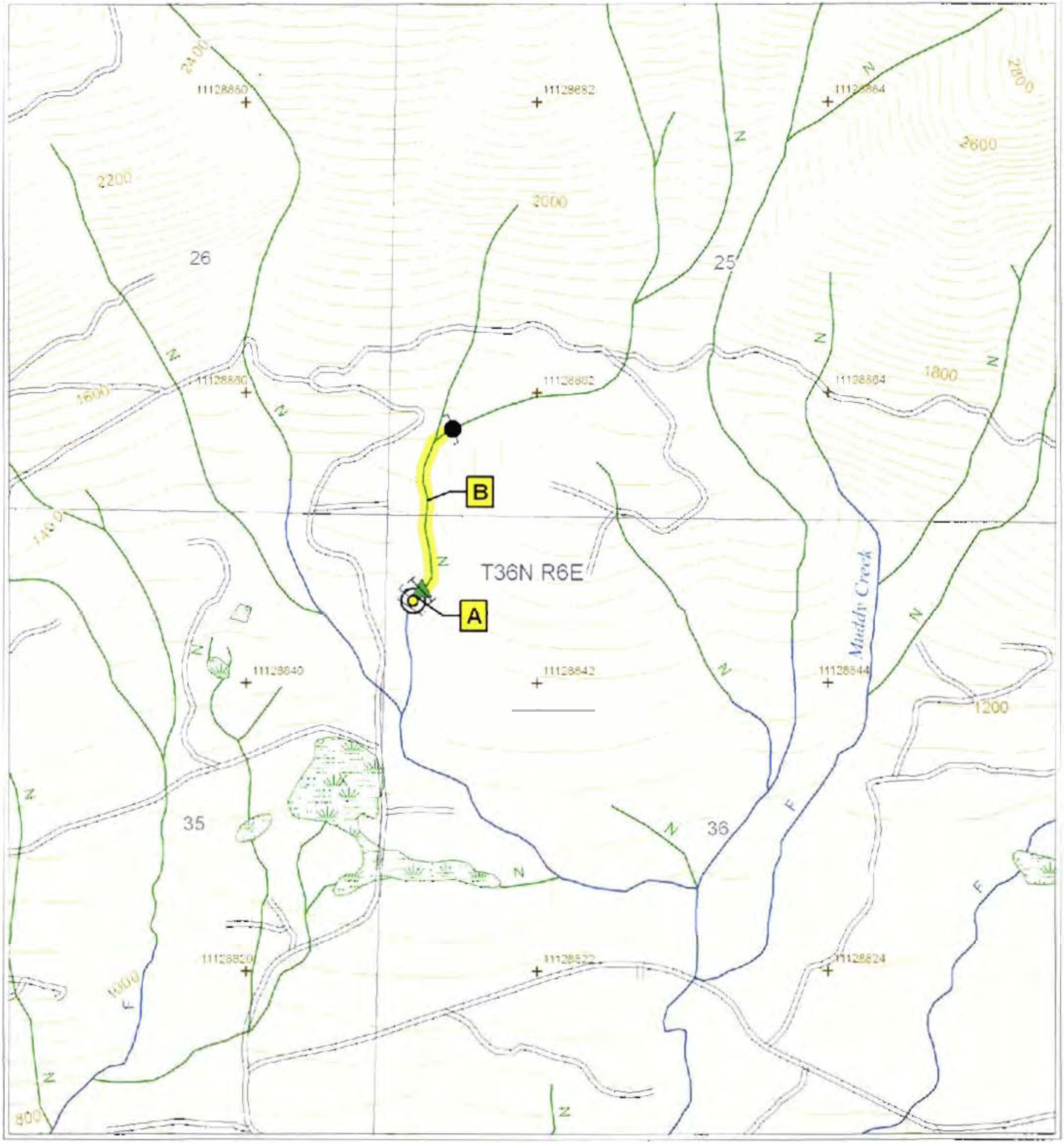
14. Is there evidence of mass wasting or scouring events?
- [ ] Yes. Describe how these affected current stream channel conditions and fish distribution in the stream.
- [x] No

*Proponent name and signature Stuart Print Name: Jason Stuart	Organization name and address WA Dept. of Natural Resources 919 North Township Sedro-Woolly, WA 98284	Telephone number (360) 856-3500
Surveyor name Kyle B. Meier	Organization name and address Forest & Channel Metrics, Inc. 1013A 85th Ave. SE Olympia, Washington 98501	Telephone number (360) 753-0485

AS 12/8/[illegible]

Water Type Modification Form Map

Forest & Channel Metrics Report ID: DNR_041508_01C_36N06E36D



0 250 500 1,000
Feet

40 Feet

Map Created: Sep 05, 2008
Map Datum: NAD 83 HARN
Coordinate System: WA State Plane, South Zone

N
W E
S

Forest & Channel Metrics, Inc.

Legend

Survey Points
- ○ Start of survey
- ● End of survey
- ● Last detected fish
- ▲ Proposed type break
- ▽ Natural limitation
- Man-made barrier

Streams
- F
- N
- S
- U
- X

Water bodies
- F
- N
- S
- X

Modified segment

Incorrect location

Segment break

Elevation contours

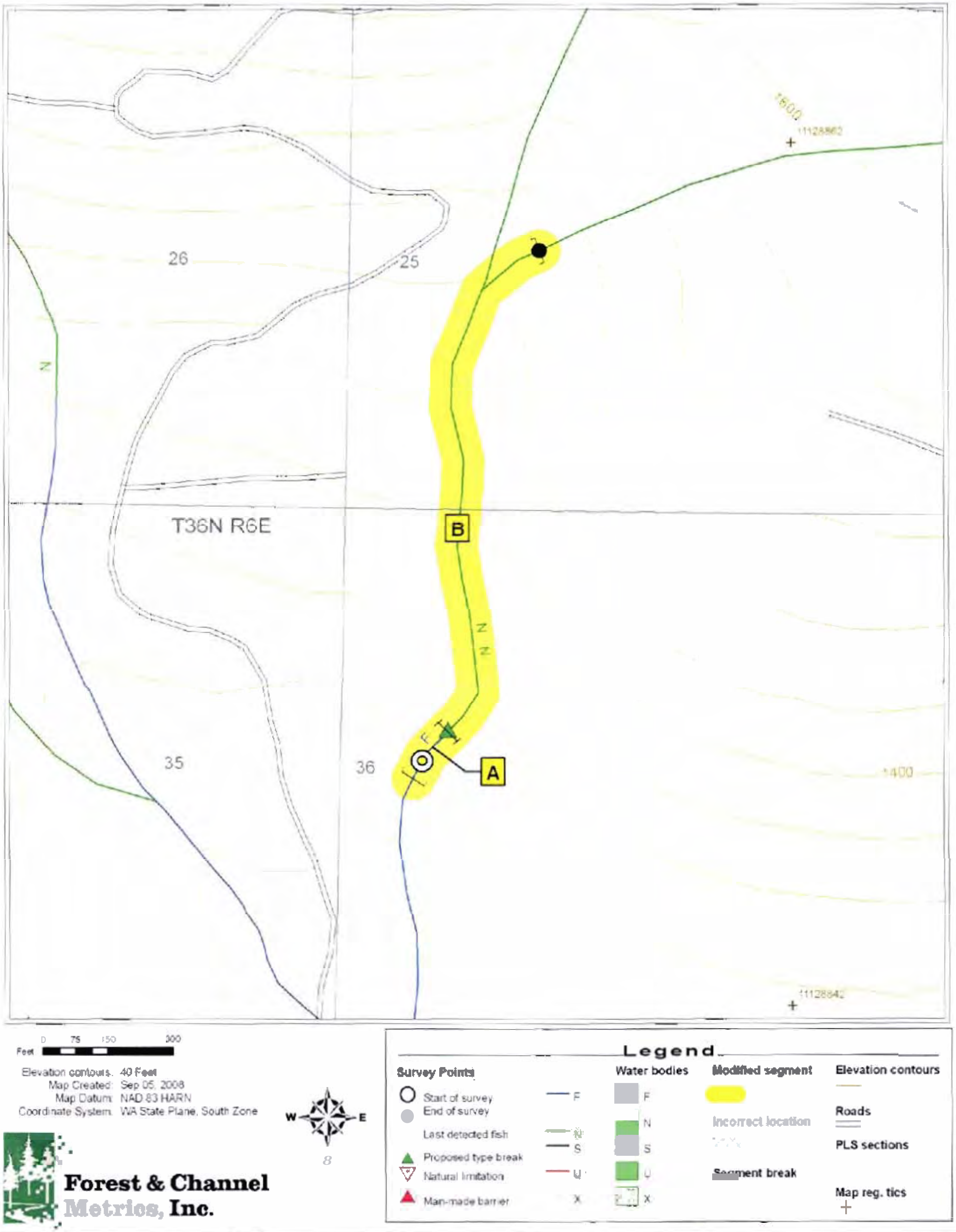
Roads

PLS sections

Map ref. tics

Basin Overview Map

Forest & Channel Metrics Report ID: DNR_041508_01C_36N06E36D



Elevation contours: 40 Feet
Map Created: Sep 05, 2008
Map Datum: NAD 83 HARN
Coordinate System: WA State Plane, South Zone

Forest & Channel Metrics, Inc.

Additional Block Text

Water Reference ID A: Unnamed tributary to an unnamed mainstem tributary
Location: Section 36, Township 36N Range 6E
Proposed modification: Change current water type: "N, 4" to "F, 3"

Block 10

An electrofishing survey was conducted on April 15, 2008 on an unnamed tributary of an unnamed mainstem tributary. The survey followed guidance provided in the Washingtan Department of Natural Resources Interim water typing rules (WAC 222-16-031(3), Chapter 13 Forest Practices Board Manual]. The extent of our survey is delineated by the start and end of survey points on the accompanying map. We sampled a total of 1,578 feet of channel, including 35 pools, 9 of which met Forest Practices Board Manual, Section 13, criteria for high quality. Water clarity was good with the streambed visible in the deepest pools. A total of 1,076 seconds of electrofisher operation were expended during this survey. Coastal cutthroat trout were detected within the surveyed reach. The last detected fish was a cutthroat trout 133 mm in length, located below a series of I-foot debris steps, at Sta. 0+00 during the survey. Additional survey details are contained in the accompanying Protocol Survey Data Table.

Block 12

The water type was determined by conducting a protocol field survey, documented in the accompanying Protocol Suwey Data Table. The proposed regulatory water type break is located at a 34% bedrock-based cobble and boulder cascade extending 268 feet upstream, encountered at Sta. 1+18 during the survey.

Protocol Survey Data Table.

Survey Data:

	Survey ID number	DNR_041508_01C_36N06E36D	
	Date	April 15, 2008	
	Surveyors	KBM, MCG: Forest & Channel Metrics, Inc.	
	Electrofisher type and setup	Smith-Root LR-24: Manual setup, 900 volts, 12 % duty cycle, frequency of 30 Hz	
Start	Weather	Slight rain	
	Temperature	Air: 2 °C	Water: 2 °C
	Specific conductivity	-	
	Discharge	4.4 cfs, Float-chip measurement	
End	Weather	Rain	
	Temperature	Air: 2 °C	Water: 2 °C
	Specific conductivity	-	
	Discharge	2 cfs, Float-chip measurement	
	Total distance	1,578 feet	
	Total qualifying pools	9	
	Total pools	35	
	Total seconds shocked	1076	

Physical Survey Data:

Distance (feet)	Wetted Channel Width (feet)	Bankfull Channel Width (feet)	Valley Width (feet)	Channel Confinement	Channel Slope (%)	Qualifying Pool Tally	Total Pool Tally	Wood Loading
0	10	12	15	Highly confined	11	-	-	High
	Figure 1. Start of survey location mid-reach.							
100	12	22	30	Highly confined	32	1	2	High
118	Figure 2. Proposed regulatory water type break location at a 34% bedrock-based cobble and boulder cascade extending 268 feet upstream.							
201	12	25	30	Highly confined	41	1	3	Moderate
309	7	9	10	Highly confined	21	2	5	Moderate
401	10	12	15	Highly confined	16	3	9	Low
501	7	7	10	Highly confined	7	5	13	Moderate
603	7	8	10	Highly confined	3	5	14	Low
700	7	10	30	Moderately confined	3	5	16	Moderate
802	6	8	24	Moderately confined	4	5	17	Moderate
900	7	10	25	Moderately confined	7	5	19	Moderate
1001	10	12	20	Highly confined	9	5	20	Low
1100	11	15	20	Highly confined	7	5	23	Moderate
1201	11	15	25	Highly confined	11	6	27	Moderate
1300	15	20	30	Highly confined	36	6	28	Moderate
1403	12	12	15	Highly confined	27	6	30	Low
1500	7	9	20	Moderately confined	13	8	33	Low
1578	5	6	12	Highly confined	9	9	35	Moderate
	Figure 3. End of survey location mid-reach in moderate gradient segment.							

Catch Data:

Fish species and age classes present	Coastal cutthroat trout (*Oncorhynchus clarki clarki*): 1			
	0+	1+	2+	3+
	0	0	1	0
Last fish description	Coastal cutthroat trout, 133 mm in length, located at Sta. 0+00 below a series of 1-foot debris steps.			
Amphibian species present	None detected			

Protocol Survey Photos

The following photographs were taken during the field survey represented In the preceding Protocol Survey Data Table. The figure labels below correspond to the figure labels in the comment fields for the respective Protocol Survey Data Table above, These photos have been Included to provide further documentation of stream conditions and other features observed within the surveyed reaches.

Figure 1. Start of survey location mid-reach (Sta. 0+00).

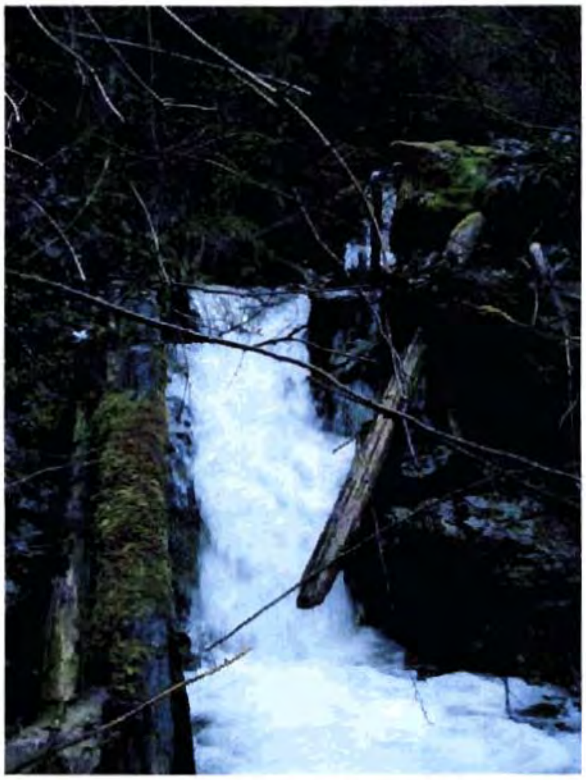


Figure 2. Proposed regulatory water type break location at a 34% bedrock-based cobble and boulder cascade extending 268 feet upstream (Sta. 1+18).

Figure 3. End of survey location mid-reach in moderate gradient segment (Sta. 15+78).

HYDRAULIC PROJECT

APPROVAL

R.C.W. 75.20.100
R.C.W. 75.20.103

DEPARTMENT OF FISHERIES

DEPARTMENT OF FISHERIES
General Administration Bldg.
Olympia, Washington 98504
(206) 753-6650

4 September 9, 1991
(applicant should refer to this date in all correspondence)

PAGE 1 OF 3 PAGES

10 LAST NAME FIRST: Skagit Co. Public Works Dept.
18 CONTACT PHONE(S): 336-9400
1 CONTROL NUMBER: 00-51416-01

19 STREET OR RURAL ROUTE: Rm. 203 County Admn. Bldg., ATTN: D. Brookings
7
8
9 WRIA: See Below

CITY: Mount Vernon
STATE: WA
ZIP: 98273
14
17

12 WATER: See Below
TRIBUTARY TO: Skagit River
11 TYPE OF PROJECT: Dredging

13 QUARTER SECTION	SECTION	TOWNSHIP	RANGE(E-W)	COUNTY
VARI	VARI	35N	05/06E	Skagit

TIME LIMITATIONS:
5 THIS PROJECT MAY BEGIN: Immediately
6 AND MUST BE COMPLETED BY: October 15, 1991

THIS APPROVAL IS TO BE AVAILABLE ON THE JOB SITE AT ALL TIMES AND ITS PROVISIONS FOLLOWED BY THE PERMITTEE AND OPERATOR PERFORMING THE WORK.

SEE IMPORTANT GENERAL PROVISIONS ON REVERSE SIDE OF APPROVAL

LEGAL DESCRIPTION: WRIA's 03.0280, .0294, .0343, .0352
STREAM's Wiseman Creek, Childs Creek, Red Cabin Creek, and Muddy Creek

NOTE: This Hydraulic Project Approval (HPA) is to repair damage caused by the November 1990 floods. Any dredging work in subsequent years will require a separate HPA.

1. Work shall be done during a low water period, preferably when the channel is dry.

2. No mud or other deleterious material shall leave the work site. If the stream is flowing, sediment barriers (one or more as necessary) shall be built downstream. Each barrier shall consist of filter fabric attached to fence posts. The base of the fabric shall be weighted down with gravel.

3. In areas where trees and brush are too dense for an excavator to work from the top of bank, a bulldozer or loader shall enter the channel and push gravel to natural openings where material shall be loaded out.

4. An oil-absorbant boom shall be deployed downstream of any site where the stream is flowing and a bulldozer or loader enters the channel.

5. Gravel shall be removed out of the floodway of each respective stream.

SEPA: MDNS - WDF September 6, 1991
REGIONAL HABITAT MANAGER - Kurt Buchanan (206) 428-1240
PATROL - Lynch
APPLICANT - WILDLIFE - READER - PATROL - HAB. MGR. - WRIA

DEPARTMENT OF FISHERIES Millard S. Deem / **DIRECTOR**

HYDRAULIC PROJECT
APPROVAL

R.C.W. 75.20.100
R.C.W. 75.20.103

DEPARTMENT OF FISHERIES

DEPARTMENT OF FISHERIES
General Administration Bldg.
Olympia, Washington 98504
(206) 753-6650

4 September 9, 1991
(applicant should refer to this date in all correspondence)

PAGE 2 OF 3 PAGES

10 LAST NAME Skagit Co. Public Works Dept.
18 CONTACT PHONE(S) 336-9400
1 CONTROL NUMBER 00-51416-01
12 WATER See Below
9 WRIA See Below

6. Great care shall be used to minimally disturb the stream banks and trees and shrubs.

7. Fish seen in a section to be dredged shall be removed prior to dredging. Joe Shedlock of the Skagit System Cooperative (466-7226) may be able to provide assistance to the County.

Wiseman Creek

8. Dredging shall begin no further than 1300 feet upstream of Minkler Road and extend downstream to the abandoned Burlington Northern (BN) trestle. Flagging was hung on September 4, 1991, at the upstream end (just upstream of the fence line upstream of Minkler Road at the approximate beginning of the old left bank berm). As much material as possible shall be removed from under the Minkler bridge.

9. The County should consider the possiblilty of extending this channel downstream of the BN trestle. There is an old channel along the toe of hill just downstream and to the west which connects into the swamp along Utopia Road.

10. The County should consider the possibility of building a gravel settling basin upstream of the Minkler Road bridge. There is a badly eroding gravel cliff upstream of SR 20 which is adding to the gravel problem.

Childs Creek

11. Dredging shall begin at the Lyman-Hamilton (LH) Road and proceed downstream no further than 760 feet. Flagging was hung at the downstream limit on September 4, 1991. As much material as possible shall be removed from under the bridge.

12. From the LH Road downstream to a road opening on the right bank, channel work shall be done with a small bulldozer pushing material to the opening. No attempt shall be made to widen the creek or to remove brush from the banks. Downstream of this right bank opening, the channel is open enough for an excavator and truck to work in the channel.

Red Cabin Creek

13. Dredging shall begin at the Hamilton Cemetery Road and proceed downstream to the Department of Transportation (DOT) State Route 20 right-of-way. The culvert under the Hamilton Cemetery Road shall also be cleaned of gravel.

HYDRAULIC PROJECT

APPROVAL

R.C.W. 75.20.100
R.C.W. 75.20.103

DEPARTMENT OF FISHERIES

DEPARTMENT OF FISHERIES
General Administration Bldg.
Olympia, Washington 98504
(206) 753-6650

4 September 9, 1991
(applicant should refer to this date in all correspondence)

PAGE 3 OF 3 PAGES

10 LAST NAME Skagit Co. Public Works Dept.	18 CONTACT PHONE(S) 336-9400	1 CONTROL NUMBER 00-51416-01
12 WATER See Below		9 WRIA See Below

14. An excavator may be used to clean the majority of this channel except in the one section just upstream of DOT right-of-way where a bulldozer shall enter the channel.

15. Trucks may use the dry streambed to drive on to haul material. Gravel in the streambed shall be loosened at project completion.

Muddy Creek

16. Dredging shall begin at the LH Road and proceed downstream no further than 470 feet. Flagging was hung at the downstream limit on September 4, 1991. Downstream of the longtime County dredging area by the BN trestle, a small bulldozer shall be used in the channel. Material shall be pushed to a natural right bank opening and removed. As much material as possible shall be removed from under the bridge.

17. Dredging shall begin at the LH Road and proceed upstream no further than 340 feet to an old concrete block weir. Flagging was hung on September 4, 1991. A bulldozer shall push material to the bridge and to a natural right bank opening approximately in the middle of the section to be dredged.

18. The County should consider building a sediment basin in the upstream dredging section. This would help trap the gravel before it jams up the bridge.

19. Final inspection is required when all four (4) projects are complete. Inspection shall occur prior to November 1, 1991.

LOCATION: Listed under each project above.

nb

STREAM SURVEY SUMMARY

DATE 8/23/89 DRAINAGE BASIN MID-SKAGIT
SURVEYORS RH / JS
STREAM NAME MUDDY CRK. WRIA 03.0352
TWP 35 N RANGE 6 E SECT 14 SW 1/4 NW 1/4
VALLEY SEGMENT TYPE ______ CODE D-1
SURVEY LENGTH BEGINNING SCOTT PAPER 2400 RD ENDING SCOTT PAPER 2000 RD.
UPSTREAM SURVEY ______ DOWNSTREAM SURVEY X

PHYSICAL DATA
WATER CONDITIONS 20 TEMP 50°
CHANNEL GRADIENT 2-12° SIDE SLOPE GRADIENT ≥ 30 BEARING 260
VIEWING CONDITIONS 37

SPAWNING HABITAT RATING HIGH - [✓ GOOD] - FAIR - POOR
LIMITING FEATURES ______

FISH COVER TYPE DOMINANT 7/4 OTHERS PRESENT 8
1. DEEP WATER
2. UNDERCUT BANKS
3. ADJ. WETLAND
[✓ 4.] LARGE ROCKS
5. SIDE CHANNEL
6. BEAVER DAM/POND
[✓ 7.] L.O.D.
[✓ 8.] BANK VEG.
9. OTHER

HABITAT DIVERSITY RATING HIGH - [✓ GOOD] - FAIR - POOR
LIMITING FEATURES ______

ADJACENT LAND USE DOMINANT LB = 8 RB = 3 OTHERS ______
1. FOREST OLD GROWTH
2. FOREST REPROD/SHRUB
[✓ 3.] CLEARCUT/BUFFER
4. ROAD/HIGHWAY/STREET
5. CULTIVATED FIELD
6. RESIDENTIAL SCATTERED
7. RESIDENTIAL DEVELOPED
[✓ 8.] FOREST SECOND GROWTH
9. FOREST HARDWOOD DOMINANT
10. CITY PARK/GOLF COURSE
11. PASTURE FENCED
12. PASTURE UNFENCED
13. INDUSTRIAL/COMMERCIAL

FISH PASSAGE BARRIER SM ____
[✓ 1. FALLS] 2. CULVERT 3. DAM 4. DEBRIS [✓ 5. CASCADE] 6. OTHER
DESCRIPTION
BLOCKING CASCADES (SMALL FALLS - ABOVE THAT) WHICH OCCURS

DIVERSION FROM/DISCHARGE INTO STREAM

1. PIPE 2. CULVERT 3. DITCH 4. HOSE 5. OUTLET 6. TRIBUTARY

TYPE	LB/RB	SIZE/DESCR.
NONE		

ARTIFICIAL BANK PROTECTION

TYPE	SM	RB LENGTH	LB LENGTH
NONE			

FISH OBSERVED TRAP SEINE [✓ SHOCKER] VISUAL

SPECIES	SIZE RANGE (MM)	ABUNDANCE	DISTRIBUTION
COHO	52- 70	MODERATE	IN LOWER SECTION ONLY AT 1362 METERS BELOW 2400 RD.
CUTTS	45-165	ABUNDANT	BELOW BLOCKING CASCADES AT 900 METERS BELOW THE 2400 RD.

COMMENTS

A SECOND ORDER STREAM WITH SEVERAL SMALL BRANCHES ORIGINATING ON THE STEEP SLOPES DIVIDING S.FK. NOOKSAK AND SKAGIT WATERSHEDS. FLOWS SOUTHERLY ACROSS ANCIENT GLACIAL TERRACES CUTTING A STEEP WALLED BOULDER/BEDROCK CANYON (ANADROMOUS BARRIER). GRADIENT LESSENS OVER LOWER 3500 M PROVIDING GOOD SPAWNING AND REARING HABITAT. ADJACENT. SLOPES ARE UNSTABLE IN SEVERAL AREAS - SOIL SLUMPING IS APPARENT - STREAM BANKS SHOW SCOURING FROM SEASONAL HIGH VELOCITY DISCHARGES. NO AREAS OF MEANDERING - RELATIVELY STRAIGHT STREAM CHANNEL DOWNCUTTING INTO COLLUVIUM. EXTENSIVE CLEARCUT AREAS THROUGHOUT UPPER WATERSHED SLOPES.

ENHANCEMENT RECOMMENDATION

NONE FOR THIS SECTION

STREAM SURVEY SUMMARY

DATE 8-23-89 DRAINAGE BASIN MIDDLE SKAGIT
SURVEYORS TLM / JB / JS
STREAM NAME MUDDY CREEK WRIA 03. 0352
TWP 35 N RANGE 6 E SECT 14 SW 1/4 NW 1/4
VALLEY SEGMENT TYPE CODE
SURVEY LENGTH BEGINNING SCOTT PAPER CEMENT BDG ENDING HAM. CEM. Rd
UPSTREAM SURVEY DOWNSTREAM SURVEY ✓

PHYSICAL DATA
WATER CONDITIONS 23 TEMP 52°
CHANNEL GRADIENT 4% SIDE SLOPE GRADIENT <30% BEARING 230°
VIEWING CONDITIONS 36

SPAWNING HABITAT RATING HIGH - GOOD - [✓ FAIR] - POOR
LIMITING FEATURES SILT / GRADIENT

FISH COVER TYPE DOMINANT 7,8 OTHERS PRESENT 4, 2
1. DEEP WATER
[✓ 2.] UNDERCUT BANKS
3. ADJ. WETLAND
[✓ 4.] LARGE ROCKS
5. SIDE CHANNEL
6. BEAVER DAM/POND
[✓ 7.] L.O.D.
[✓ 8.] BANK VEG.
9. OTHER

HABITAT DIVERSITY RATING HIGH - [✓ GOOD] - FAIR - POOR
LIMITING FEATURES Gradient

ADJACENT LAND USE DOMINANT 3/8 OTHERS 9, 6, 11
1. FOREST OLD GROWTH
2. FOREST REPROD/SHRUB
[✓ 3.] CLEARCUT/BUFFER
4. ROAD/HIGHWAY/STREET
5. CULTIVATED FIELD
[✓ 6.] RESIDENTIAL SCATTERED
7. RESIDENTIAL DEVELOPED
[✓ 8.] FOREST SECOND GROWTH
[✓ 9.] FOREST HARDWOOD DOMINANT
10. CITY PARK/GOLF COURSE
[✓ 11.] PASTURE FENCED
[✓ 12.] PASTURE UNFENCED
13. INDUSTRIAL/COMMERCIAL

FISH PASSAGE BARRIER SM
1. FALLS 2. CULVERT 3. DAM 4. DEBRIS 5. CASCADE 6. OTHER
DESCRIPTION NONE

DIVERSION FROM/DISCHARGE INTO STREAM

1. PIPE 2. CULVERT 3. DITCH 4. HOSE 5. OUTLET 6. TRIBUTARY

TYPE______LB/RB_____SIZE/DESCR.________________________________

ARTIFICIAL BANK PROTECTION

TYPE *Rip Rap*____________SM___RB LENGTH *1968* LB LENGTH *1968*

1900 *1900*

FISH OBSERVED TRAP SEINE [✓ SHOCKER] [✓ VISUAL]

SPECIES	SIZE RANGE (MM)	ABUNDANCE	DISTRIBUTION
Ct			
Coho	*50-60*	*mod.*	*throughout*

COMMENTS

ENHANCEMENT RECOMMENDATION

- *MAINTAIN WATER QUALITY*
- *INSTREAM FLOW CONTROL DEVISES*

SKAGIT RIVER KILOMETER INDEX

Stream No.	km	km	km	km	km	Description
3.0340		1.21				Unnamed tributary (RB)
			0.11			Highway 20
			0.64			Swamp
			0.65			Burrese Road
		1.21				Hamilton Cemetery Road
		1.27				Beaver dam
		1.47				Beaver dam
		1.95				Highway 20
Unnumbered		2.22				Unnamed tributary (LB)
		2.49				Hamilton Cemetery Road
Unnumbered		2.89				Unnamed tributary (RB)
Unnumbered		2.92				Unnamed tributary (RB)
		2.96				Beaver dam
3.0342		3.29				Unnamed tributary (LB)
			0.36			Road
Unnumbered		3.54				Unnamed tributary (LB)
		3.64				Blockage cascade
3.0343	56.6					Etach Slough
3.0343		2.41				Red Cabin Creek
		2.43				Lyman-Hamilton Road
		2.79				Highway 20
		3.27				Cabin Creek Road
		3.81				Trail crossing
		4.92				Trail crossing
Unnumbered		5.60				Unnamed tributary (RB)
		5.87				Scott Paper Road
3.0350	60.0					Loretta Creek (LB)
		0.19				South Skagit Highway
		0.27				Waterfall
		0.85				Waterfall
		0.97				Waterfall
		1.04				Cascades
		1.48				Blockage cascades
3.0352	62.8					Muddy Creek (RB)
		0.18				Railroad
		0.20				Lyman-Hamilton Road
3.0353		0.21				Mannser Slough (LB)
		0.56				Log yard bridge
		0.61				Log yard bridge
		0.95				Highway 20
		0.98				Road
		1.44				Hamilton Cemetery Road
Unnumbered		2.40				Unnamed tributary (RB)
		3.43				Logging road
		4.83				Blockage cascade
3.0354	63.2					Carys Creek (RB)
		0.48				Leaves Skagit floodplain
		0.62				Lyman-Hamilton Road
		0.70				Beaver dam
		0.89				Railroad
		0.90				Road
		0.90				Hamilton Slough (outlet)
		1.69				Hamilton Slough (inlet)

Supplement
3.0352

MUDDY CREEK

STREAM PHYSICAL DESCRIPTION

Tributary To:	Skagit River		
Entering:	(RB-39.0) SW 1/4 NW 1/4 Sec 14, T35N, R6E		
Drainage Area:			
Total Length:	3.2 miles		
Accessible Length:	3.0 miles		
Accessible Surface Area:	Summer 18,257 m^2		
Accessible Tributary Length:	None		
Major Tributaries:	None		
Lakes:	None		
Estimated Flow (cfs):	Summer 2.9	Winter	@ mile 0.0 - 3.0
Average Width (meters):	Summer 3.8	Winter	@ mile 0.0 - 3.0
Pool:glide:riffle:rapid ratio:	4:15:81:0		@ mile 0.0 - 0.5
	8:0:91:1		@ mile 0.5 - 1.7
	10:0:75:15		@ mile 1.7 - 3.0
Boulder:rubble:gravel:sand ratio:	0:10:65:25		@ mile 0.0 - 0.3
	0:15:70:15		@ mile 0.3 - 0.7
	5:30:50:15		@ mile 0.7 - 2.0
	10:30:50:10		@ mile 2.0 - 2.6
	25:35:30:10		@ mile 2.6 - 3.0
Gradient:	2.1%		@ mile 0.0 - 1.8
	3.9%		@ mile 1.8 - 3.0
Shade and Cover:	25% canopy, alder and maple - 2% cover, salmon and blackberry, low instream.		@ mile 0.0 - 0.5
	100% canopy, alder - 5% cover, brush, low instream.		@ mile 0.5 - 0.6
	50% canopy, alder - 1% cover, blackberries, low instream.		@ mile 0.6 - 1.1
	90% canopy, mixed - 5% cover, vine maple, salmon berries and logs, fair instream, LOD.		@ mile 1.1 - 3.0
Land Use:	Woods and log yard		@ mile 0.0 - 0.5
	Pasture		@ mile 0.5 - 1.1
	Forest		@ mile 1.1 - 3.0

Other Water Use:	None	@ mile 0.0 - 3.0
Spawning Quality/Quantity:	Coho - poor/good	@ mile 0.0 - 0.3
	Coho - good/good	@ mile 0.3 - 2.2
	Coho - good/low	@ mile 2.2 - 3.0
Summer Rearing Quality:	Coho - good	@ mile 0.0 - 3.0

SALMON USE DESCRIPTION

Species	Transportation	Spawning	Rearing
Coho	0.0 - 3.0	0.3 - 3.0	0.0 - 3.0

Spawning (Rearing) Potential: Coho
(18,257 m^2)

Limiting Factors:

Lower 1 mile has been channelized. Lower 0.3 miles dredged in 1984. Lack of instream cover. Lack of pools.

Improvement Projects and Production Potential:

Increase instream debris.

General Comments:

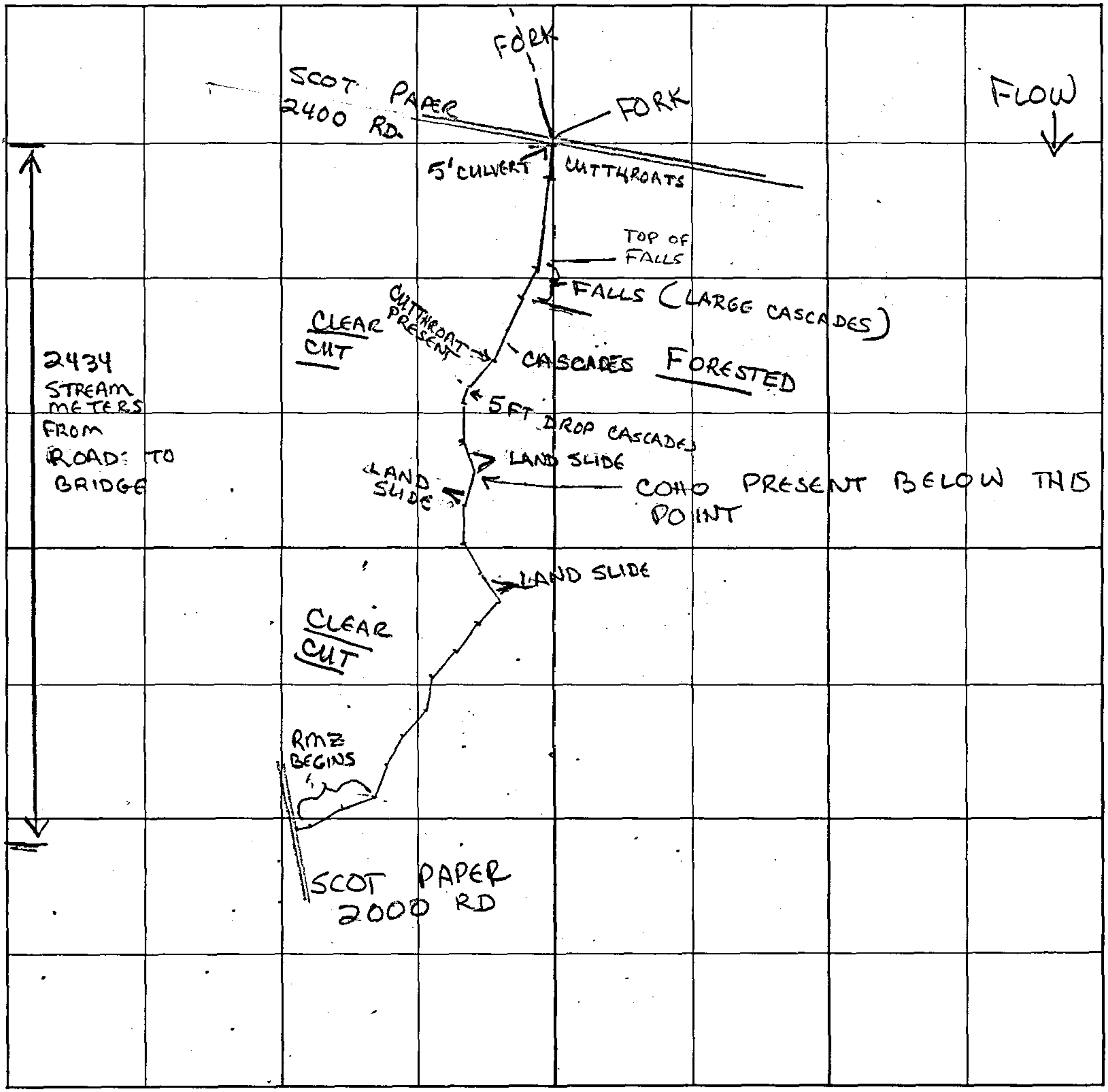
Lower 0.3 miles dredged 9/84, spoils used to create levy. Mile 0.3 to 0.5 is in log yard, small alders along the creek, channelized, shallow riffle, only a couple of small pools, which do have numerous 0+ coho. Above Highway 20 (mile 0.5) there is pastures on both shores, trees along the creek. The stream is straight and riffly, tapered shores, few pools, little cover. At mile 1.1, the creek enters the forest, running between hills in a ravine. Logs and vine maple across the stream, logging on nearby hills. Creek is confined, mostly riffle, coarse bottom. Some spawning areas up to the blockage cascade, but lack of good pools from mouth to blockage.

SECTION PLAT SHEET

~~OWNER~~ MUDDY CRK. 03.0352 DATE 8/23/89

SECTION 14, SW¼ of NW¼ TOWNSHIP 35 N RANGE 6 E

COUNTY SKAGIT STATE WA SCALE ¼" = 100 M.



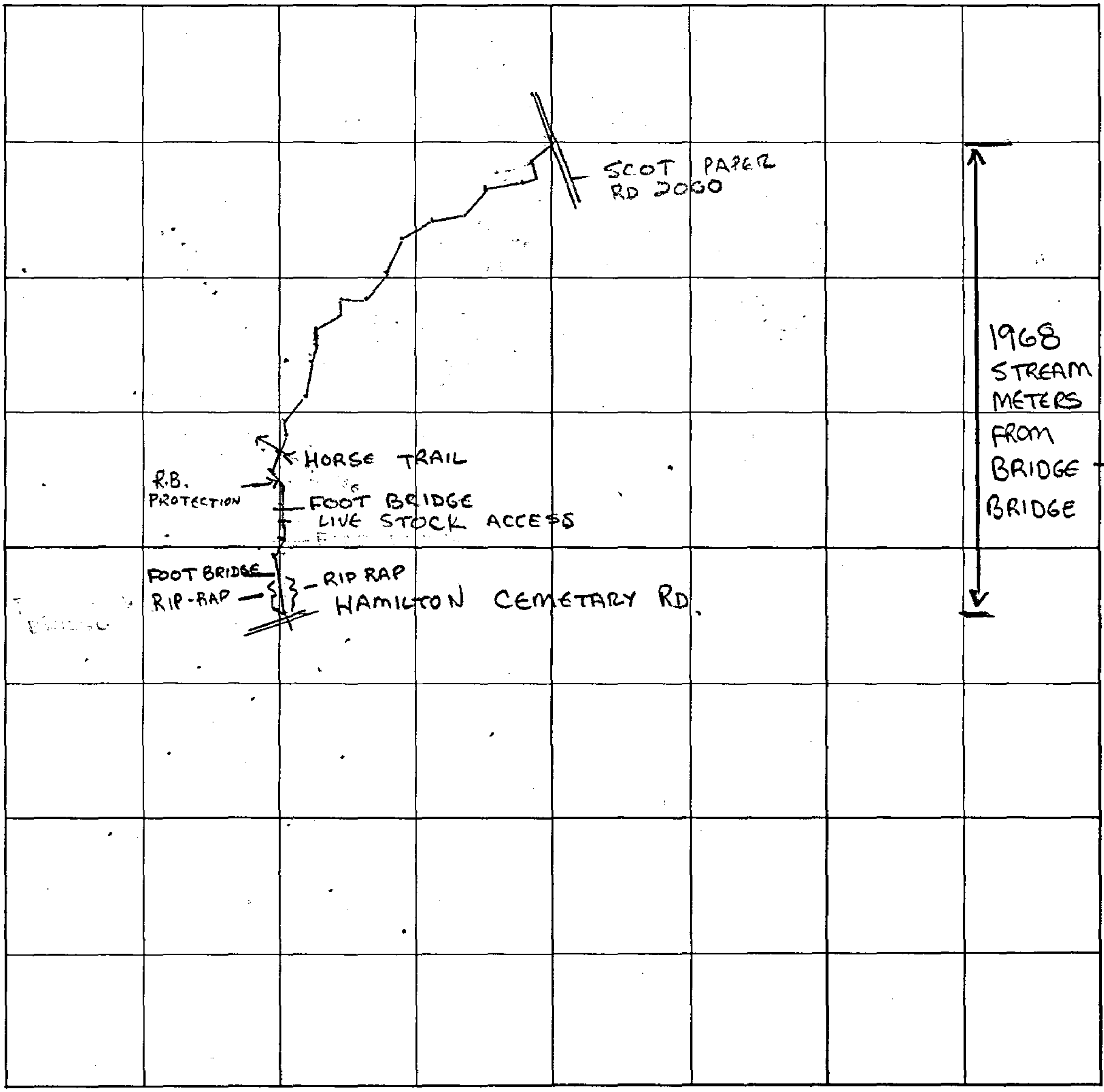
The Ben Meadows Co., Atlanta, Ga. # 102432

SECTION PLAT SHEET

~~OWNER~~ Muddy 03.0352 DATE 8/23/89

SECTION 145 - SW1/4 of NW1/4 TOWNSHIP 35 N RANGE 6 E

COUNTY SKAGIT STATE WA. SCALE 1/4" = 100 M



The Ben Meadows Co., Atlanta, Ga. # 102432

STREAM NAME: Muddy Creek WRIA #: ______ DATE: 8-23-89

ACCESS PT. LEGAL T35 R6 SECT 14 1/4 SW 1/4 NW SURVEYORS: TLM/JS/JB

START (METERS)	REL. BEARING DOWNSTREAM	SURVEY DIRECTION ☐ UP ☒ DOWN	COMMENTS
0000	230°	Cement Bridge (bearing 160°)	
0100	165	Turning pt	52°
0150	250°	" "	Water = 23
0200	260°		V. Condition = 36
0300	220°		St. Chan Grad. = 4%
0400	260°		incised channel
0500	240°		< 30° SS
0600	205		LOD, OHC, CB
0700	220	Limiter	2nd growth / clear cut
0800	275°	Turn Pt Silt/Grad.	S Gravel Rating: fair
0877	180	" " Grad.	HBH Rating: Good
0000	240	" "	
1025	205	" "	
1100	180	" "	
1150	200	" "	
1200	190		
1300	220	" "	
1400	170	" "	
1430	200		
1487	200	HORSE TRAIL X ing	Entering residential area
1564	140	RB Bank protection – wood barrier 20' long	
1600	180		
1678		Foot Bridge	
1700	180	live stock access	
1750	210	occasional RR track Xing stream in streambed – creating pools	
1800	170		
1900		RB & LB rip rap starts / Foot Bridge	
1968	160 @	Ham. Cemetery Rd Bridge (bearing 248°) End of Rip Rap	

STREAM NAME: ____________ WRIA #: ____ DATE: ____________

ACCESS PT. LEGAL T__ R__ SECT__ 1/4__ 1/4____ SURVEYORS: ____________

START (METERS)	REL. BEARING DOWNSTREAM	SURVEY DIRECTION ☐ UP ☐ DOWN COMMENTS

STREAM NAME: MUDDY CRK WRIA #: ...... DATE: 8-23-89

~~ACCESS PT. LEGAL T__ R__ SECT__ 1/4__ 1/4__~~ SURVEYORS: RH / JS

START (METERS)	REL BEARING DOWNSTREAM	SURVEY DIRECTION ☐ UP ☒ DOWN COMMENTS
00	185	2400 RD. BEARING 100°
≈		PARELLEL READINGS FROM TOP OF CANYON
≈ 350	210	TOP OF BLOCKAGE
420		PHOTO 12 UPSTRMEAM TOWARDS FALLS
425	210	PHOTO 13 " " "
570	205	14 " CASCADES (12° 25% GRAD.
		2ND GROWTH ON LB, C.C/SHRUB ON RB
*		READINGS NOW FROM BED STREAM
740	205	PHOTO 15 UPSTREAM AT CASC.
780	220	CUTTS PRESENT, WE'RE NEAR BOTTOM OF
*		CASC. 10°/ 18% GRADIENT
* 850	205	PHOTO 16 - UP. 8° GRAD, 5' DROP AT FALLS
910	200	CUTTS 50→130
1010	180	STILL DROPPING
1100	160	
1164 →	1200)	LB MASS WASTING (SAND SLIDE)
		W, SHALE, AREA IS STARTING TO LOOK LIKE COHO AREA
1200	195	CUTTS UP TO 165 mm
1250	195	4° GRAD., R.B MASS WASTING ≈ 30m LONG
1300	180	
1362		COHO PRESENT
1382		COHO - GETTING ABUNDANT 1/2 THE FISH TURNED ARE COHO
1400	150	3 1/2° GRAD, VERTICAL HEIGHT OF SIDE
		SLOPE INCITION IS DECREASING ON BOTH
		SIDE
1500	145	

STREAM NAME: MUDDY WRIA #: . DATE: 8/23/84

ACCESS PT: LEGAL T__ R__ SECT __1/4__1/4______ SURVEYORS: RH / JS

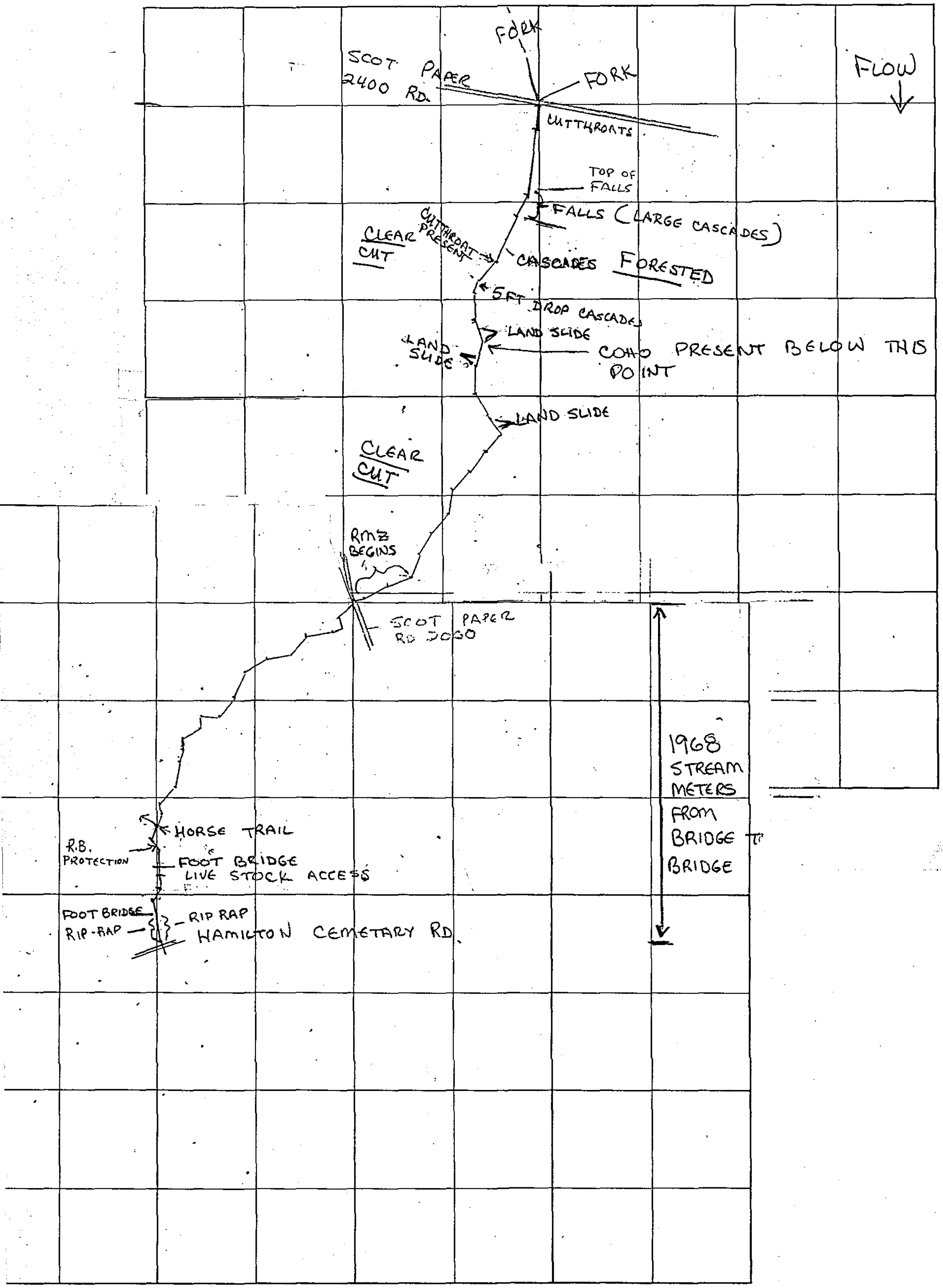
START (METERS)	REL BEARING DOWNSTREAM	SURVEY DIRECTION ☐ UP ☐ DOWN COMMENTS
1530-1545		LB MASS WASTING
1600	220	3° GRAD.
1700	216	COHO & CUTTS
1800	220	2° ↓ ↓
1900	190	2°
2000	220	
2100	210	COHO / CUTTS
2200	200	RMZ ON RB 2 20-30 M DEEP
2300	250	LB STILL FORESTED
2400	240	
2434	260	2000 ROAD AT CONCRETE BRIDGE - 350°

SECTION PLAT SHEET

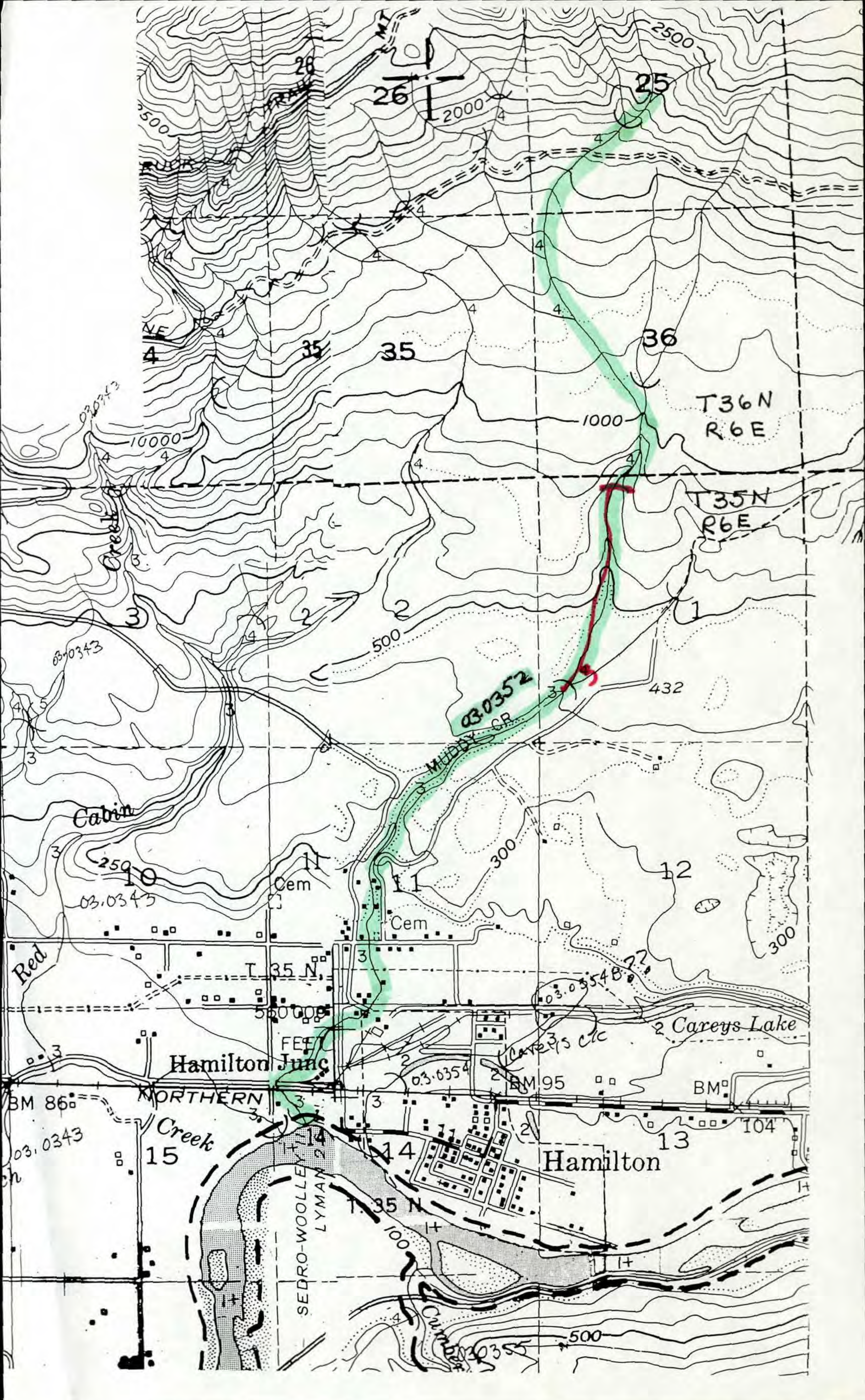
~~OWNER~~ MUDDY CRK. 03.0352 DATE 8/23/89

SECTION 14, SW¼ of NW¼ TOWNSHIP 35 N RANGE 6 E

COUNTY SKAGIT STATE WA SCALE ¼" = 100 m.



Ben Meadows Co., Atlanta, Ga. # 102432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26
26
2000
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TRAIL
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36
T36N R6E
T35N R6E
1000
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03.0343
Creek
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2
2
1
500
03.0352
MUDDY CR.
432
Cabin
250
10
11
11
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03.0343
Red
T. 35 N.
550000 FEET
03.03548
Careys Lake
Careys Crk
Hamilton Junc
NORTHERN
BM 86
BM 95
BM
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Hamilton
SEDRO-WOOLLEY
LYMAN
T. 35 N.
100
1+
Cumber
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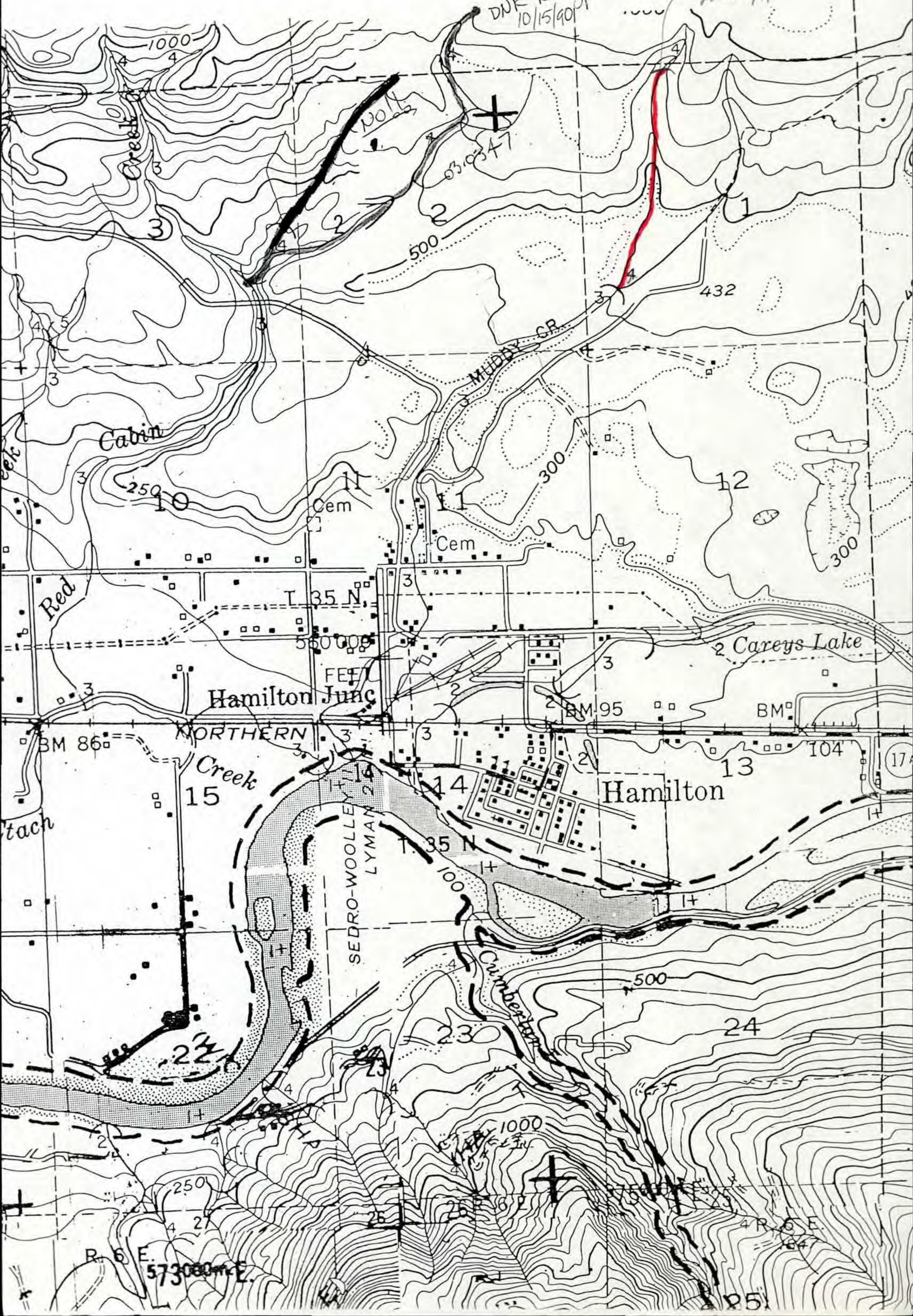
500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Mt Josephine
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Josephine Lakes
2741T
2874T
1539T
1707T
2016T
1306T
1139T
976T
1051T
1018T
1041T
1104T
2400 rd
2000 rd
T36N
T35N
788T
Creek
GRAVEL PIT
501T
Creek
497T
438T
378T
543T
561T
Muddy
Alder
157T
2 TRANS LINES
Careys Lake
2 TRANSMISSION LINES
GRAVEL PIT
BM 141
BM 124
134T
139T
144T
131T
303T
GATE
102T
100T
121T
111T
CEM
Hamilton
BM 91
WT
S K A G I T
V A L L E
SKAGIT
W I L D
A N D
RIVER
S C E N I C
SAND
Mile 40
BOAT RAMP
Davis Slough
124T
129T
TRAILER
Cumberland
Creek
1478T
1315T
2107T
Marietta Falls
536T
O'Toole
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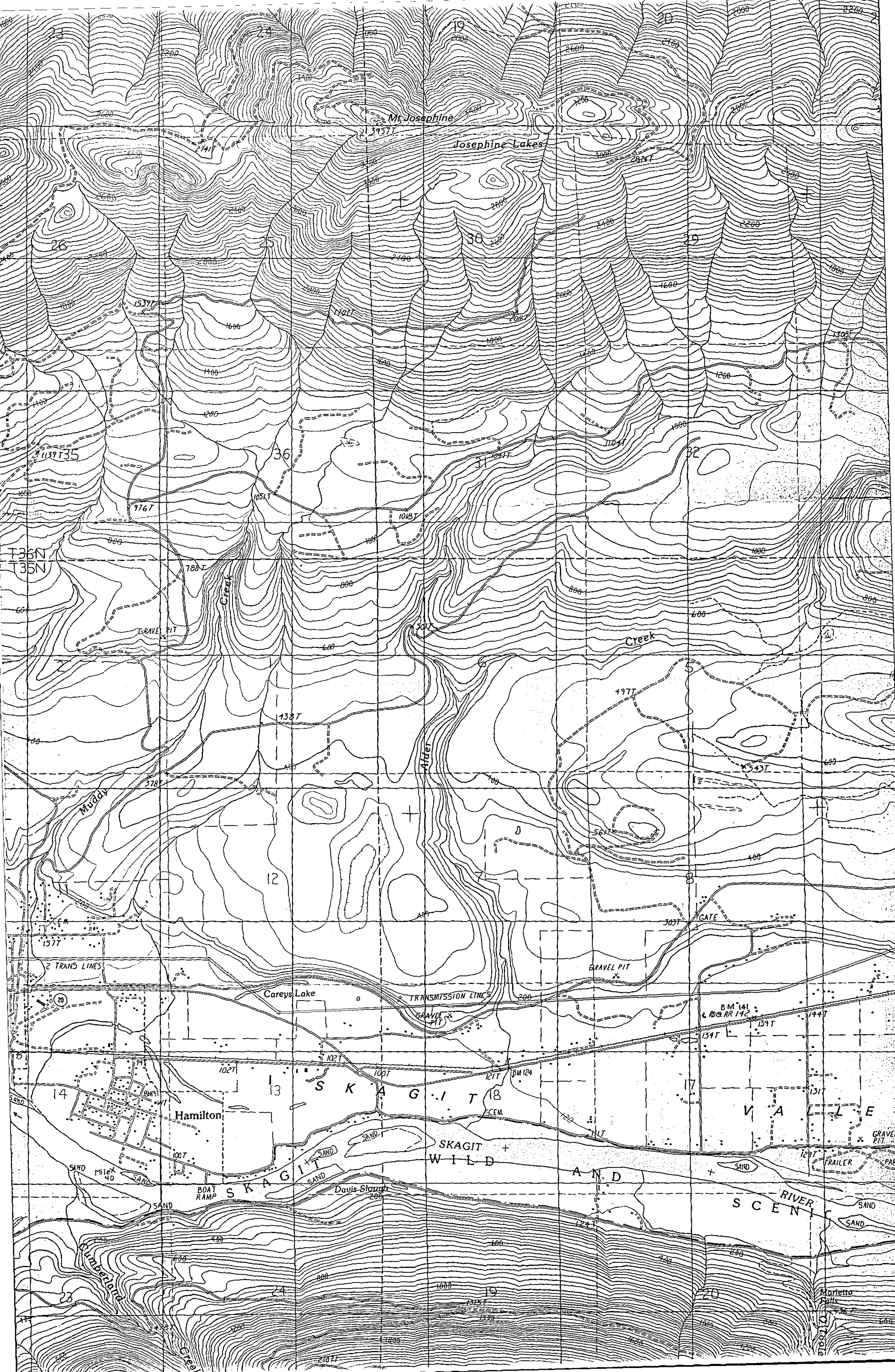
Mt Josephine
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Josephine Lakes
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1707T
2016T
1303T
1139T
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1018T
1091T
1104T
788T
Creek
GRAVEL PIT
Creek
750T
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Alder
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Muddy
378T
543T
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CEM
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2 TRANS LINES
Careys Lake
2 TRANSMISSION LINES
GRAVEL PIT
GRAVEL PIT
GATE
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BM 124
147T
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Hamilton
BM 97
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V A L L E
SKAGIT
W I L D
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SAND
Mile 40
BOAT RAMP
S K A G I T
Davis Slough
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TRAILER
GRAVEL PIT
Cumberland
Creek
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Marietta Falls
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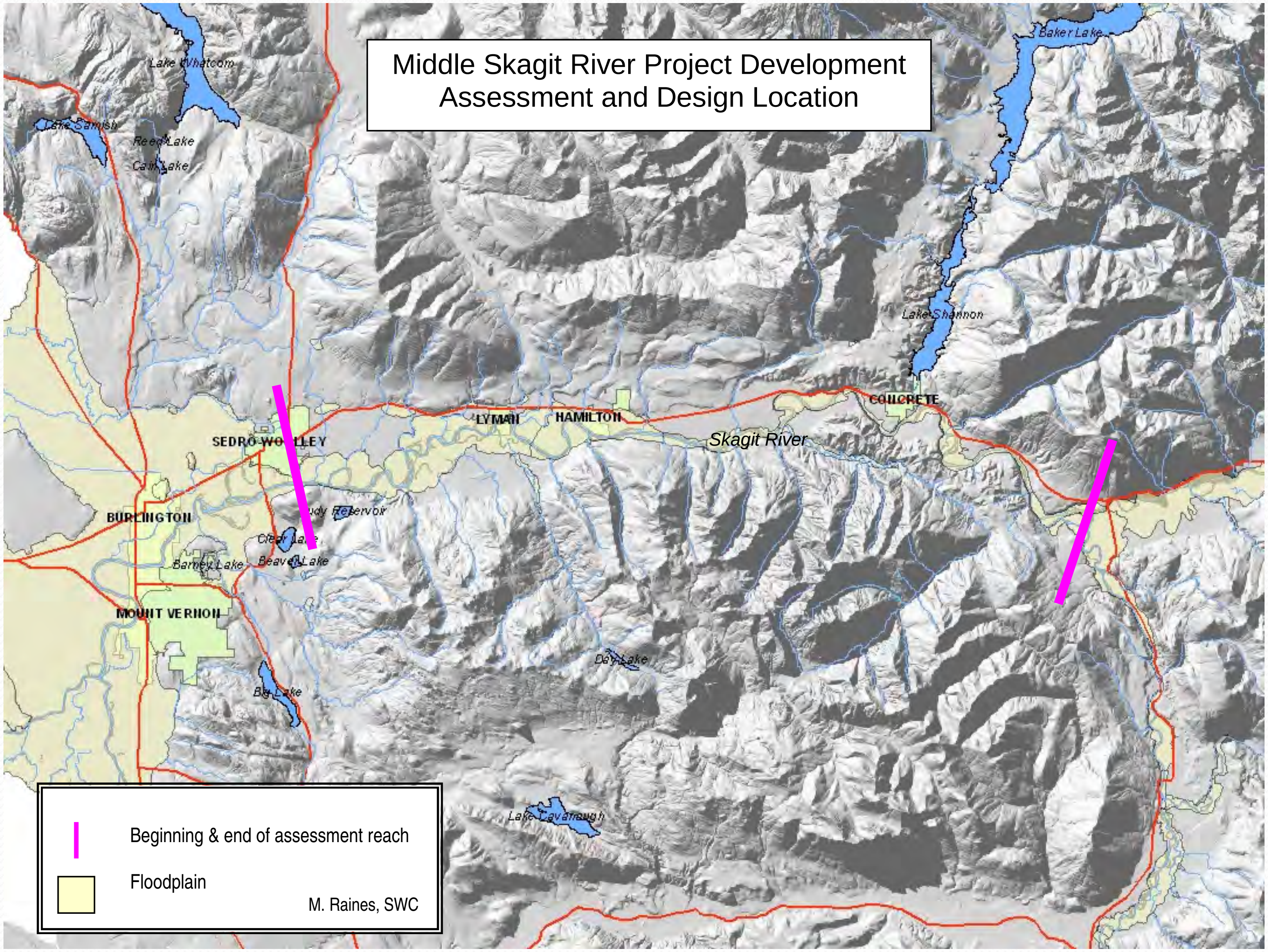
Habitat Simulation Modeling of the Middle Skagit River for Juvenile Chinook

Ed Connor
Seattle City Light

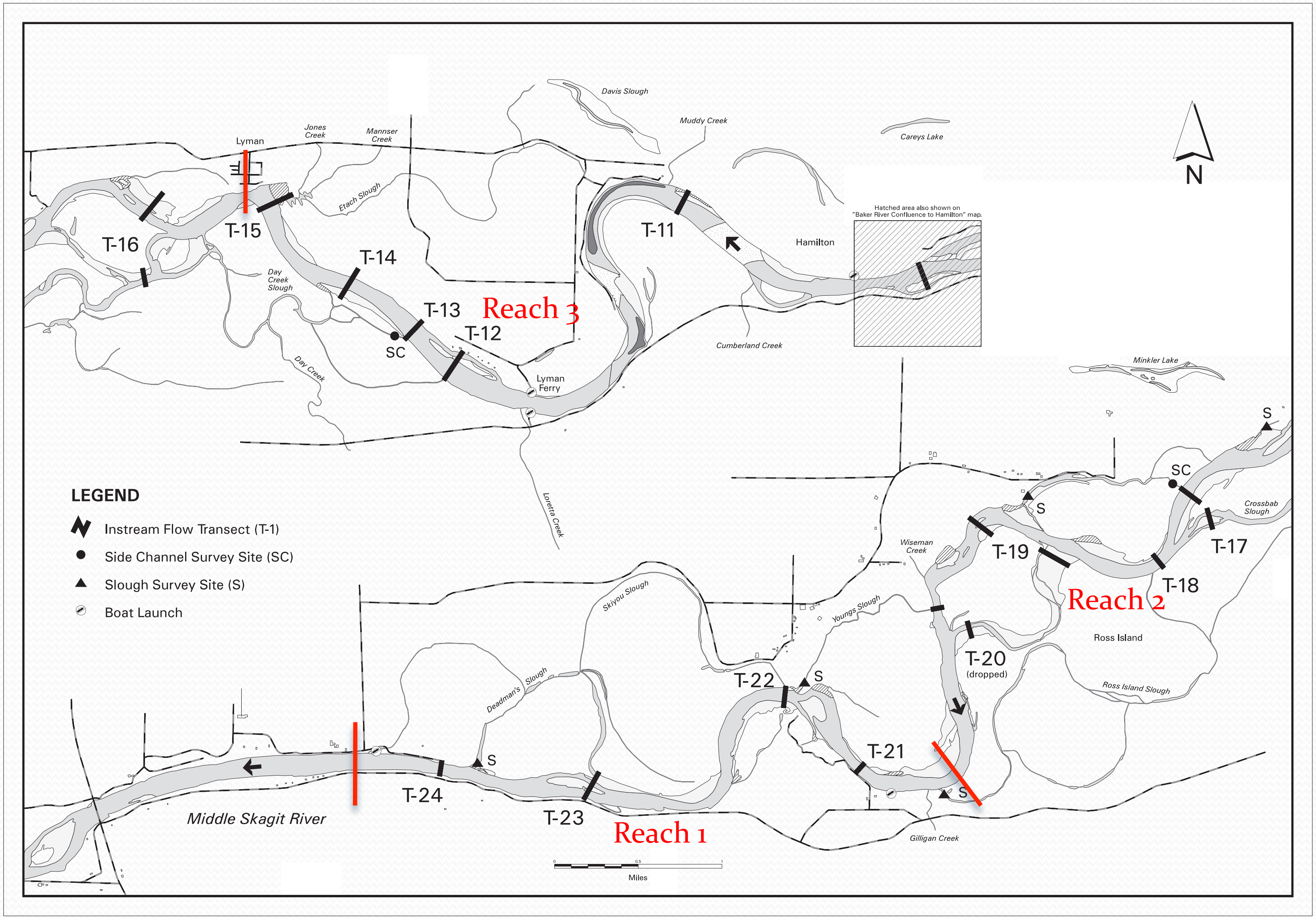
Middle Skagit Assessment Area



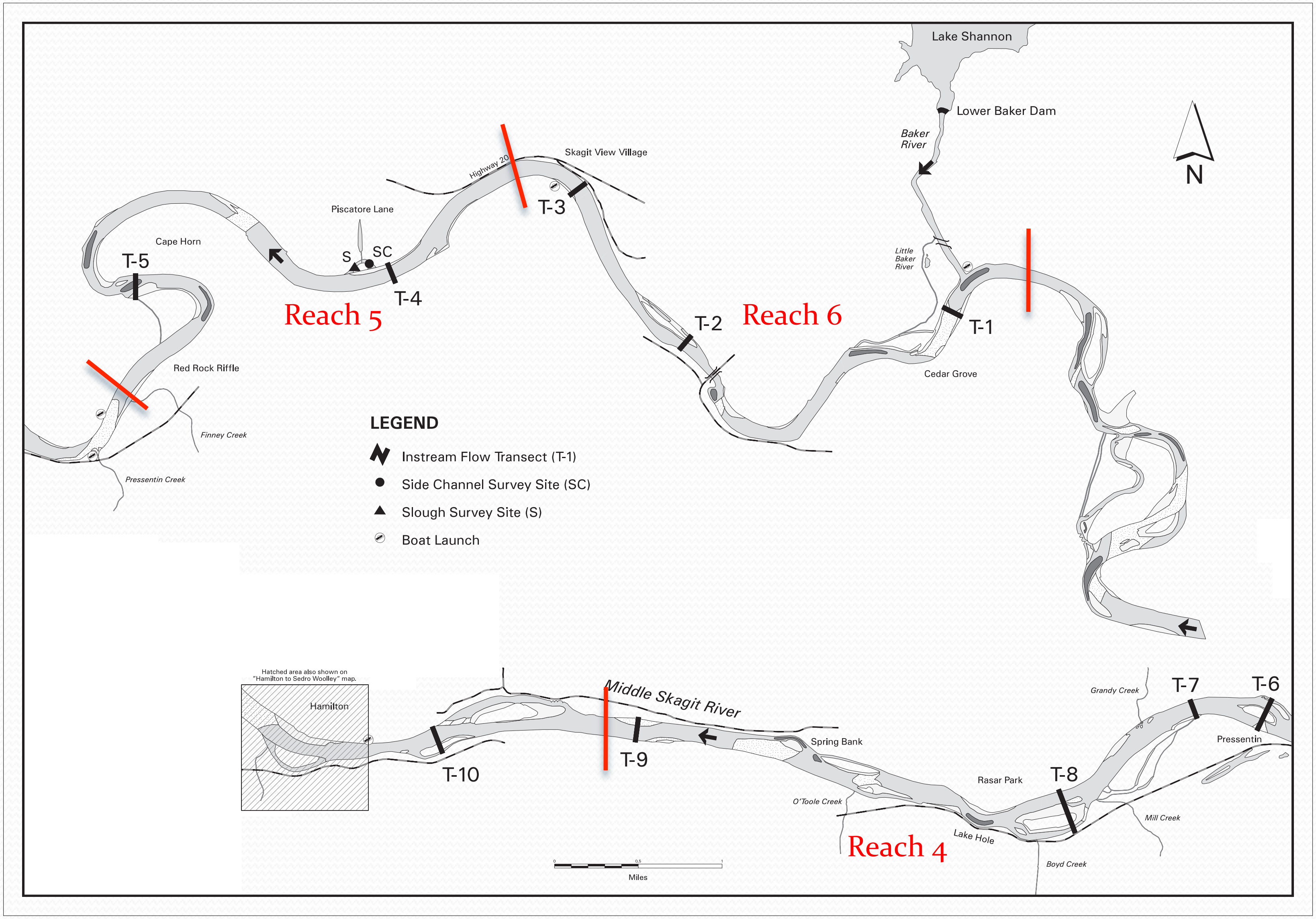
Middle Skagit River Project Development Assessment and Design Location

M. Raines, SWC

Puget Sound Energy Transects



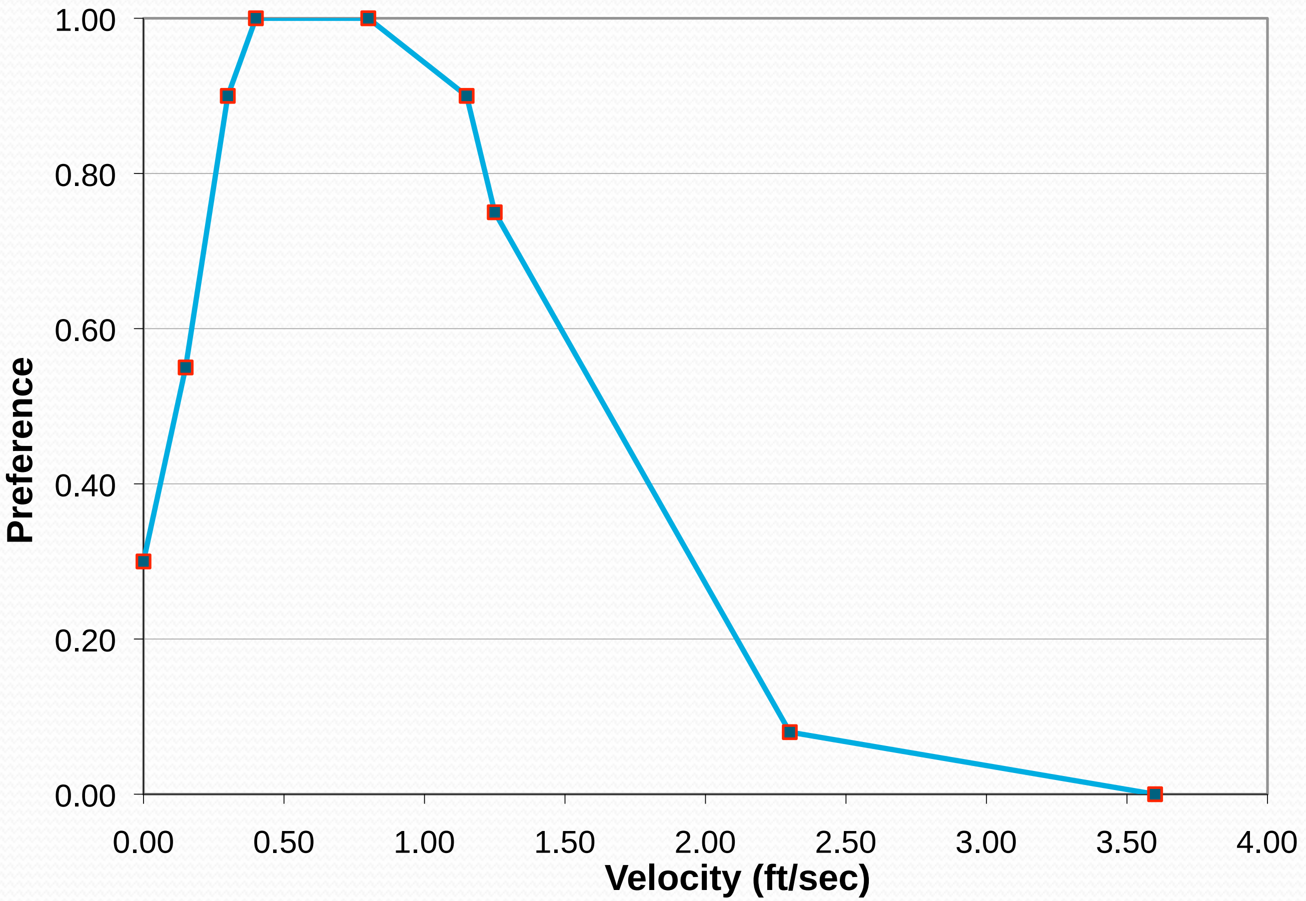
Puget Sound Energy Transects



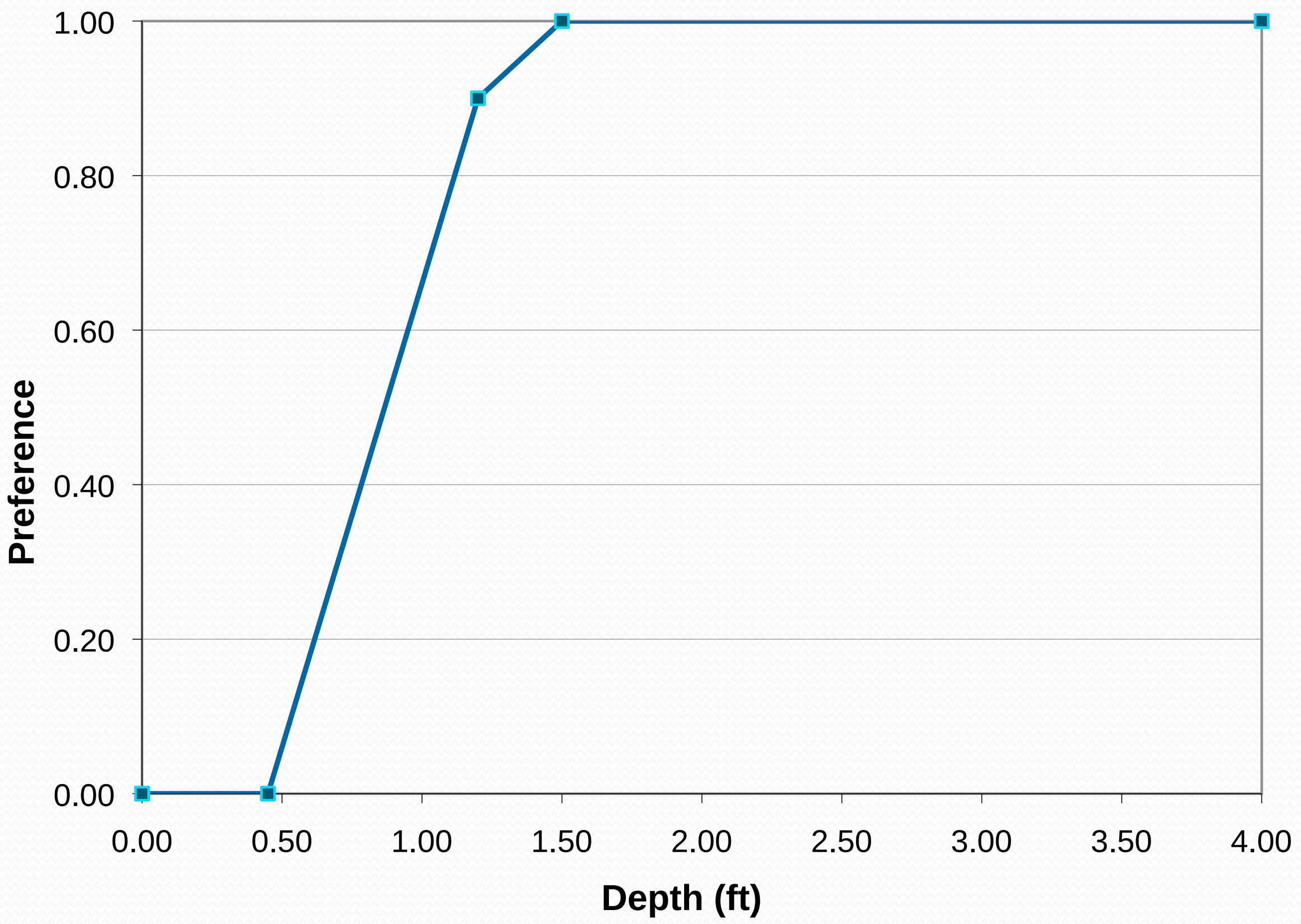
Habitat Simulation Modeling Steps

- Calibrate PSE Transects (rating curve and velocities)
- Calculate Flow Distribution at Islanded Sites
- Calculate Flow Accretion in each Reach of Middle Skagit
- Develop Preference Curves for Juvenile Chinook
- Run PHABSIM for each transect for flows ranging from 3,000 to 25,000 (low flow model), and from 25,000 to 50,000 (high flow model)
- Calculate Total Suitable Habitat in each Reach by Combining Transects (weighted sum)
- Develop Suitable Habitat and Suitable Width versus Flow Relationships for Each Reach
- Calculate Habitat Values on Daily Basis for each Reach during Spring Outmigration Period of Juvenile Chinook

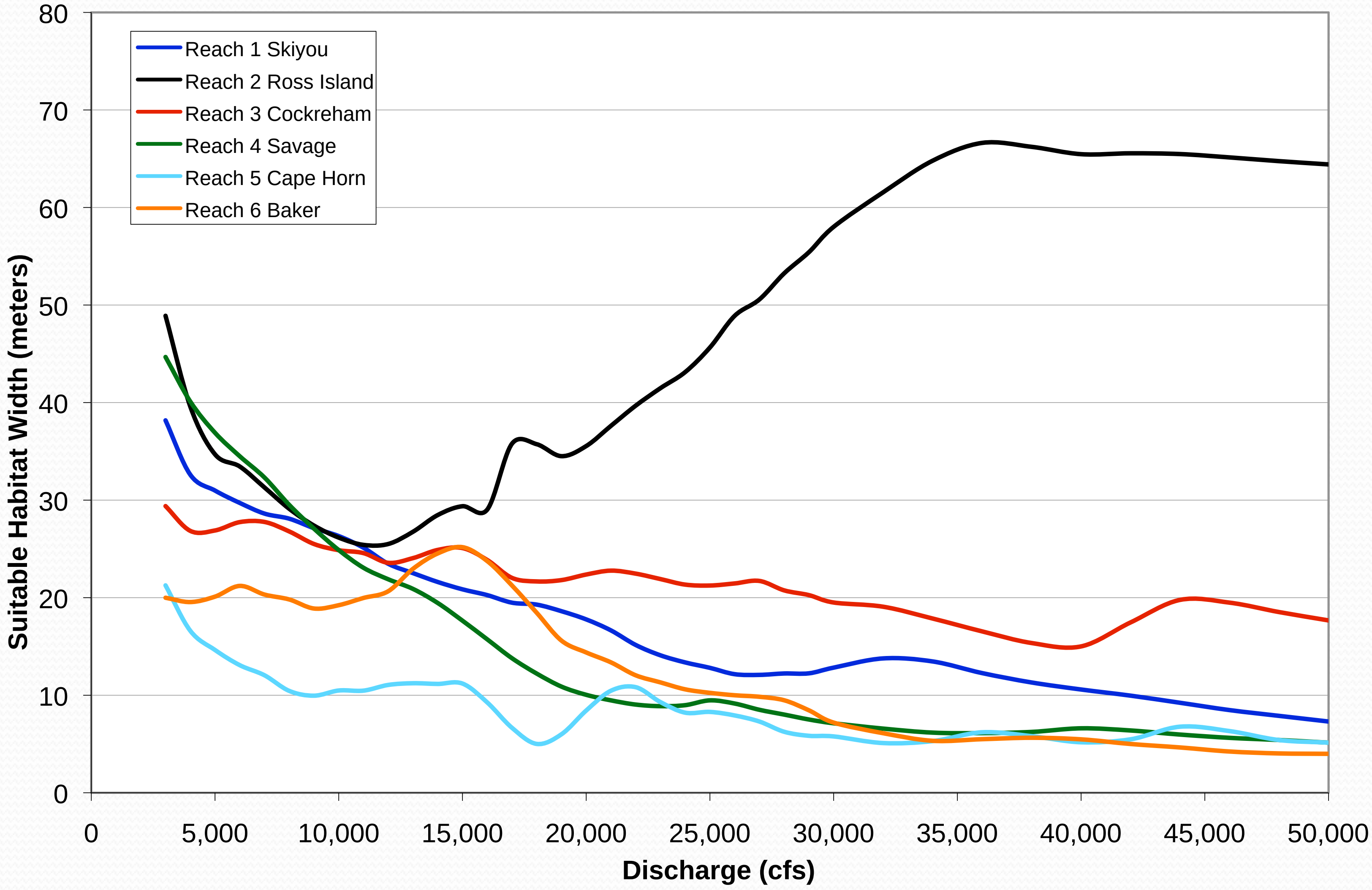
Velocity Preference Curve for Juvenile Chinook



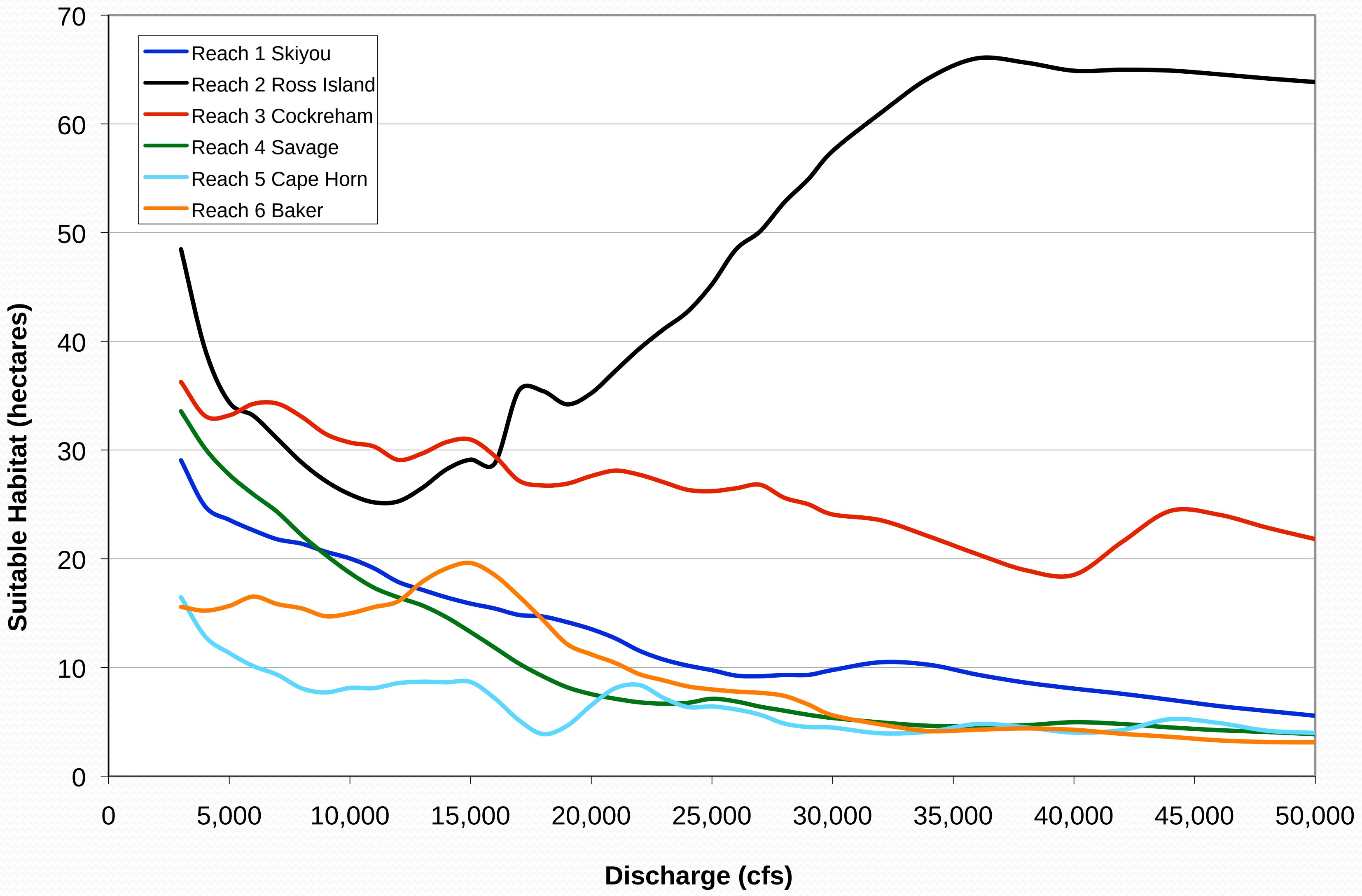
Depth Preference Curve for Juvenile Chinook



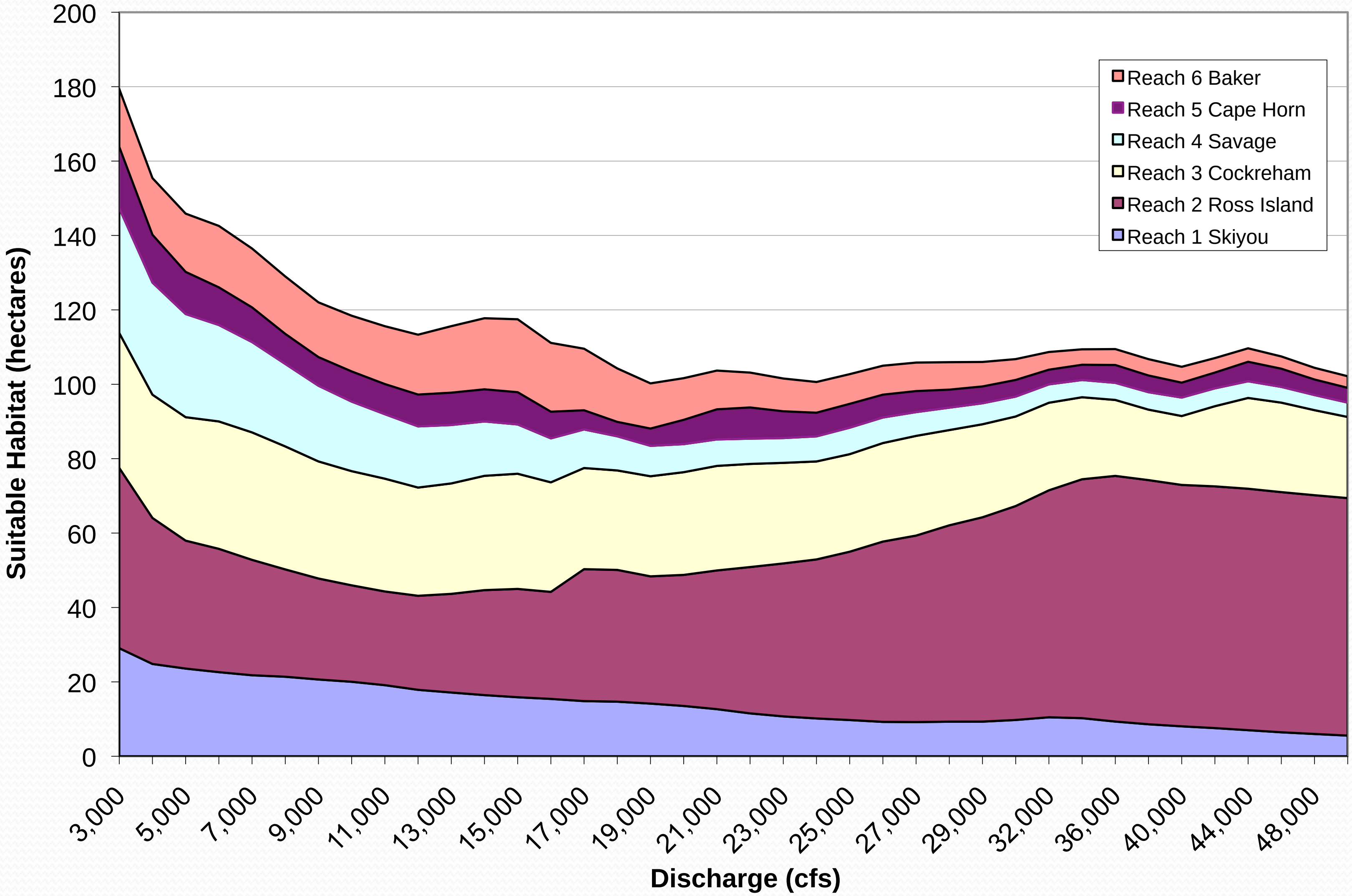
Middle Skagit Mainstem Juvenile Chinook Habitat Width Versus Flow



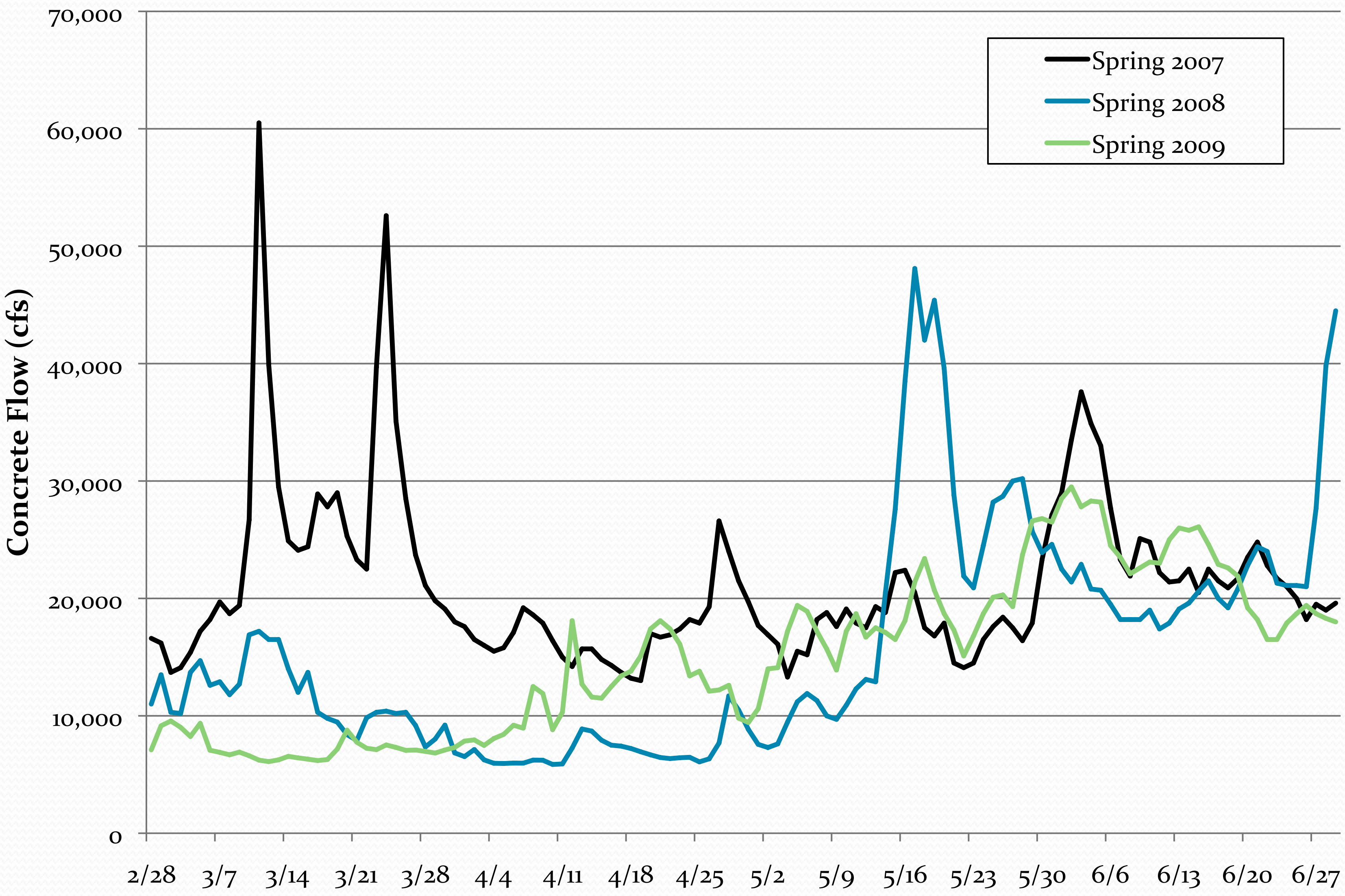
Middle Skagit Mainstem Juvenile Chinook Habitat Area Versus Flow



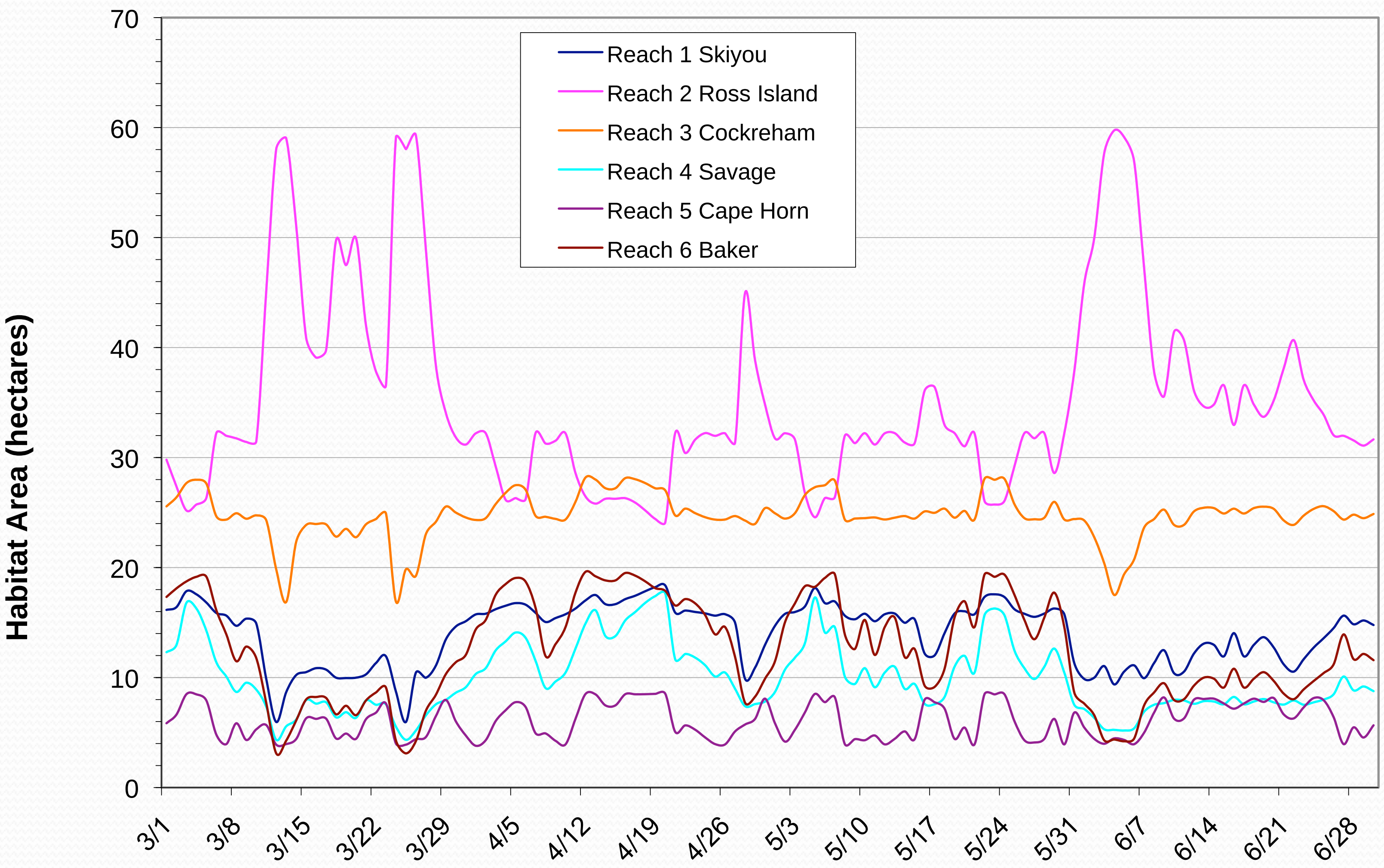
Middle Skagit Mainstem Juvenile Chinook Habitat Area Versus Flow



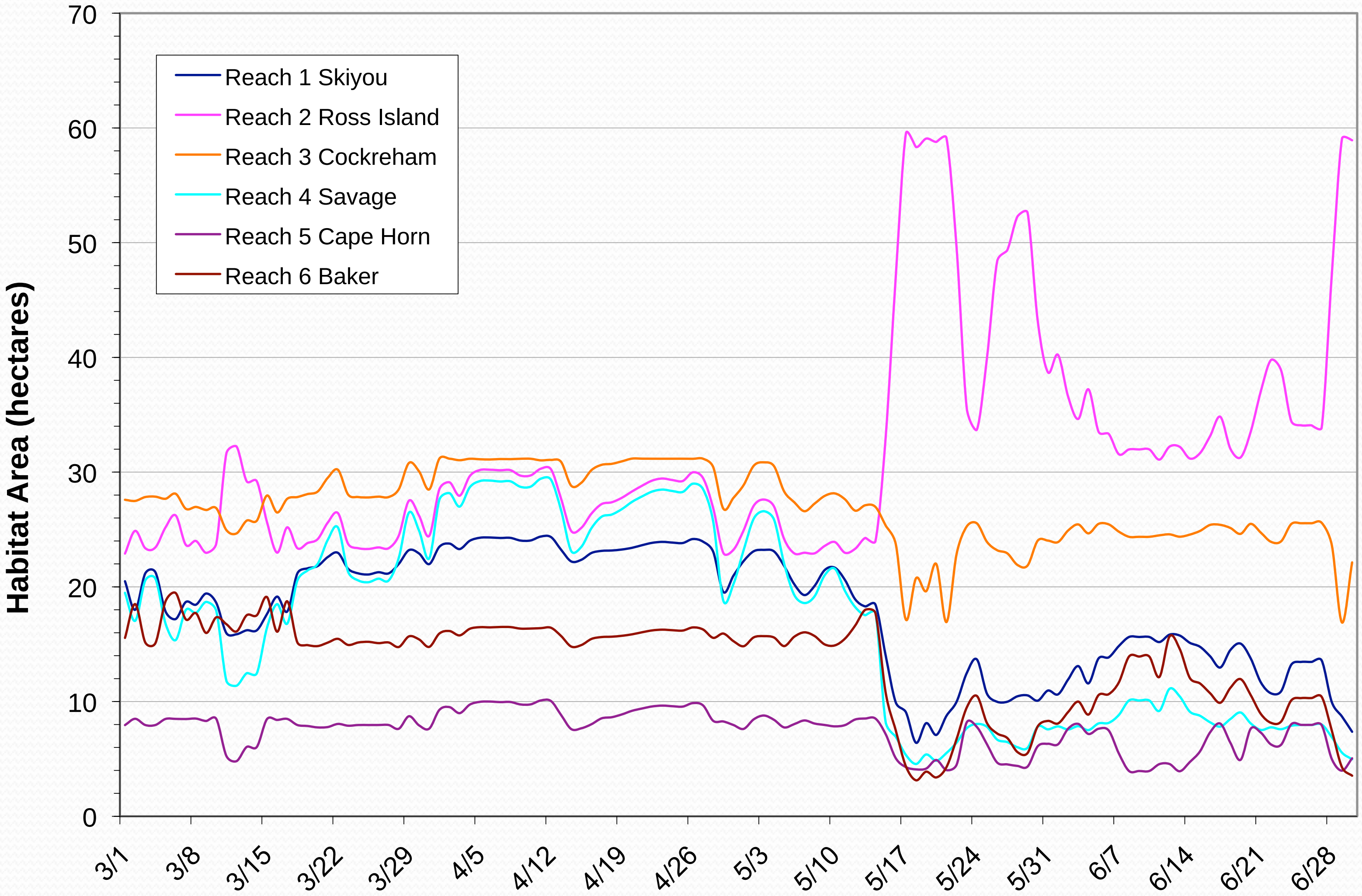
Spring Flows at Concrete Gage: 2007-2009



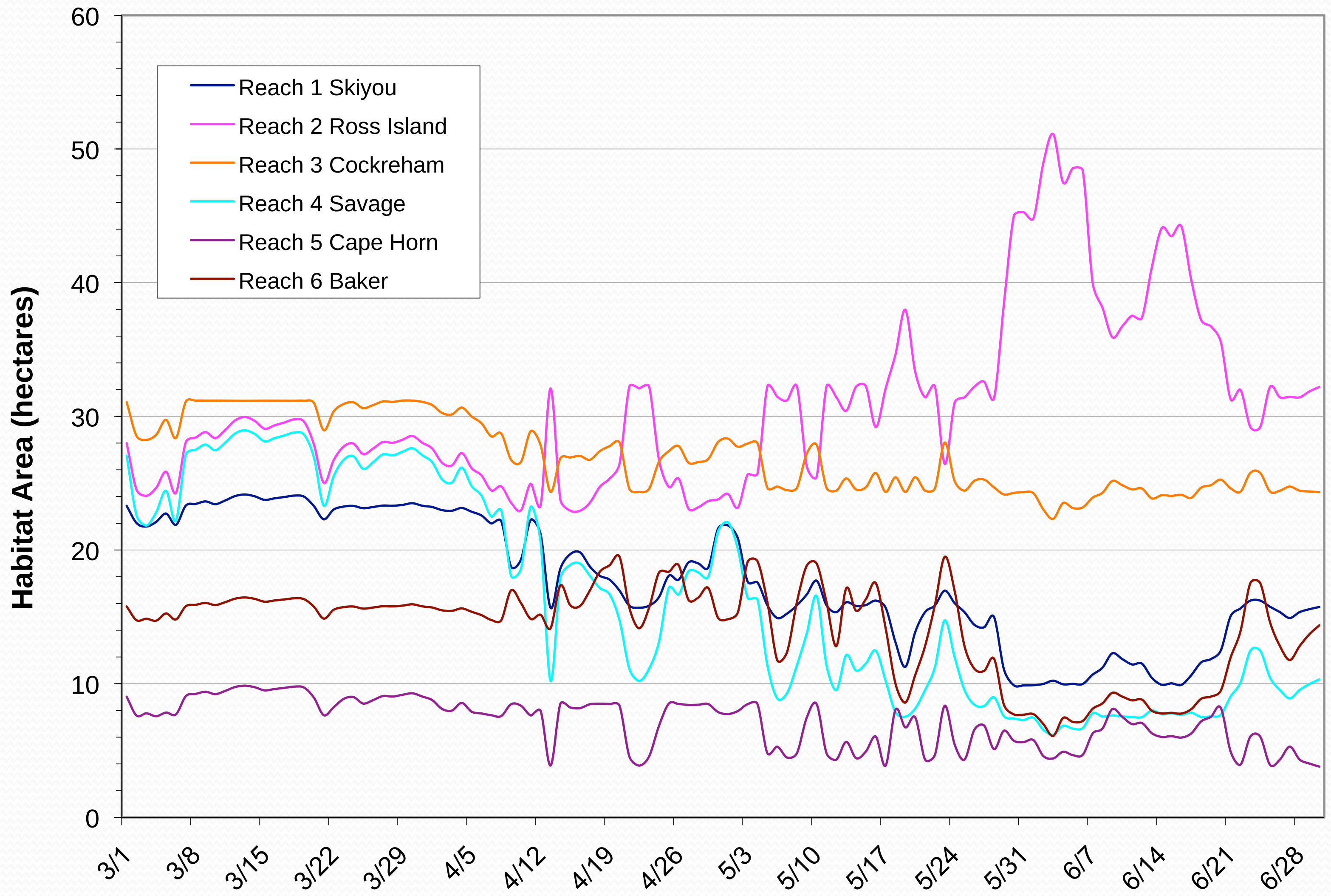
Middle Skagit Mainstem Juvenile Chinook Habitat Area – Spring 2007



Middle Skagit Mainstem Juvenile Chinook Habitat Area – Spring 2008



Middle Skagit Mainstem Juvenile Chinook Habitat Area – Spring 2009



Middle Skagit Mainstem Juvenile Habitat Statistics

Year **2007**
Period March 1 - June 30

Statistic	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	All Reaches
Mean	14.0	35.2	24.7	9.9	6.0	12.5	102.4
Minimum	6.0	24.1	16.9	4.3	3.8	3.1	95.2
Maximum	18.4	59.7	28.2	17.7	8.5	19.6	115.2
Median	15.1	32.2	24.7	9.1	5.9	12.0	100.0
7-Day Min	9.5	25.5	21.2	5.9	4.4	5.6	97.7
7-Day Max	17.5	53.8	27.8	15.8	8.2	19.1	113.5

Year **2008**
Period March 1 - June 30

Statistic	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	All Reaches
Mean	17.9	31.7	26.9	16.9	7.4	13.4	114.3
Minimum	6.4	22.9	16.9	4.6	3.9	3.1	95.8
Maximum	24.4	59.5	31.2	29.4	10.1	19.5	141.6
Median	18.8	29.4	27.2	18.1	8.0	15.2	113.4
7-Day Min	8.5	23.2	20.4	5.6	4.2	4.8	97.5
7-Day Max	24.2	55.9	31.2	29.1	9.9	17.6	140.9

Year **2009**
Period March 1 - June 30

Statistic	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	All Reaches
Mean	17.7	30.9	27.0	16.4	7.1	14.1	113.1
Minimum	9.9	22.9	22.3	6.2	3.8	6.1	96.1
Maximum	24.2	51.1	31.2	29.0	9.9	19.5	140.5
Median	17.0	29.4	26.6	14.7	7.6	15.5	111.8
7-Day Min	10.0	23.8	23.3	6.8	4.5	7.2	97.2
7-Day Max	24.0	47.8	31.2	28.6	9.7	17.5	139.3

Conclusions

- Ross Island (Reach 2) provides greatest amount of habitat in Middle Skagit. Ross Island is only reach where habitat increases with flows during spring outmigration periods (may provide habitat to fish displaced from upstream reaches).
- Cockerham (Reach 3) is second most important reach (habitat remains steady over range of flows).
- Savage (Reach 4) has abundant habitat at lower flows, but undergoes greatest decline in habitat at with increasing flows. Skiyou (Reach 1) and Baker (Reach 6) have similar pattern
- Cape Horn (Reach 5) provides least amount of habitat over range of flows during outmigration period.

Thanks to…

- Puget Sound Energy and R2 Resource Consultants
- Skagit River System Cooperative
- SWC Middle Skagit Technical Review Committee

APPENDIX E
Stakeholder Meetings Summaries

SKAGIT COUNTY
PUBLIC WORKS DEPARTMENT
1800 Continental Place, Mount Vernon, WA 98273-5625
(360) 336-9400 FAX (360) 336-9478

Muddy Creek – Sediment Management

Alternatives Feasibility Study

Tuesday, June 14, 2011, Skagit Room

Agenda

1. Team Process Check
2. Review Research Completed to Date
3. Discuss Potential Alternatives
4. Outline Next Steps

Meeting Summary

Attendees: Paul Pittman (Element Solutions), Tim Hyatt (SRSC), Wendy Cole (WDFW), Chris Kowitz (Skagit County Public Works - Operations), John Cooper (Skagit County Planning and Development Services), Jeff McGowan, Emily Derenne, and Kara Symonds (Skagit County Public Works – Natural Resources)

Alternative Identification and Stakeholder Update, Presentation by Paul Pittman, LEG

Problems

- Sediment impacts the Lyman-Hamilton Highway Bridge and can exacerbate flooding
- Past management strategies (dredging) cause fisheries impacts
- Occasional events damage the bridge and nearby roads

Objective

- Identify and explore alternatives to manage the infrastructure and fisheries impacts from a watershed perspective
- Assess the feasibility of implementing selected alternatives and develop a management strategy

Upper Watershed Characteristics

- Steep slopes, incompetent geology (e.g. soft roads), mass wasting, sediment input (phyllite and mud)
- Upper portions of the east fork of Muddy run over an historic landslide

- Avulsion potential on both the west and east fork in the upper watershed (could be triggered by large debris flows)
- Sediment dominated by angular phyllite

Mid-Watershed

- Some sediment storage and some throughput
- Additional sediment input (from glacial geology)
- Great fish habitat

Lower Watershed

- Limited sediment storage during average flows
- Modified channel
- Poor fish habitat
- Influences from the Skagit
    - Base level changes in Muddy Creek when Skagit River is high which effects deposition
    - Skagit River flooding creates reverse flow and is the cause of damage to infrastructure
- Sediment compreised more of glacial lithologies than phyllite
- Approximate 1000 CY of deposition (bedload sediment) from the bridge to confluence (2010 estimate), but will vary depending on upper watershed conditions and winter hydrologic conditions

Preliminary Alternatives

1. No Action
    a. Pros: No upfront costs, minor flooding impacts to infrastructure (potential for private property impacts and some transportation delays)
    b. Cons: Flood impacts (some maintenance), fish impacts (passage to Skagit)
2. Stabilization of Upper Watershed – Wood and/or rock toe protection at base of unstable slopes, instream gradient control
    a. Pros: Watershed scale approach, decrease sediment inputs into stream thus reducing dredging needs
    b. Cons: Expensive (large area difficult to access), uncertain success, potential consequences and risk
3. Sediment Basin and/or Removals
    a. Pros: Sediment removal worked “OK” in the past at managing flooding
    b. Cons: Fish habitat impacts and permittability, expensive over time, potential consequences and risk
4. Infrastructure Abandonment – Red Cabin Creek Road and/or Lyman Hamilton Highway
    a. Low cost and no maintenance obligation, allows for natural processes, fairly minor traffic impacts
    b. Cons: difficult and expensive to construct in future, traffic impacts

5. Infrastructure Improvements – Bridge widening and/or raising, culvert replacement and resizing, shoulder improvements for overflow
    a. Pros: Decreased maintenance obligation
    b. Cons: Some improvements are very expensive to reconstruct in the future, traffic impacts
6. Construct Setback Levees (Janicki Reach)
    a. Pros: Decreased maintenance obligation (increased sediment and flood storage), improved fish habitat
    b. Cons: Projects costs (easements, earthworks), implementation relies upon voluntary action of private property owner
7. Reroute Muddy Creek - Davis Slough or Carey's Slough
    a. Pros: Could be decreased maintenance obligation, could be improved fish habitat conditions
    b. Cons: Project costs (easements, earthworks, infrastructure), Implementation relies upon voluntary action of private property owner
    c. Permittability
8. Forestry Land Use Management
    a. Pros: Could be decreased maintenance obligation over time
    b. Cons: Forest Practices are outside of County jurisdiction, results take time to show

Discussion of Alternatives and Report Documentation by Group

The group discussed the range of alternatives presented to better focus the next phase of the research – alternatives analysis. Rerouting Muddy Creek, infrastructure modifications/abandonment, Muddy Creek levee setback scenarios, fish habitat, the connection to Davis Slough, and capturing costs of historic projects were discussed at length.

The following is a compilation of items to incorporate into the final alternatives analysis:

- A simple cost benefit analysis for the various alternatives.
- A relocation alternative for a connection to Carey's Slough through the eastern portion of the Janicki property. The County will meet with Janicki to review the proposal and assess the feasibility. Levee setback scenarios will also be discussed with the landowner. The connection of Carey's Sough to the Skagit will also need to be further explored.
- A discussion of the Cockreham Levee in context of Muddy Creek, outlining that a management strategy for the Levee is outside of the scope of this project, but actions to reduce flood levels in this vicinity will reduce the frequency of costly road and bridge damages at the Lyman Hamilton Bridge site.

- A description of the potential infrastructure abandonment decision making process for future flood events. The bridge and road will be damaged again in the future from Skagit River flood events. This study can help outline the costs and benefits to aid in the decision making processes for future repairs.
- A description of infrastructure improvement elements (existing bridge elevation, bridge replacement (widening and elevating), shoulder armoring and backsloping, road lowering for overflow, culvert resizing) and costs to each element.
- Documentation of the flood frequency at which damages occur and plotting damages to flood heights.

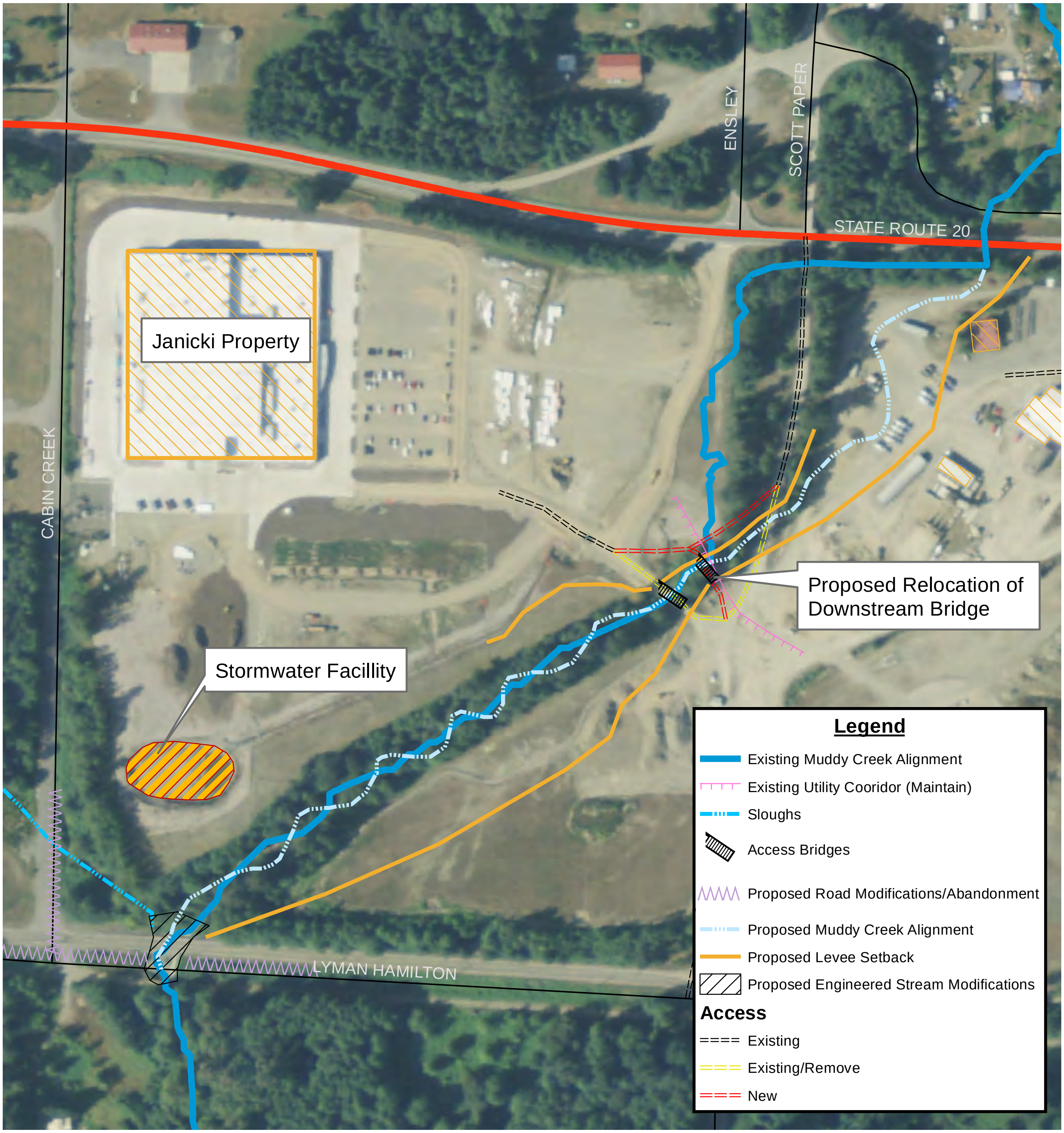
Next Steps

A draft Muddy Creek Alternatives Feasibility Study is scheduled for mid-July. The final presentation to the County and project stakeholders will take place by mid-August. The final Alternatives Feasibility Study will be distributed to all project stakeholders. The contract expires at the end of August.

APPENDIX F

Conceptual Plan Design Sketches

Note: These sketches are for discussion only and designs are subject to change. No agreements or commitments with or from landowners have been made. If a project is to go forward that includes private property, it will be with the voluntary consent of landowners.



Notes:
1. Additional road repairs west on Lyman-Hamilton Hwy

Feet
0 120 240 360 480

ELEMENT solutions

1812 Cornwall Avenue
Bellingham, Washington 98225
t: 360.671.9172
f: 360.671.4685
w: ElementSolutions.org

Earth • Energy • Environment

Muddy Creek Geomorphic Analysis

Conceptual Alternatives

Client: Skagit County Public Works

Figure F-1

Location:

DATE: July 13, 2011

Project Number:

Path: I:\GIS\SkagitCounty_GIS\ChildsCreeek\MXD\levee_alternatives1.mxd