Childs Creek Sediment Management Alternatives Feasibility Study

Prepared for Skagit County Public Works

December 17, 2012

ELEMENT solutions

CONTENTS

APPENDICES

TABLES

FIGURES

Executive Summary

The Childs Creek watershed is located within Skagit County near the town of Lyman. The watershed drains a portion of the southern flank of Lyman Hill and flows into the Skagit River via Minkler Lake and a beaver influenced wetland complex, and any number of low gradient floodplain channels (flow quantity and inlet control dependent). Childs Creek has been an ongoing maintenance problem for Skagit County at the Lyman-Hamilton Highway Bridge for many decades and periodic maintenance dredging and flooding have been frequent. Regulatory agencies have stated that the periodic dredging management strategy has had negative impacts on fisheries habitat and requested that Skagit County consider other management strategies to avoid, reduce or mitigate these impacts. In response to this request, Skagit County retained Element Solutions to assess Child Creek management alternatives from a watershed perspective and evaluate the most feasible management alternative.

The evaluation of the watershed conditions revealed that the Childs Creek alluvial fan is a dynamic system and sediment transport and deposition will forever be a maintenance and management issue so long as there remains a built environment on the alluvial fan. Sediment transport and deposition characteristics and rates are extremely variable and range from average-annual bedload deposition of approximately 500 cubic yards per year up to large events which can deposit many tens of thousands of cubic yards in a single event. The focus of this study is the smaller end of this range which has been the cause of the chronic maintenance issues that face Skagit County. Nine alternative strategies were identified to address the chronic sedimentation and address the flooding, maintenance, habitat objectives. It was learned through the development of this study that Washington Department of Transportation is considering sediment management alternatives to address sediment issues they are experiencing at the SR 20 and Childs Creek crossing. Efforts were made in this analysis to integrate management efforts since there are apparent mutual benefits offered by partnerships. The project selected as most effective and feasible consisted a sediment basin, setback levee(s), and periodic in-stream sediment management. Habitat mitigation strategies can be developed with this project suite.

The final design of a project will be realized once all the opportunities and constraints with respects to private property ownership and environmental permitting are revealed. We recommend working closely with WDFW to develop a long-term maintenance program. In addition to pursuing the active management strategies in the conceptual project described above, we recommend passive management strategies as part of the overall management strategy, such as abandoning costly and seldom utilized infrastructure and raising/widening bridges as they are replaced, and providing technical assistance to help residents who are experience frequent flood damages, and encouraging conservative forest practices. On the alluvial fan, Skagit County should continue to administer the Critical Areas Ordinance to try to minimize risk from the alluvial fan hazards through regulatory controls. Future development proposals on the alluvial fan should consider the hazards and risks that are present and mitigate accordingly.

Through the implementation of any management strategy for a dynamic system, adaptations may be needed as changes to the system, or the regulatory environment, occur. At such time, alternatives currently excluded as not feasible, may become feasible, or alternatives not identified may be needed. Given the ability to look forward in the short-term, changes to sediment removals is one project element that will need ongoing adjustments. In addition, evaluating habitat conditions will also need frequent consideration. Pursuing a monitoring program and periodic review of management practices should be part of the overall management strategy.

1 Introduction

The Childs Creek watershed is located in Skagit County, Washington east of Mount Vernon near the town of Lyman (Figure 1). Sediment deposition occurring within Childs Creek in the vicinity of the bridges at SR 20, Nicholson Road, and Lyman-Hamilton Highway (#40063) causes infrastructure impacts and that adjacent residences are experiencing flooding issues. The traffic count per day for the Lyman Hamilton Highway was 759 in 2011. The “project area” is defined as the area where deposition and flooding occur and impact the built environment (Figure 2).

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 Childs 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:
	  - managing point sources
	  - managing in-stream storage
	  - allowing for natural storage; and
	  - 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 Childs 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 Child 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:

John Cooper – Skagit County
Chris Kowitz – Skagit County
Kara Symonds– Skagit County
Anthony Hamerski– Property Owner
Cynda Graver– Property Owner
Tim Hyatt – Skagit River System Coop
Kevin Lautz – WSDOT

2 Childs Creek Watershed Analysis

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

2.1 Watershed Assessment

The hydrology, geology and geomorphic investigation and interpretation of the Childs 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 2).

Table 2: Data used for desktop analyses

Data	Format	Date	Source
Aerial photography	SID	2011	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)

2.1.1 Watershed Physiography

The Childs Creek watershed is located on the southern slope of Lyman Hill at the western front of the Cascade Mountains along the Skagit Valley (Figure 2). The watershed consists of multiple intermittent, ephemeral, and perennial mountain streams that drain a steep bedrock upper watershed, incises through relict glacial landforms in the middle of the watershed, eventually coalescing into a single branch as it exits the mountain terrain creating an alluvial fan. The lower portion of the watershed is dominated by low gradient slopes as it crosses the Skagit flood plan, where it enters Minkler Lake (a former Skagit River channel slough) and a large wetland complex where the hydrology has been altered by a relict railway grade (Centennial Trail) and frequently modified by beaver activity. Childs Creek eventually reaches the Skagit River via multiple flow paths, one of them being Tank Creek (Figure 3).

The drainage area of Childs Creek is approximately 2.1 square miles with a relief of approximately 3,475 feet (elevation approximately 65 feet at Minkler Lake and a maximum elevation of 3,520 feet) (NAVD 1988). The mean basin elevation is approximately 1550 feet (USGS 2012). The basin is generally steep with approximately 65% of the watershed having a slope of greater than 15%. Approximately 15% of the watershed area has slopes greater than 30% (LiDAR 2006)(Figure 4).

2.1.2 Channel location(s)

The Childs Creek Watershed consists of four main channels, however the majority of flow is carried by three of these channels. The eastern most two channels have a confluence approximately 300 feet up gradient of the apex of the alluvial fan and for the purpose of this report will be called the eastern and middle forks. The next channel west of the middle fork has it's confluence with the other two combined channels approximately 360 feet down gradient of the apex of the alluvial fan and will be referred to as the western fork. The fourth channel does not have a confluence with the other combined channels until below the Lyman-Hamilton Highway and for this report has been called "Little Childs Creek".

The Little Childs Creek contributes flow and sediment below are study area therefore it has been mostly excluded from our project analysis.

2.1.3 Hydrology

The drainage area of Childs Creek is approximately 2.1 square miles with a relief of approximately 3465 feet. The elevation at the Lyman-Hamilton Highway Bridge is approximately 80 feet (NAVD 1988). The mean average precipitation within the basin is approximately 60.4 inches (USGS 2012, 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 resulting rise in freezing level can rapidly melt snow and with the addition of rain (rain-on-snow event), can cause extreme flooding events.

The Childs 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 feet and 4,000 feet (365 m to 1220 m) (Washington Forest Practices Board, 1997). Lyman Hill, which has multiple watersheds on it, with Childs Creek basin being one of them, is approximately 4,300 feet at its maximum (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 Childs Creek (approximately bankfull) is approximately 83.7 cubic feet per second (cfs)(USGS 2012). These events are significant for channel forming processes and sediment transport. A 100-year return period peak discharge is approximately 251 cfs for clear-water type floods (USGS 2012). These larger events are important for landscape forming processes. No gauging station exists for Childs Creek or nearby basins; therefore, peak discharges were estimated using published regional regression equations

(Sumioka et al, 1998) and are presented in Table 3. 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 3: Estimated Peak Discharges for Childs Creek at SR 20

Return Interval	Discharge (cfs)	Standard Error (%)
2-year	83.7	56
10-year	152	53
25-year	189	53
50-year	223	53
100-year	251	54
500-year	331	--

The residences located on the banks adjacent Childs Creek upstream of the Lyman-Hamilton Highway Bridge report to have been flooded several times in the past 10 years and they claim that the frequency of flooding has increased since 2009 (C. Garver, personal communication) Cynda Garver who own property on the eastside of the creek directly south of State Route 20 reported that the 2009 a rain on snow event caused Childs Creek to flood and sent 0.5 to 2 feet of water running through their property, which damaged their house and barn and necessitated the evacuation of humans and livestock (Photo 1; Figure 5). Topographic depressions south of their home also allow the flooding to extend across Robinson Road and flood properties to the east of Robinson Street.

Photo 1: Flooding from Childs Creek near Robinson Road in 2009. Photo courtesy of Cynda Garver.

2.1.4 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 glaciations. Continental glaciers have occupied the Skagit Valley at least four times over the past 1.6 million to 10,000 years. These glacial stades and interglacial periods have greatly altered the landscape by eroding bedrock, and depositing large amounts of sediments. The most rescent glaciation was the Fraser Glaciation which occurred in the late Pleistocene and transitioned into the Holocene (approximately 21,000 to 10,000 years before present). Glacial deposits from the Fraser Glacieation and previous stades now 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).

Childs Creek Watershed

The geology of Childs Creek watershed consists of bedrock that has been eroded by glacial advances and retreats with varying amounts and types of glacial sediments overlaying the bedrock. These glacial deposits have since been incised through downward cutting by Childs Creek through the basin and within the Skagit Valley by the Skagit River and other tributaries.

The bedrock below the basin has been reported (Dragovich et. al 1999, Brown 1986) and observed (field observations 2012) to be Darrington Phyllite (Jurassic phyllite, phylonites, and greenstone). The bedrock is mantled with glacial deposits from the Vashon Stade and Everson Interstade, which have been interpreted by Dragovich et. al (1999) as glacial till, advance outwash, glacial marine drift, and terrestrial to glacial marine outwash. Others have interpreted portions of the glacial deposits as glacial lacustrine deposits (Riedel 2007, Riedel 2008, McShane per. communication 2012). These lacustrine deposits would have been derived when the Puget ice lobe blocked the drainage of the Skagit Valley forming a temporary lake.

Interpretations

For this assessment, we subdivided the Childs 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).

Upper Watershed Reach

The Upper Watershed Reach of Childs Creek is defined as the area of the basin that exhibits a generally steep slope and is above the glacial terraces. The upper watershed is dominated by steep stream gradients ranging from 20% to 40%, the geomorphology of the stream channel consist of primarily steep walled narrow gorges with some slope failures, slumping, and tree throws. The stream itself consists of pools, cascades, falls, and woody debris jams (with and without sediment impoundment). The upper watershed is predominately an erosional and transport reach. The Darringtion Phyllite is exposed in most places within the stream gorges both at the base of the gorge and on the side walls. A mantle of glacial deposits ranging between 1 to 20 feet thick overlays the phyllite between the gorges. The soils of the upper basin are predominantly loams ranging from gravelly silt loam to gravelly loam, permeability is typically moderate above the glacial till and slow below it (Figure 8, soils from 2009 USDA-NRCS).

Mid Watershed Reach

The Mid Watershed Reach of Childs Creek is defined as the area of the basin that exhibits generally moderate slopes, incises through the glacial terraces, and terminates at the apex of an alluvial fan. The Mid Watershed Reach is dominated by moderate gradients ranging from 10% to 20%, the geomorphology of the stream channel consist of steep walled gorges that are slightly wider and have a larger amount of slope failures, slumping, and tree throws when compared to the upper watershed gorges. The stream itself consists of pools, riffles, cascades, woody debris jams (with and without sediment impoundment). The mid watershed is predominately an erosional and transport reach. The western fork of Childs Creek has a wider incised valley compared to the other two forks, and shows signs of braiding and multiple channel development. The Darringtion Phyllite is exposed in some places within the stream gorges primarily at the base of the gorge and on the side walls in some locations. A mantle of glacial deposits ranging between ~20 to ~250 feet thick overlays the phyllite between the gorges. The soil of the mid basin arranges from a very gravelly loam to loam with a typically rapid permeability and low water capacity (Figure 8, soils from 2009 USDA-NRCS).

Lower Watershed Reach

The Lower Watershed Reach of Childs Creek is defined as the area of the basin that exhibits generally low slope, travels across the Skagit Valley, and terminates at Minkler Lake. The Lower Watershed Reach is dominated by low gradients ranging from 3% to 5%, the geomorphology of the stream channel consist of small alluvial fan at the top of the reach and shallow banked aggrading stream that travels across the Skagit Valley by occupying several historical Skagit River channels (LiDAR 2006). The stream itself consists of pools, riffles, glides, runs, and some side channels and braided morphology. The Darringtion Phyllite bedrock is not present in this portion of the stream. The lower watershed is predominately a depositional reach. The lower watershed crosses relict Pleistocene outwash channels and Holocene alluvium from floodplain deposits from the modern Skagit River. The soils of the lower basin are predominantly loams ranging from silt loam to very gravelly sandy loam, permeability is typically moderate to rapid (Figure 8, soils from 2009 USDA-NRCS).

An alluvial fan has formed where Childs Creek exits the slopes of Lyman Hill and enters the Skagit Valley. The alluvial fan is hypothesized to be a composite alluvial fan created by both floodwaters and debris flows; however, no trenching of the fan has been conducted to confirm this hypothesis. The alluvial fan transitions into relict fluvial channels and floodplain terraces (piedmonts) and eventually into the modern Skagit Valley floodplain at Minkler Lake.

Background on Natural Hazards and Alluvial Fan Risks
Many natural hazards exist within the study area. These hazards include, but are not limited to:

- landslide hazards (including debris flows);
- flooding hazards;
- volcanic hazards (including lahars); and
- seismic hazards.

The purpose of this study was not to assess the natural hazards (the source of danger) or the risks (the probability of occurrence and the consequences) within the study area. However, it should be noted that many of these hazards could impact the infrastructure and community located on the alluvial fan and 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 historic research that debris flows from the upper watershed occur with moderate frequency and we saw evidence of fairly large debris flows occurring within the watershed. 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 (Photo 2 below).

Photo 2: Hamerski residence, 1983. The house was unoccupied at the time it was impacted by debris and transported 100 feet downstream of its foundation. In the same storm event, a debris flow fatality occurred in Skagit County near SR 9.

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 a large portion of sediment adding to the volume and therefore discharge. The empirical equation:

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

was derived for bouldery to muddy debris flows in southwestern British Columbia (Jakob, 1996). Applying this equation to a small Childs 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 ~4 times higher than the estimated 100-year return period flood flow of 251 cfs.

A detailed debris flow analysis was completed on the Jones Creek alluvial fan near the town of Acme in Whatcom County. The basin geology, elevation and size is comparable to that of Childs Creek. 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.

Childs Creek also experienced a significant debris flow in 1983 that came down the West Fork of Childs Creek. The debris flow originated from a failure of an orphaned logging road in the middle of the watershed (Photo 3 & 4). The 1983 debris flow delivered approximately 10,000 to 15,000 cubic yards of sediment in a single event and resulted in an estimated instantaneous peak discharge of approximately 4000 cfs where the 100-year return period clear water flood is calculated to be 251 cfs. During this event Mr. Hamerski's house, which was located near the apex of the alluvial fan and the confluence of the three forks, was destroyed and moved 100 feet off its foundation by debris (Photo 2, preceding page). During the 1983 debris flow event a large volume of material was deposited across the majority of the alluvial fan. This material consisted of a wide range of sediment from sands and fines to car sized boulders as well as large and woody debris (Photo 5). The flow cause extensive flooding and debris requiring the closure of State Route 20 until it could be cleared. Additionally the debris flow resulted in the alteration of the stream channel location. Prior to the debris flow Childs Creek flowed more westerly from the apex of the alluvial fan and crossed perpendicular to State Route 20. Currently the stream flows directly south from the alluvial fan apex until it reaches State Route 20 before turning 90 degrees and following it until it reaches the bridge at which point it makes another 90 degree turn (Figure 2). This new Childs Creek channel alignment has been maintained over the years by both Mr. Hamerski , and Washington State Department of Transportation. A collection of photos provided by Mr. Hamerski following the 1983 debris flow event is presented in Appendix A.

Photos 3 & 4: Initiation point of 1983 debris flow (Photos courtesy of Mr. Hamerski).

Photo 5: Debris broadcast across the alluvial fan included "car-sized" boulders, gravel, mud, and wood debris. Looking south across the alluvial fan toward SR 20. Photo by A. Hamerski.

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. Childs Creek has a significant amount of sediment stored in its upper and mid-watershed. 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.

2.2 Watershed History

2.2.1 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 land use 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. Several of these older forestry roads were observed during our field analyses, and are visible on the LiDAR image of the basins (Figure 4).

2.2.2 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 2 & 3 shows the present infrastructure in place in the lower Childs Creek watershed study area. Today, major infrastructure includes Washington State and Skagit County roads, bridges, and power lines.

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 Lyman (Figure 2).

The original Lyman-Hamilton Highway bridge was replaced in 1948 and remains in use today. The current bridge is not scheduled for replacement in the near-term. The last Hydraulic Project Approval issued by Washington Department Fish and Wildlife in 2007 requested as mitigation that the bridge be replaced by 2009 through the Transport Improvement Program (WDFW HPA 110707-1).

It is believed the Nicholson Road Bridge was constructed in 1950s and is currently in use. The current bridge is not scheduled for replacement in the near term.

The State Route 20 Bridge was constructed in approximately the 1960s and is currently in use. The current bridge and maintenance is currently being evaluated. This bridge has been identified by WSDOT as a Chronic Environmental Deficiency (CED) and an analysis has been initiated to assess the alternative management strategies to manage it.

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.

2.2.3 Historic Infrastructure Maintenance

Recent records (1996-2006 HPAs; Appendix A) of maintenance on the Lyman-Hamilton Highway Bridge, Nicholson Road Bridge, and State Route 20 Bridge show that frequent, but relatively small quantities of sediment removals are routine. The documented maintenance history as reported through HPA permits and letters from private landowners is shown in Table 4. Discussions with the Skagit County personnel, local residences, and field observations indicate that all three bridges routinely had dredging occur to clear the deposition of sediment under the crossings. It is likely that dredging increase in the 80's due to the increase sediment pulse release by the 1983 debris flow. It is possible, but not confirmed, that dredging occurred ever 1 to 4 years until 2007 when WDFW mandated the further dredging would not be allowed due to possible impacts to priority habitat and species.

Table 4: Documented Maintenance on Childs Creek (Skagit County works and others as noted)

Year	***Activity***
1978	Private landowner build levees, detention ponds, upstream of Hwy 20 Bridge
1983	Dredging at Lyman-Hamilton Hwy (and SR 20)
1990/1991	Dredging at Lyman-Hamilton Hwy
1996	Dredging at Lyman-Hamilton Hwy
2000	Dredging at Lyman-Hamilton Hwy
2002	Dredging at Lyman-Hamilton Hwy
2006	Dredging at Lyman-Hamilton Hwy
2007	Dredging at Lyman-Hamilton Hwy

*Note: It is likely that additional, undocumented maintenance occurred beyond what was referenced in Table 4.

2.2.4 Current Development and Land Use

Currently developments and land use 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 land use 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 as interpreted from air photos.

2.2.5 Existing Reports

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

2.2.6 Hansen Watershed Administrative Unit Report (DNR, 1994)

The Washington Department of Natural Resources (DNR) initiated a Level 1 watershed analysis in the Hansen Watershed Administrative Unit (WAU) in 1994. The Hansen WAU includes the following drainages:

- Hansen Creek;
- Coal Creek;
- Wiseman Creek;
- Tank/Childs Creek; and
- Jones Creek.

The Hansen WAU was selected as a priority based on present/future fisheries values, reduction of fish habitat productivity and the likelihood of continued high levels of forest practice activities.

Land-Use History

A land-use history included in the WAU indicates that railroad logging of the Skagit River floodplain and lower terraces began in the late 1800's, with the first logging of the lower slopes in the WAU starting in about 1905. Much of the area had been logged by 1940, apart from the highest elevations in the watersheds. By this time, agriculture was the dominant land-use on the floodplain and low terraces. Upper elevations in the watersheds were harvested in the 1960's and 1970's.

Mass Wasting

Shallow-rapid landslides and debris torrents are the dominant mass wasting processes in the Hansen WAU, accounting for nearly 95% of the inventoried failures. Other processes included sporadic deep-seated landslides, gullying, and stream-channel destabilization. In addition, large-scale ancient failures involving bedrock and/or till were identified in middle to upper elevations of the watersheds. The assessment identified forestry activities as being associated with many of the landslides included in the mass wasting inventory.

The mass wasting module identified three major mapping units in Childs Creek associated with mass wasting: Inner gorges; Incised stream channels; and Glacial Terrace Escarpments

A mass wasting inventory was conducted using historical air photographs. Mass wasting events in Childs Creek are summarized in the following table (Table 5).

Table 5: Mass wasting inventory for Childs Creek (from Hansen WAU, 1994).

Year	Description
1943, 1948, 1956	No documented mass wasting events in Childs Creek
1970 (approx.)	1. Shallow-rapid landslide/debris; elevation: 2500 ft; source area: incised channel, road landing, parent material: till/phyllite; sediment delivered to watercourse.
Pre-1983	1. Shallow-rapid landslide/debris; elevation: 350 ft; source area: inner gorge carved in glacial terrace, 50 year old forest, parent material: glacial; sediment delivered to watercourse. 2. Shallow-rapid landslide/debris; elevation: 350 ft; source area: inner gorge carved in glacial terrace, 50 year old forest, parent material: glacial; sediment possibly delivered to watercourse. 3. Shallow-rapid landslide/debris; elevation: 400 ft; source area: inner gorge carved in glacial terrace, 50 year old forest, parent material: glacial; sediment delivered to watercourse. 4. Shallow-rapid landslide/debris; elevation: 400 ft; source area: inner gorge carved in glacial terrace, 50 year old forest, parent material: glacial; sediment delivered to watercourse. 5. Shallow-rapid landslide/debris; elevation: 350 ft; source area: inner gorge carved in glacial terrace, 50 year old forest, parent material: glacial; sediment possibly delivered to watercourse. 6. Shallow-rapid landslide/debris; elevation: 500 ft; source area: inner gorge initiated in headwall of terrace, old road landing top of failure, parent material: glacial; sediment delivered to watercourse. 7. Shallow-rapid landslide/debris; elevation: 2,800 ft; source area: incised channel, clear-cup 20-50 years ago, parent material: till/phyllite; sediment delivered to watercourse. 8. Shallow-rapid landslide/p??; elevation: 2,550 ft; source area: incised channel, clear-cut 20-50 years ago, parent material: till/phyllite; sediment delivered to watercourse, 500ft of channel affected.
1983	1. Shallow-rapid landslide/debris torrent/debris; elevation: 2,400 ft; source area: incised channel, road landing, parent material: till/phyllite; sediment delivered to watercourse. Debris torrent ran for 10,000 ft. 2. Shallow-rapid landslide/debris torrent/debris; elevation: 1,300 ft; source area: inner gorge, clear-cut 8 years ago, parent material: till/phyllite; sediment delivered to watercourse. Debris torrent ran for 500 ft. 3. Shallow-rapid landslide/debris; elevation: 1,200 ft; source area: planar slope, clear-cut 8 years ago, parent material: till/phyllite; sediment not delivered to watercourse. Debris torrent ran for 500 ft.
1984-1991	1. Shallow-rapid landslide/debris; elevation: 250 ft; source area: concave part of inner gorge in glacial terrace, clear-cut 0-10 year ago, parent material: glacial; sediment delivered to watercourse. 2. Shallow-rapid landslide/debris; elevation: 200 ft; source area: inner gorge in glacial terrace, 50 year forest, parent material: glacial; sediment delivered to watercourse. 3. Shallow-rapid landslide/debris; elevation: 300 ft; source area: inner gorge in glacial terrace, 50 year forest, parent material: glacial; sediment probably delivered to watercourse. 4. Shallow-rapid landslide/debris; elevation: 250 ft; source area: glacial terrace escarpment, 50 year forest, parent material: glacial; sediment not delivered to watercourse.
Note: Adapted from Form A-1 from Hansen WAU (DNR, 1994).	

As Table 5 indicates, there have been at least 16 landslides in the Childs Creek watershed, most of which delivered sediment to Childs Creek or its tributaries. At least some of the 1983 mass wasting activity was likely triggered by a severe storm that occurred Jan. 9-10, 1983, as well as triggers related to logging activities and logging roads.

2.2.7 Coal Creek Alternatives Feasibility Study (Element, 2008)

This report was prepared by Element Solutions and Kerr Wood Leidal Associates Ltd. and commissioned by Skagit County Department of Public Works in order to assess the Coal Creek watershed, and develop and evaluate the feasibility of management alternatives in the watershed context.

The report summarized a comprehensive understanding of management issues from a watershed perspective (fish habitat conditions, land use, slope stability, sediment transport, public safety, and infrastructure management); identified and performed an analysis of management alternatives; identified the most viable and sustainable management alternative to address the problems of Coal Creek; and developed a funding strategy for implementation.

2.2.8 Muddy Creek Management Alternatives Feasibility Study (Element, 2011)

This report was prepared by Element Solutions and commissioned by Skagit County Department of Public Works in order to assess the Muddy Creek watershed, and develop and evaluate the feasibility of management alternatives in the watershed context.

The report summarized a comprehensive understanding of management issues from a watershed perspective (fish habitat conditions, land use, slope stability, sediment transport, public safety, and infrastructure management); identified and performed an analysis of management alternatives; identified the most viable and sustainable management alternative to address the problems of Coal Creek; and developed a funding strategy for implementation.

2.2.9 Site and Reach Assessment Evaluation of Treatment Alternatives (WSDOT, 2005)

This report was prepared by Washington State Department of Transportation as part of the Chronic Environmental Deficiency program in order to provide for highway improvements to specific locations where repeated maintenance and preservation activities create unacceptable environmental impacts. Chronic environmental deficiency problems are identified and prioritized using an environmental retrofit index, which gives special weight to protection of fish habitat (WSDOT, 2002).

The report summarized a comprehensive understanding of the chronic sedimentation issues associated with the Highway 20 stream crossing at Red Cabin Creek. The report detailed the sedimentation, continued excavation needed to keep the bridge functioning, and the adverse impacts to fish and fish habitat associated with dredging and high sedimentation rates. These impacts included direct mortality due to channel dewatering, scouring of redds, and reduced cover due to filling of pools. Additionally the report found that Highway 20 was susceptible to frequent inundation and road closures and was at a risk of failure due to erosion of the bank downstream of the culvert.

The report evaluated 4 alternatives including 1) No action, 2) Elevate the road at the Red Creek crossing, 3) Modify the channel, 4) Construct a sediment retention basin. Furthermore this report recommended that the elevation of the road grade was the most efficient way to satisfy their stake holders and rectify this environmental deficiency.

2.2.10 Biological Evaluation, Essential Fish Habitat Assessment, and Determination of Effect (Welch, 2004)

This report was prepared by Skagit Fisheries Enhancement Group (SFEG). The purpose of this report was to evaluate the impacts of a purposed salmon restoration project on sensitive, threatened, or endangered species.

The report found that bull throat, bald eagles, marble murrelets, Puget Sound Chinook, and coho salmon all have been found within the vicinity of Childs Creek. However, the report also concluded that the restoration project would have “no effect” or “not likely to effect” any of this listed species.

2.2.11 A Report Summarizing Monitoring Activities and Results for the Skagit Fisheries Enhancement Group (Welch, 2006)

This report was prepared by the SFEG. The purpose of this report was to update the status of SFEG’s salmon enhancement projects monitoring reports, and bring to date their 2003 report and document the data collected over the previous 7 years.

The majority of this report addressed streams outside of the Childs Creek watershed, however a portion of the report referred to two restoration projects that have occurred on the Hamerski and Garver properties. The Hamerski restoration projects were completed in 1996 and 2001. The Garver project was completed in 2005.

This report references that before the 1983 debris flow Childs Creek contain salmon runs of coho, pink, chum and steelhead. After the 1983 event only two steel head were observed until 1996. After the completion of the restoration projects survey were conducted that showed a return of large numbers of salmon until 2005-2006 spawning season when the numbers dropped off again (Table 6).

Table 6: Spawning Salmon Survey for Childs Creek (from Welch, 2006 and SFEG website 2011).

Year	Live Coho Carcasses	Coho Redd	Steelhead	Steelhead Redd	Rainbow	Sea-Run Cutthroat	Sea-Run Cutthroat Redd
1998	9	3	--	--	--	--	--
1999-00	--	--	--	--	--	--	--
2000-01	168	69	4	16	8	5	4
2001-02	295	71	--	--	2	2	--
2002-03	8	--	--	--	--	--	--
2003-04	329	57	--	--	--	--	--
2004-05	307	92	--	--	--	--	--

2005-06	--	--	--	--	--	--	--
2006-07	--	--	--	--	--	--	--
2007-08	--	--	--	--	--	--	--
2010-11	113	45	--	--	--	--	--
2011-12	19	3	--	--	--	--	--

2.2.12 Terrain Stability Field Assessment (Gold 2004)

This report was prepared by John Gold & Company in cooperation with Golder and Associates Ltd., it was commissioned by Mr. William Blunt in order to assess the terrain stability related to forest harvesting and a Forest Practices Application.

The report evaluated the terrain stability conditions on Mr. Blunt's and Mr. Hamerski's property in and around the confluence of the Child Creek Forks with the intention of developing a forest harvest plan. This report described the background geology and land use history as well as found four types of landforms that are found in this area. This area is dominated by landforms that include Glacial Terrace Escarpment and Inner Gorges, with some Steep Stream Banks and Slopes.

2.2.13 Geological Hazard Assessment (Stratum Group 2007)

This report was prepared by Dan McShane of Stratum Group, it was commissioned by Mr. William Blunt in order to assess the slope stability and build set back related to a proposed residential development

The report evaluated the geological hazards and conditions on Mr. Blunt's property east of the confluence of the Child Creek Mid Fork and Eastern Fork with the intention of developing a necessary setback for building on the property. This report described the background geology, land use history, and the stability of the slopes.

2.3 Sediment Analysis

The stream sediment of interest in this analysis is bedload sediment that is deposited in the study reach of the alluvial fan to Lyman-Hamilton Highway Bridge at Childs Creek. The bedload size fractions depositing in this area are dominantly course sand through cobble based on the Wentworth Scale (see definitions below). Collectively, the size fractions between granule and cobble are termed "gravel". To evaluate the sources, transport nature, and volumes of the sediment in the Childs Creek watershed and to assess the conditions at the bridge, we performed a reconnaissance-level sediment budget.

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

Bedload sediment transports by rolling, tumbling, or saltating along the channel bed. Most bedload sediment is transported during higher flows. Debris flows transport all ranges of sediment in one non-Newtonian flow “mass”. While debris flows do and will occur in this stream system, they are not the management focus of this analysis. In addition, this study does not consider suspended sediment nor the associated impacts.

2.3.1 Reach Characterization

For the purpose of this analysis, we defined three sub-reaches based primarily on stream morphology, slope, geology, and sediment processes. A slope map generated from the LiDAR is shown in Figure 4.

Upper-Basin Sediment Processes

The upper watershed is step and the channel has incised into the bedrock and glacial geologies. Channel form is generally straight with little to no floodplain and the channel stores very little material over the long-term as storage is temporal in nature. Large boulder lag remains in the channel and sediment wedges form behind boulder lag or woody debris. The upper watershed is, over the long-term, supply limited and incision is still occurring. Sediment delivery occurs as steep inner gorges collapse and erode. Evidence of shallow rapid landslides (photo 6 at right), larger rotation failures, and colluvial creep are the primary forms of mass wasting delivering sediment to the channel. Tree-throw and bioturbidation also deliver

Photo 6

sediment, but at a small level when compared to the other inputs. The effects of logging are difficult to quantify, but literature and observations overwhelmingly supports that the changes in hydrology and surface water routing resulting from timber harvest and road construction do affect hill-slope processes and stability, and therefore increase contribution of sediment to the system.

Sediment delivery to the system in this reach occurs in two primary ways, episodic and chronic. Episodic delivery results as mass wasting events occur and deposit large volumes of sediment to the stream. Locally, transport limited conditions may result as the stream can only remove portions of the sediment input and therefore there is an increase of in-stream stored sediment, or if the conditions are favorable, the sediment delivery could trigger a debris flow and the stream will transport the sediment through the system to be deposited further downstream, potentially at the alluvial fan. The sediment delivered to the system that becomes stored is often stored only temporarily until such time that higher stream flows and erosion mobilize the stored sediment and transport it down stream, therefore contributing to chronic sediment delivery.

We estimated that the average quantity of material stored in the channel to be less approximately 2 cubic yards per 1 lineal yard of channel. Using this estimate, the three primary forks in this reach have approximately 15,000 cubic yards of sediment stored in the channel. Much of this material is larger boulders and cobbles which are transported only during very large flow events and debris flows, and this material only reaches the alluvial fan area during debris flows. As a result, the bulk of this stored sediment is not part of the management concern of this study, but would be if this study focus was assessing debris flow potential and risk.

Photo 7

Sediment delivery (creep, colluvial unraveling and shallow rapid failures in this example)

Channel cross-section

Sediment storage (debris/boulder formed sediment “wedges” in this example)

Over the long term, the upper watershed could contribute to the largest portion of cumulative bedload sediment to the subject management reach, in part because of the total stream lengths are greater than in the middle reach, the high frequency of shallow rapid sediment delivery, and the characteristics of sediment delivered (bedrock derived sediment inputs have a higher percentage of course grained “bedload” sized sediment per volume than in the fine-grain dominated glacial sediment contributions in the Mid-Basin). We estimate that, on average, approximately 200-400 cubic yards of “chronic” bedload sediment are delivered to the system annually in the Upper-Basin Reach given “normal” conditions (precipitation, flow, and mass wasting activities). This estimate is likely extremely variable and will underestimate sediment volumes delivered through episodic mass-wasting occurrences.

Mid-Basin Sediment Processes

The Mid-Basin, while less steep than the Upper-Basin from a stream profile standpoint, has a greater surface area of steep, unstable inner-gorge morphology adjacent to the stream. The reason for this is there is a change in geology from bedrock to glacial sediments, and the glacial sediments are more erodible and less stable at steep slopes. While bedrock (Darrington Phyllite) was observed locally within this reach, the reach is dominated by glacial sediments exposed in the channel banks. Mass wasting events in this reach tend to be of a larger scale and include more deep seated rotational failures, thus there is a larger overall volume of sediment contributed to the stream episodically (Photo 8).

Photo 8

Photo 8 Example of mass wasting of glacial deposits within the Mid-Basin Reach. Note that the bulk of material is fine grained and will not be deposited within the project management reach.

In addition, there is a larger volume of stored in-stream sediments occurring in high flow terraces/floodplains and larger debris wedges. We estimate that approximately 5 cubic yards of sediment storage per 1 lineal yard of channel exist, on average, in this reach, totaling approximately 20,000 cubic yards of stored material in the three forks. Similar to the upper-basin, this reach is incising and therefore vertical erosion is contributing to sediment as is the inner-gorge widening process (lateral erosion, mass wasting) (Photo 9).

Photo 9 Example of erosion and "re-recruitment" of a former alluvial sediment deposit temporarily stored at the margin of the channel as a terrace deposit.

Debris flows are capable of originating from this reach as well as potentially being transported through or deposited. Because of the larger volume of in-stream stored sediment, larger debris flows transporting through this reach could entrain a significant volume of sediment from the in-stream stored sediment. The net sediment process is that it is supply limited; however there are periods in which it is transport limited. It is likely that the transition from supply limited to transport limited occur when large debris flows evacuate the in-stream stored sediment. The 1983 debris flow on the West Fork, which originated near the upstream end of the Mid-Basin reach, accomplished this and scoured much of the stored sediment and debris from the Mid-Basin (Photo 4). As a result, the inner gorges became over steepened and unstable, as did in-stream sediment storage. Mr. Hamerski reports that the West Fork continues to be the source of most of the turbidity observed in this stream and that sediment pulses can still be observed 30 years after the disturbance. The DNR inventory additionally shows that the slope instability in the Mid-Basin Reach increased following the 1983 event (Table 5).

The geologic characteristics of the sediment being recruited from the erosion and mass wasting within this reach are different than in the Upper-Basin Reach. The glacial geologies are predominantly fine-grained and therefore will be throughput in the subject management reach (Photo 8). Therefore, while this reach may contribute to the greatest total sediment volume delivered to the system over time, the volume of material that is deposited in the subject project reach as bedload originating from this reach may not be as great, cumulatively, as the Upper-Basin Reach. We estimate that, on average, approximately 100-500 cubic yards of "chronic" bedload sediment are delivered to the system annually in the Upper-Basin Reach given "normal" conditions (precipitation, flow, and mass wasting activities). This estimate is likely even more variable than in the Upper-Basin Reach, but regardless will underestimate sediment volumes delivered through episodic mass-wasting occurrences.

Lower-Basin Sediment Processes

The Lower-Basin is predominantly transport limited, and therefore depositional landforms (alluvial fan and floodplain) have formed (Photo 10). As a result of the net deposition, the development of an alluvial fan extends onto a relict fluvial floodplain with the distal extent of the geomorphic alluvial fan reaching just south of SR 20. While the net sediment process is transport limited, periods of supply-limited conditions may occur and thus erosion and incision in portions of the alluvial fan. When this occurs, the upper portions of the alluvial fan can contribute sediment to the lower portions of the alluvial fan. Alluvial fans are convex in cross-sections perpendicular to the stream profile, so that water that leaves the banks often exists the watershed, thus at times the alluvial fan reach has a hydrologic loss.

Photo 10
Example of deposition near the apex of the alluvial fan inundating the forest in sediment.

Compared to other alluvial fans originating from Lyman Hill with similar watersheds (size, elevation, aspect, and geology), Childs Creek alluvial fan is relatively small. The reason for this is that the upper watershed is relatively stable when compared with the other watersheds, such as Coal Creek. The Childs Creek alluvial fan is believed to be a composite alluvial fan formed by both debris flows and clear-water sediment deposition, although no trenching was done to support this hypothesis.

The management activities in the built environment over the past century have affected alluvial fan morphology. In particular, channelization through the alluvial fan reach has translated coarser bedload deposition and hydraulic forces further downstream than would be anticipated in an un-channelized alluvial fan condition. The consequences of this are that sediment impacts at the two County Bridges have been exacerbated. However, had channelization and management not occurred, it is likely that Childs Creek would be flowing through the bridges that were built to cross it. It is also possible that the rate of alluvial fan growth may have increased or be increasing from additional sediment inputs resulting from upper watershed management activities relative to the pre-managed watershed conditions.

2.3.2 Historic Sediment Management

Past sediment volume removals have been poorly documented. We understand through HPA records that both Skagit County and WSDOT have routinely conducted extensive in-stream sediment removals.

For example, a HPA dated September 9, 1991 shows that approximately 760 lineal feet of channel downstream of Lyman-Hamilton Bridge was permitted and that there was no limit of sediment volume that could be removed from the channel. The 1991 permit was to manage the transport and deposition that resulted from the 1990/91 hydrologic events that caused region-wide flooding. We used the following assumptions to estimate sediment volume removed by Skagit County during that removal:

> *760 lineal feet of channel x 15 feet wide x 2 feet deep = 22,800 cubic feet (844 cubic yards)*

During that same winter WSDOT removed a reported 1,200 cubic yards. Therefore, a total of approximately 2,000 cubic yards was removed from the channel following the 1990/1991 events.

Although the records are incomplete, sediment removals appear to be event driven. The next documented sediment removals appear to have occurred approximately a decade later following the events of the mid and late 1990s. If removals and base elevations were similar, then we can use the existing volume and divide it by the time interval. Doing this, we have a rough estimate of approximately 200 cubic yards as an average annual deposition rate. We suspect that this underestimates the average annual rate somewhat as there appears to be a net channel bed elevation gain through the combined alluvial fan and project reach during that period and it is possible that removal volumes were underestimated or underreported. We understand from anecdotal information that private sediment management (dredging and levee construction) may have also occurred during this time period as well as throughout the past. Therefore, using a “best guess”, an average annual deposition rate in the alluvial fan and project reach may be closer to 500 cubic feet per year.

Because the frequency of the historic sediment removals, in addition to the uncertain volumes, are poorly known, the value of 500 cubic yards an average per year is largely speculative, but can be used as a gage of relative magnitude.

Based on what we know about the upper watershed, we anticipate that the actual annual sediment delivery rate will be highly variable. Based on the records that were found and the channel morphology observed in the study reach, it is clear that there is a net deposition and that without management of the sediment or some alternative management action, the natural alluvial fan processes will result in frequent and difficult to predict channel avulsions, increased bed elevations and continued flooding of the infrastructure and residences.

In 1992, WSDOT proposed a "Gravel Reservoir" on Childs Creek immediately upstream of SR 20 to reduce the need to dredge at the SR 20 Bridge. The reservoir was to be approximately 300-feet long by 90 to 230-feet wide area contained with a 5 to 7-foot high armored berm. An engineered outlet consisted of an adjustable invert weir. The design documents we reviewed did not estimate a maintenance schedule. The project was never constructed. We interpreted that the cancelation of this project was related to potential fish habitat impacts (particularly from the weir) which the Skagit System Cooperative asked WSDOT to reevaluate following 3-years of performance review on Hansen Creek in which a similar control structure was either proposed or possibly installed.

2.3.3 Current Conditions in the Project Management Reach


Photo 11

The "project reach" conditions from an infrastructure management perspective can be characterized as severely impacted by bedload sediment deposition. Channel bed elevations, locally, are higher than the surrounding floodplain and even major infrastructure (Photo 11 at right: SR 20 looking east observed to the right or south of Childs Creek where the base channel elevation is several feet above the adjacent highway). These channel conditions require WSDOT to address more frequent flooding of SR 20 and property owners and in response, "Jersey Barrier Levees" and sandbags have been utilized to reduce the flooding frequency. Erosion of the box culvert passing under SR 20 is currently damaged from erosion and hydraulic capacity through the culvert is currently reduced.

The current bedload conditions have greatly affected channel conveyance capacity at the Lyman Hamilton Bridge (Photo 12 at right). The capacity is so greatly reduced that we estimated that it cannot pass even less than a two-year event under these conditions without backing up and increasing water surface elevations and exacerbating flooding upstream.


Photo 12

Capacity beneath the Nicholson Bridge, while reduced, is of a relatively lesser impact than to the Lyman Hamilton Bridge, although overtopping of this bridge also occurs relatively frequently with overflow paths evident to the right of the bridge. Flooding at this location frequently impacts private residences (Photo 13 of Nicholson Bridge capacity in May 2012 shown at right).


Photo 13

From a habitat perspective, the current sediment deposition trends negativley impacts habitat in the project reach (Appedix B). Transport and depsotion rates in the project reach are high and impact habitat forming features such as logs and other structures that tend to form stable pools for holding and refugia.

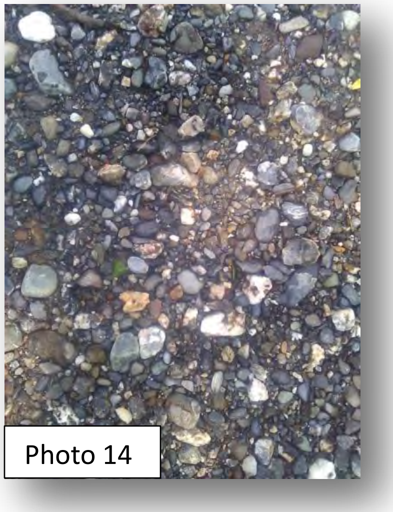


Photo 14

The bedload characteristics occurring at both the Nicholson and Lyman Hamilton Bridge is a phylitte dominanted substrate with dominant substrate dimensions (D50) of approximately 0.25-1.0 inches (B-axis). The upper watershed is represented by two distinct geologies, phyllite bedrock from the upper watershed and unconsolodated glacial deposits occurring in the lower watershed above the alluvial fan. The dominance of phyllite in the substrate at the two County bridges suggests that currently, the phyllite geology is the greater contributor of sediment to the overall budget. It is likely that localized events occurring in the glacial deposits may change this charcteristic eposidically. We anticipate that the sediment we are observing in the project reach, specifically near the two county bridges, is residual transport related to the January 2009 hydraulic event.

2.4 Fish Habitat Characterization

Fish Habitat Historical Background

The quality of the fish habitat within the Childs Creek watershed changes with location within the basin as well as through time. Childs Creek watershed has been evaluated in the past by Washington State Department of Natural Resources (DNR) and SFEG (DNR 2004, Welch 2004, & Welch 2006).

Discussions with Mr. Hamerski and Ms. Garver who have been living along the Childs Creek since 1963 and 1969 respectively, indicate that the stream use to be populated by salmon to a much greater extent and that after the 1983 debris flow event the spawning returns dropped off significantly.

The lower basin of Childs Creek has had several salmon restoration projects conducted on the reach just north and south of State Route 20 in 1996, 2001 and 2005 (Welch 2006). The subsequent restoration monitoring and surveys of these projects showed that the lower reach of Childs Creek has been frequented by coho, steelhead, rainbow, and sea-run cutthroat. However, the number of spawning salmon appears to be highly variable and may be dropping off (Welch 2006).

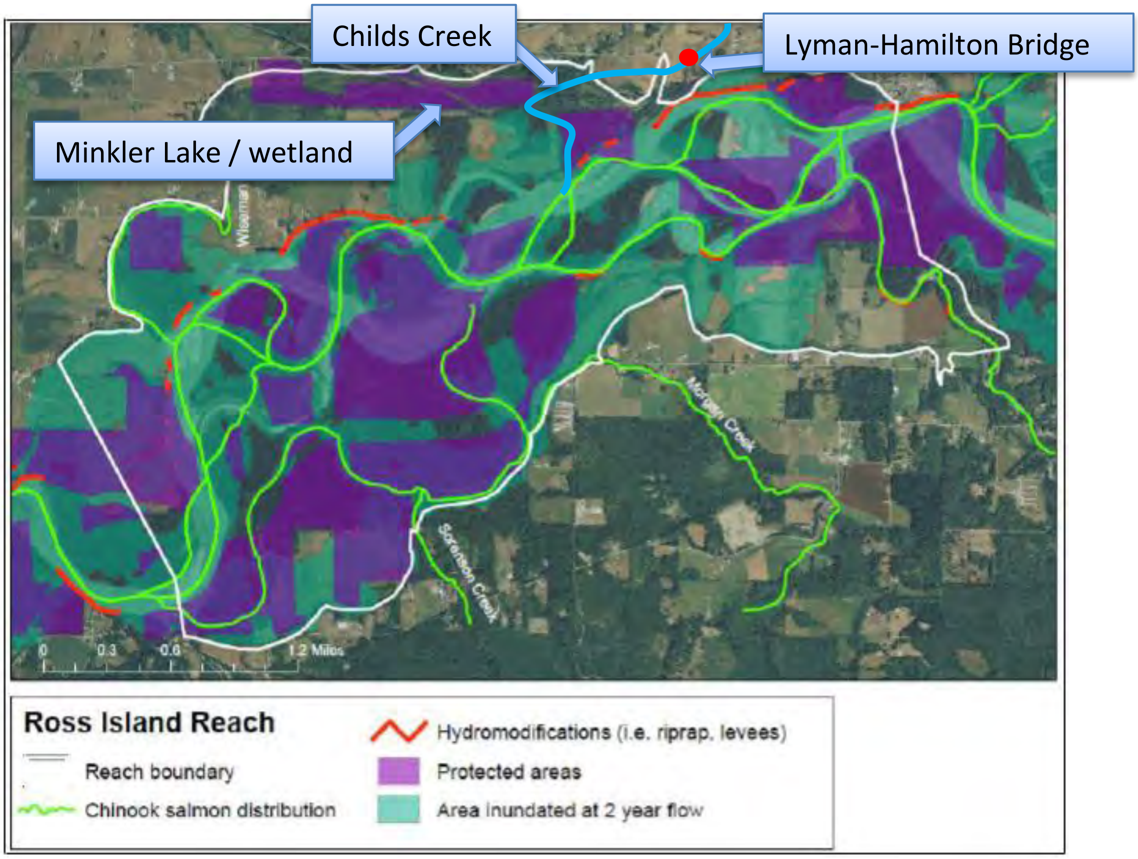
DNR found the presence of an unidentified fish located in the Eastern Fork with the mid-basin at ~500 feet of elevation. They also reported that a 10-12 foot waterfall created a natural fish barrier at ~520 feet of elevation on the same fork (DNR 2004).

The 2006 SFEG report by Welch was the most recent report that we found during our document search so more recent information was not readily available. However, during one of our site visits on May 24th, 2012 one unidentified fry was observed in Childs Creek near the Nicholson Road Bridge.

In 1992, WSDOT proposed a “gravel reservoir” (sediment basin) on Childs Creek to help manage sediment impacts at the SR 20 crossing. At that time, Skagit System Cooperative documented their concerns through the SEPA comment period and stated that potential habitat impacts could be incurred by the proposed project design and encouraged a more comprehensive assessment.

Restoration Strategies

The Plan for Habitat Protection and Restoration in the Middle Reach of the Skagit River (July, 2011) did not identify Childs Creek or the Minkler Lake (wetland) connection as a high priority. Childs Creek and Minkler Lake were not identified as Chinook habitat and had poor floodplain connectivity (2-year flow) as shown below. Childs Creek and Minkler Lake were identified as isolated and potential connectivity pathways were shown as shadowed habitat, but with the potential for off-channel habitat opportunities.



Graphic from the Plan for Habitat Protection and Restoration in the Middle Reach of the Skagit River (July, 2011) modified with labels and highlighting of Childs Creek.

Current Fish Habitat Assessment

A habitat assessment of the alluvial fan and low-gradient floodplain reaches of Childs Creek was conducted to inform future sediment management strategies and possible restoration efforts, using the Field techniques generally followed guidelines described in Washington Forest Practices Board Manuals (1997 and 2004). The habitat assessment was conducted on September 6th and covered approximately 1.2 lineal miles of

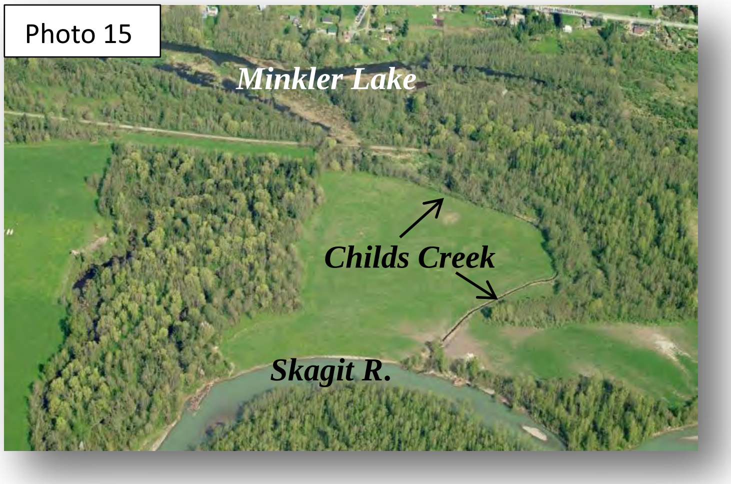


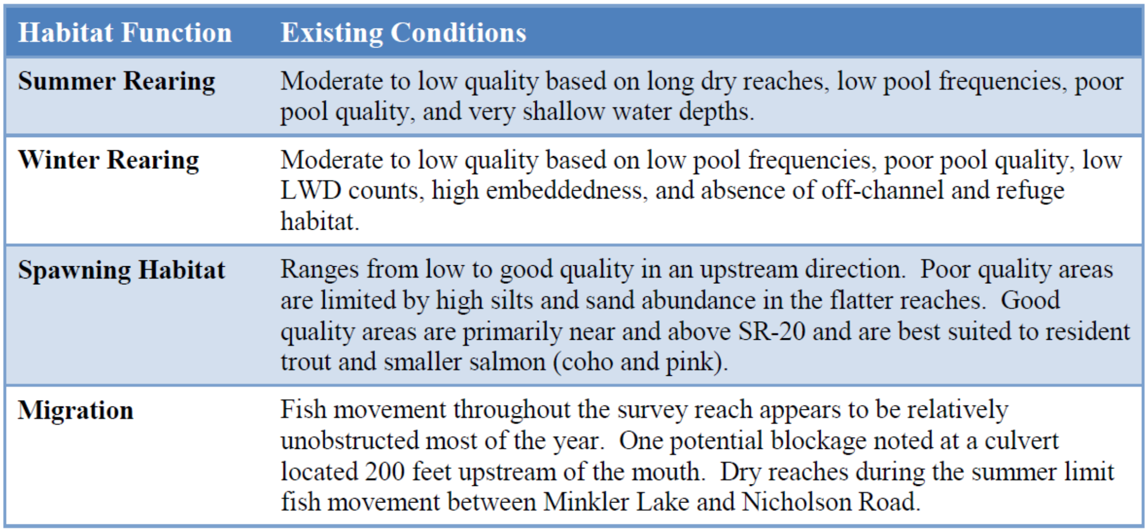
Photo 15

channel consisting of two disconnected reaches, the lowest (Reach 1) beginning at the confluence with the Skagit River upstream to the Centennial Trail at Minkler Lake (approximately 0.5 miles)(Photo 15, above; curtsey of Skagit County (Pictometry)). Reach 2 began from a few hundred feet downstream of the Lyman Hamilton Bridge up to the apex of the alluvial fan (approximately 0.7 miles). Minkler Lake, because of its accessibility, was excluded from the quantitative analysis. The complete Habitat Assessment report is presented in Appendix B.

Conclusion

The habitat survey concluded that many of the reaches within the study area were at risk or not functioning, with the exception of water quality (temperature) which was found to be functioning, potentially because of hyporheic flow or springs contributing ground water. The following table (Table 7) is a summary of the habitat conditions in the study area. Net habitat quality, in general, increased in an upstream direction.

Table 7: From Table 3 Childs Creek Stream Habitat Report (Cedarock 2012 – Appendix B)



Habitat Function	Existing Conditions
Summer Rearing	Moderate to low quality based on long dry reaches, low pool frequencies, poor pool quality, and very shallow water depths.
Winter Rearing	Moderate to low quality based on low pool frequencies, poor pool quality, low LWD counts, high embeddedness, and absence of off-channel and refuge habitat.
Spawning Habitat	Ranges from low to good quality in an upstream direction. Poor quality areas are limited by high silts and sand abundance in the flatter reaches. Good quality areas are primarily near and above SR-20 and are best suited to resident trout and smaller salmon (coho and pink).
Migration	Fish movement throughout the survey reach appears to be relatively unobstructed most of the year. One potential blockage noted at a culvert located 200 feet upstream of the mouth. Dry reaches during the summer limit fish movement between Minkler Lake and Nicholson Road.

The primary influences affecting overall habitat within the study reach appears to consist of some natural processes, such as a dry channel and in-stream sediment deposition, as well as past management practices, particularly channelization, which have left a legacy of impaired natural processes that are beneficial for habitat forming conditions.

3 Alternatives Identification and Analysis

Natural process and hazard management strategies can be categorized into three generalized adaptation approaches:

- Retreat Strategies (removing assets from potential impacts)
- Accommodation Strategies (integrating techniques for "living with" impacts)
- Protection or Buffering Strategies (utilizing natural or artificial barriers to address impacts)

The "retreat strategy" typically results in the most comprehensive long-term solution; however, because of social, legal, or economic justifications to maintain an established built environment, it is often the most challenging adaptation approach to implement. The purpose of adapting to the "problem" with a management approach is to address risk. Risk is the integration of probability of the "hazard" and the consequences. "Management" is often compromise bracketed by constraints rather than a perfect solution, especially when trying to create a fixed built-environment within an area influenced by dynamic natural process.

We have identified a suite of potentially feasible management alternatives that utilize the general aforementioned approaches with the objective to manage the average annual and small storm sediment deposition and frequent flooding occurring within Childs Creek in the vicinity of the bridges at SR 20, Nicholson Road, and Lyman-Hamilton Road area. While the ultimate solution could be to acquire all the properties and remove or relocate all the infrastructure from the area of impact, this alternative was considered not feasible. Sediment deposition and flooding in this area are natural processes and will continue indefinitely as will land use in this area for at least the foreseeable future, thus the management alternatives that were identified and analyzed focus on integrating these realities.

The impacts, or consequences, from the average annual and small storm deposition processes on the existing built environment are that infrastructure becomes occasionally inundated with water and sediment resulting in road closures, erosion of road shoulder. Additional impacts from this process are that adjacent residences are experiencing flooding issues (water and sediment in yards and structures, road closures, septic system impacts). It should be noted that some of the residential development occurs in topographically low areas and none of the identified alternatives will solve the flooding problem for these properties. It should also be noted that WSDOT is currently considering management alternatives for the SR 20 crossing. At the time of this report, their management strategy was not fully developed, but it is likely that there could be mutual benefit offered by integrating management efforts. Beyond this report, additional efforts to coordinate strategies either to maximize opportunities or avoid conflicts should be taken.

The management objective for the alternatives identified below does not consider all natural processes or hazards associated with Childs Creek, specifically debris flows transporting large volumes of sediment and debris (for this analysis, greater than 1,000 cubic yards per event). As previously discussed in this analysis, the occurrence, and therefore the hazard, of debris flows on the Childs Creek alluvial fan area should be anticipated. Because the impacts from debris flows on the built environment and public safety are much more significant than the management objectives of this analysis, different management approaches would be needed to mitigate these impacts. The following alternatives identified do not address debris flow hazards.

3.1 Alternatives Identification

Nine groups sediment management alternatives are described below. The positives and negatives of each alternative are shown in Table 7.

1) No Action

With a no-action approach, the unmanaged Childs Creek natural process (deposition) will continue and with no adaptation strategies, the impacts to infrastructure and private properties will be realized more often as time goes on. It is anticipated that in time, the stream sediment would eventually aggrade to the point that bridge is buried and that the stream will seek a new route over road infrastructure and through private properties. Damage to the bridges and infrastructure is possible, particularly with higher flows that may scour approaches. It is anticipated that the damage from inundation of the infrastructure from each occurrence is relatively, but that the ongoing and frequent maintenance costs likely accumulate to a substantial amount over time.

2) Stabilization of Upper Watershed Sediment Sources

In past studies (Coal Creek and Muddy Creek) WDFW suggested the possibility of building log-jam/boulder structures in the upper watershed to retain sediment in the upper watershed. These sorts of features form naturally in Childs 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 Childs 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 to the management area. Although it is not possible to predict, such failures might result in larger-scale destabilization of the streambed.

Given the likely eventual failure of these structures, there may be legal implications for the County if the structures are man-made rather than forming naturally.

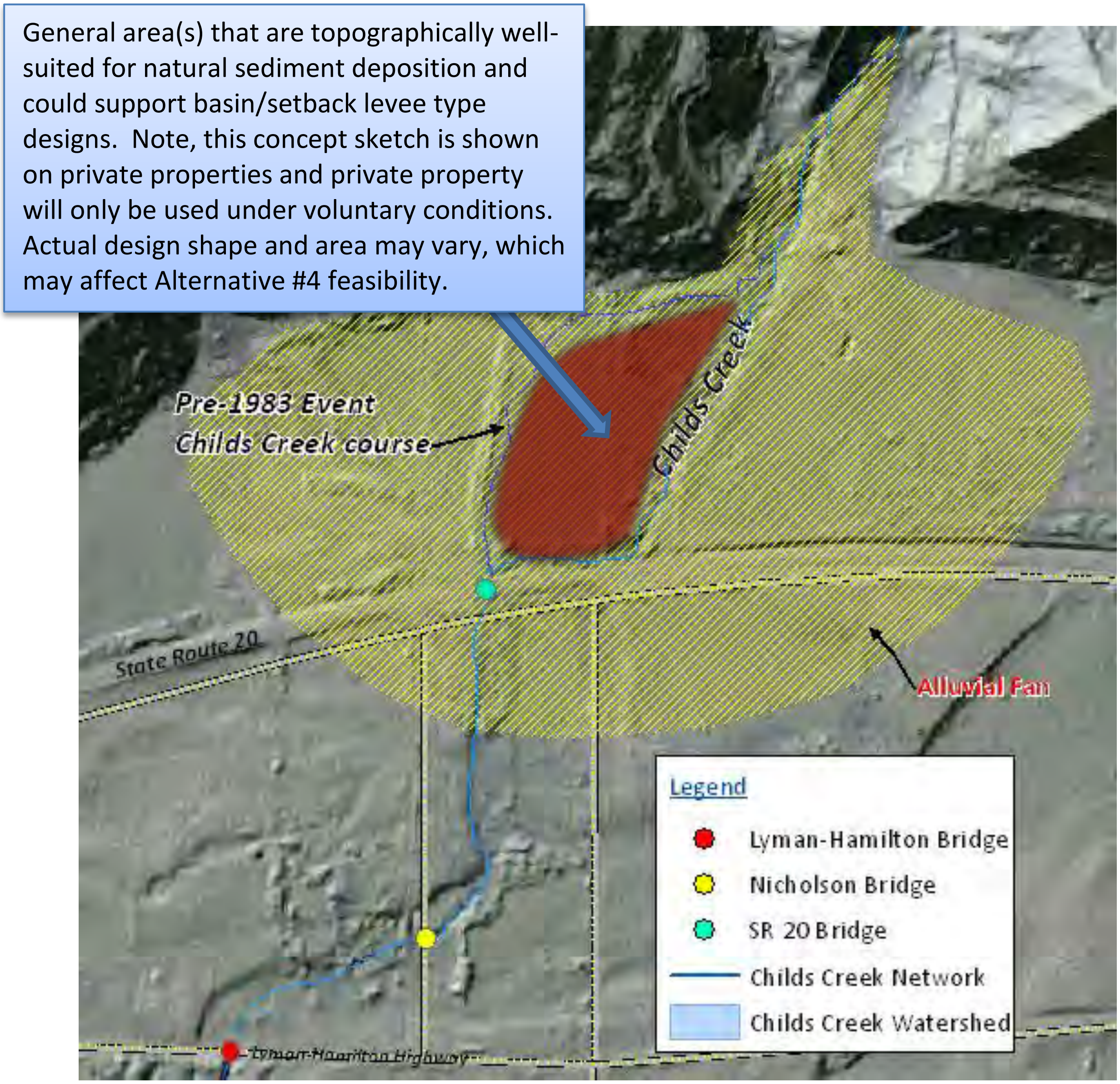
3) In-Stream Sediment Removals (Dredging)

Removal of accumulated sediment from the channel was the historic management approach. This approach has been found to have impact on the ecological conditions of the stream, and thus impacts fish species valued by the greater community and potentially species protected under the Endangered Species Act. The historic maintenance approach 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 on fish habitat either directly relating from the sediment removal action or longer-term habitat forming process, for each strategy have not been fully quantified, but the more frequent, smaller disturbance approach would appear to have a greater net habitat impact and was recently the strategy favored by WDFW as specified on previous HPA's issued for Coal Creek. This option may have slightly higher associated costs for the County (given the increased mobilization/ demobilization costs of conducting annual removals), but this is likely minimal. From a infrastructure management and flood perspective only, the in-stream sediment removal strategy utilized historically appeared to be moderately effective at managing the impacts to infrastructure and private properties.

4) Construction of a Sediment Basin and/or Managed Sediment Removal Area

WSDOT identified an area in 1992 in which a "gravel reservoir" could be constructed to allow for sediment deposition and a realignment of the channel to reduce the hydraulic impacts of the two sharp bends that exist under current conditions. The proposed design had some components that Fisheries Co-manager felt were likely to inhibit fish passage and that the maintenance of the trap is expected to have some impacts on ecological conditions for some duration of time. The sediment basin concept is one that could be modified to reduce some of the potential ecological impacts downstream and possibly even increase habitat conditions within the basin area. The concept is that an area that is broad, lower gradient, and/or "rougher" would encourage natural deposition of sediment, thus reducing the downstream transport of sediment. The current straight and leveed channel causes a downstream translation of sediment deposition, beyond where it would be expected if unconfined. The area identified by WSDOT (immediately upstream, north, of SR 20) in the early 1990s is again being reconsidered by them in their preliminary investigations through their current analysis, and is therefore a management alternative that has some technical merit as long as it can work with some of the private property constraints. The area identified by WSDOT is toward the distal part of the alluvial fan, and so deposition in the reach upstream of this basin would be expected, and so maintenance upstream of the basin would be needed periodically. It is possible that a basin located more toward the apex of the alluvial fan may provide a stronger technical argument, but because of existing development, this area is less accessible and would require discussions with the current private resident. In 1978, the private resident (Mr. Hamerski) had proposed and partially developed settling basins near the alluvial fan apex to manage the sediment transport and deposition. These shallow basins were overwhelmed in 1983 by the debris flow.

In order to create a deposition basin, the channel confinement would need to widen. In concept, the wider the area, the more material that can be deposited, thus reducing the frequency of maintenance needs both at the basin and downstream. This may be difficult in the vicinity of the three bridges given the constraints of private property. Other techniques within the basin area could be implemented to encourage deposition, such as increased roughness (trees, shrubs, large woody debris, and boulders), grade breaks or check dams, or weirs. The use of trees, shrubs, large woody debris, and boulders additionally creates habitat forming or enhancing features. Therefore use of the natural materials can provide mutual benefits. Ultimately, this area would need to be maintained and a long-term maintenance plan (schedule and methods) would need to be developed and agreed upon as part of this strategy. In addition, on-going monitoring of the basin and the downstream reaches would be prudent, to assess the channel and habitat response of downstream reaches to the interruption of sediment supply. In concept, this project may offer benefits to both WSDOT and County and private properties downstream of SR 20. The development of this alternative, if selected, would need to be developed in coordination with WDFW and the tribal co-managers, and stakeholders.



General area(s) that are topographically well-suited for natural sediment deposition and could support basin/setback levee type designs. Note, this concept sketch is shown on private properties and private property will only be used under voluntary conditions. Actual design shape and area may vary, which may affect Alternative #4 feasibility.

Alternative 4 – *Concept Illustration* of potential basin area for sediment management

5) **Infrastructure Abandonment**

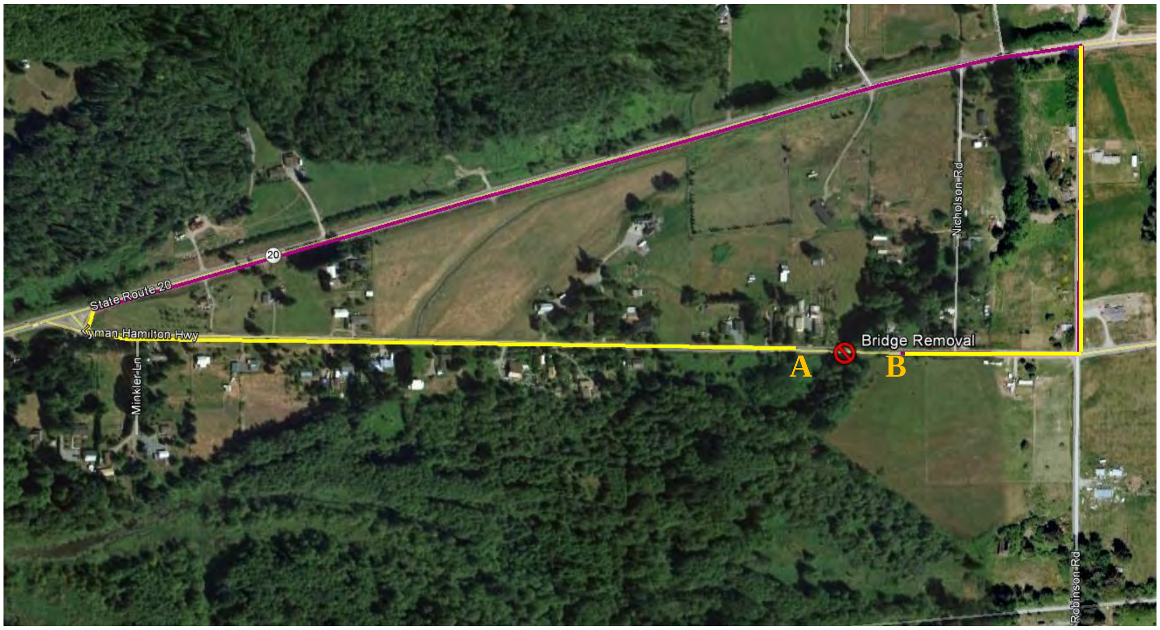
The removal of all of the bridges assessed in this evaluation would essentially eliminate the infrastructure maintenance needs and related flooding issues caused by the bridges. We recognize that bridges that serve local traffic likely has a fair amount of social, economic, or public safety value. However, it should be noted that SR 20 offers a traffic alternative that is managed by WSDOT if Skagit County were to consider the removal of its bridge infrastructure over Childs Creek.

5A. Nicholson Road Abandonment

The removal of the bridge at Nicholson Road would eliminate the inundation of the bridge and the associated management needs, plus reduce any flooding impact caused by the bridge. Overbank flooding and impacts to the adjacent property owners would still be expected as would sediment accumulation in the channel. The Nicholson Road Bridge is located on a small one way thru road connected between SR 20 and the Lyman-Hamilton Hwy, this road is not a high traffic road and although the removal of it will inconvenience some people, alternative routes can be take that would not significantly increase the public's transit time and would not be expected to reduce emergency response time.

5B. Lyman-Hamilton Highway Bridge Abandonment

The removal of the bridge at Lyman-Hamilton Highway would eliminate the inundation of the bridge and the associated management needs, plus reduce any flooding impact caused by the bridge. The existing bridge is not scheduled for replacement in near-term, so Skagit County would not be saved the replacement costs with this alternative at this time. Even with a new bridge, overbank flooding and impacts to the adjacent property owners would still be expected as would sediment accumulation in the channel. For this analysis, we evaluated the travel times for bridge removal using an alternate route (image below) and determined that a worst case detour could delay a traveler up to 6 minutes (given appropriate travel speeds, deceleration, stopping, estimated wait time, acceleration for a detour of 2.2 miles). Traffic counts in 2011 were 759 vehicles per day.



Alternative 5B – *Concept Illustration* (Worst case traffic detour route A to B)

6) Infrastructure Improvements

Bridge Modification – increase height:

The Lyman-Hamilton Bridge, Nicholson Bridge, and SR 20 Bridge currently have impaired conveyance conditions, with vertical clearance of about 0.5 feet, 2.5 feet, and 3 feet respectively between lowest channel bed elevation and the horizontal bridge member as of May 24th 2012. Although the Nicholson Bridge and SR 20 Bridge could sustain a small ~2 year flooding event, it is unlikely that the Lyman-Hamilton Bridge could accommodate any size flooding event without exacerbating upstream flooding, possible bridge/road damage, and possible road closures. Since the sediment management activities in the creek are driven by a need to manage flooding at each of the respective bridges, one option is to raise the Lyman-Hamilton Bridge and Nicholson Bridge using their current structural frames, in order to improve flow conveyance. This option depends on if the construction of these two bridges allow for structural changes.

The bridges would need to be elevated to allow the appropriate return period flood profile, and should include some allowance for sedimentation in addition to freeboard. This approach would reduce the time needed until aggradation trends again diminish the conveyance beneath the bridges, one this occurs, the interval, and perhaps the frequency, of maintenance needs may resemble today's conditions. Flooding impacts for private properties would still be expected, but the effects caused by the bridges could be reduced slightly for some of the properties currently impacted by backwater flooding conditions for a period of time, but overall flooding will likely increase as channel bed elevations increase.

Bridge Replacement – resize and raise:

The County bridges (and SR 20) could also be replaced with higher wider structures that would allow for greater storm and sediment conveyance. The bridges would need to be re-designed to the appropriate return period flood profile, and would include an allowance for sedimentation in addition to freeboard. If properly designed inundation, maintenance, road closures, and upstream flooding impacts should be reduced. For the purpose of cost estimates, a three-sided prefabricated concrete bridge with a 40-foot span was assumed for the replacement structure.

Road Overflow Design (lowering with armored shoulder apron):

A fairly low-cost road and shoulder modification could be constructed to help to reduce maintenance and repair costs resulting from shoulder and pavement damages. The concept is that during higher flows, the modified section of the road would be designed to overtop without damage and that following the flood, only cleanup would be needed. This alternative is assumed to be part of a suite of management actions as it is not a good "stand-alone" management alternative.

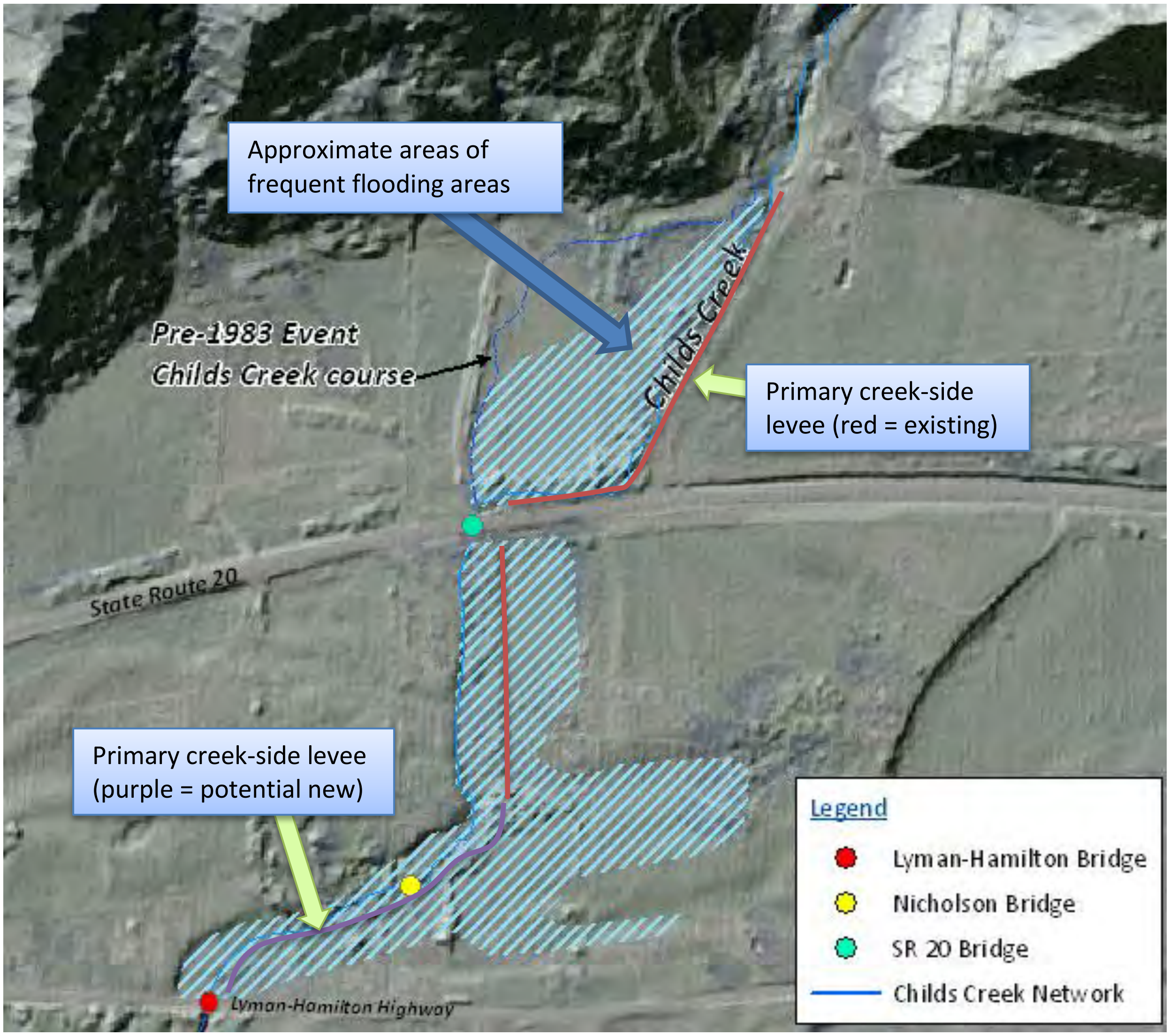
7) Create Levees

Two conceptual levee alignments were considered for illustrative and cost purposes for this potential management strategy.

7A. Creek-side Levees

The sedimentation in Childs Creek is aggravated at the Lyman-Hamilton Bridge reach by the fact that the creek is confined within a narrow channel and levees. This technique increases the depth and transport power of the stream and translates sediment deposition further downstream. In addition, it does not allow for as much in-stream and floodplain storage capacity of sediment, therefore increasing the rate of aggradation in the project area. However, by building larger creek-side levees, the residential flooding issue would be reduced for smaller floods for some interval of time; however, the inundation of the road would still occur and the frequency would likely increase, therefore dredging would still be needed to maintain flow conveyance under the bridges. It is also likely that this technique would degrade the existing habitat conditions by creating greater hydraulic forces.

An additional issue would likely be that by reducing the amount of floodplain storage that is currently available (in light blue on illustrative example below) that occurs primarily along the left bank (east) side of the stream downstream of SR 20, and on the right bank of the upstream of SR 20, would cause flooding to occur on the opposite bank where it may not currently flood. For the illustrative example below, we show only the primary levee (in red). Hydraulic modeling and detailed surveying would be needed to determine the levee heights and then accounts for sediment deposition would need to be taken into account. The construction of levees would cause conflicts at the existing crossings and so it is anticipated that modification to the crossings would be needed as part of this strategy.



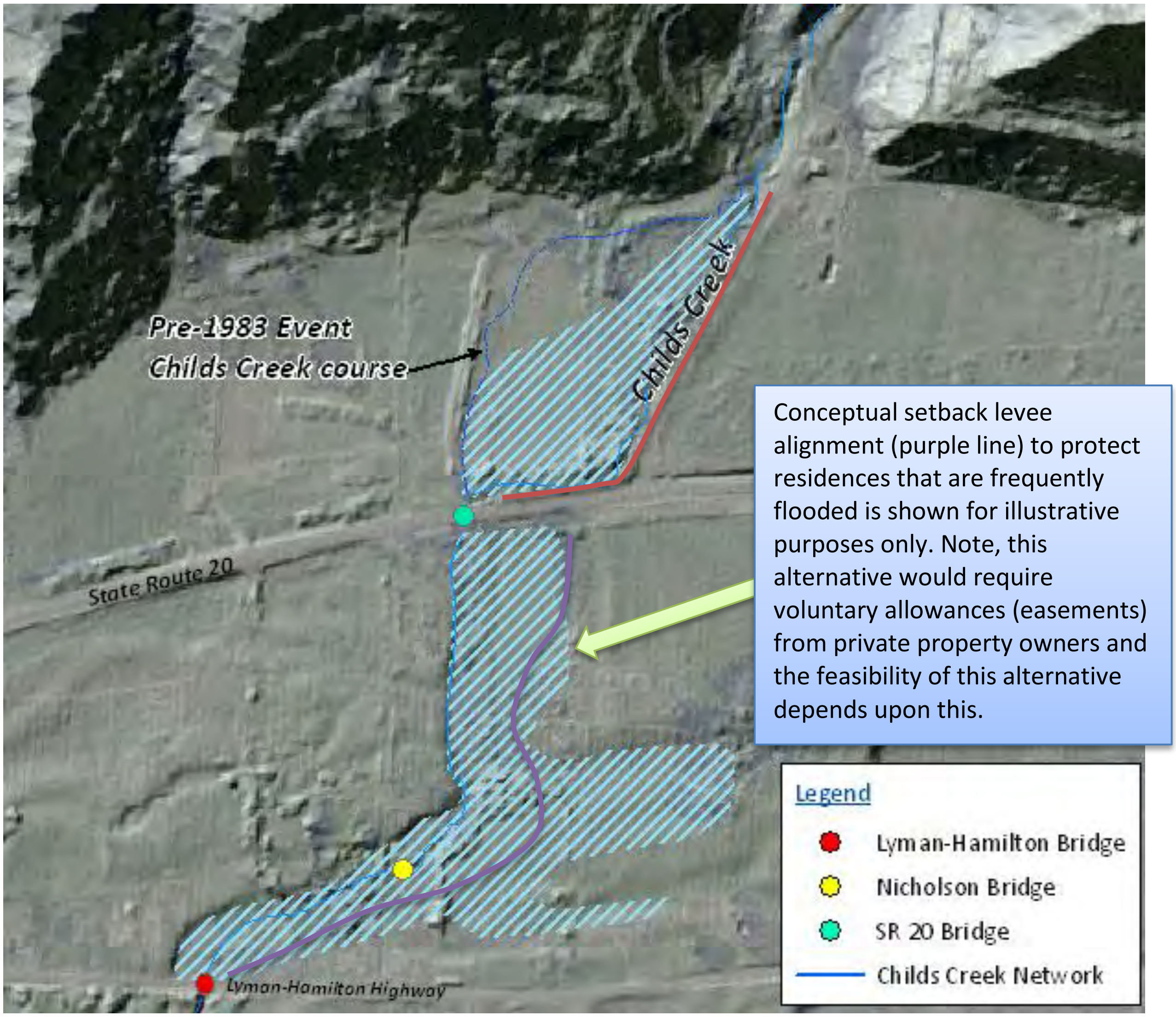
Alternative 7A – *Concept Illustration* of Creek Side Levees in relationship to flooding (from 2009 event) as interpreted from personal communications with property owners, Skagit County staff, and topographic maps.

7B. Setback Levees

By setting back the levees, the creek would be allowed to overflow its banks and deposit material on the alluvial fan floodplain. There are numerous alignment alternatives that could be considered for this approach, some with more of a flood and damage prevention approach, and some with more of an ecological function approach, and some combination thereof. The setback levee concept is to provide a much larger area for storage of sediment and water, as well as dramatically decreasing hydraulic forces.

An example of a setback levee done for ecological function is at nearby Hansen Creek. The primary disadvantage to this option is that a very large amount of private property acquisition is required in order to be able to set back the levees from the creek for restoration management purposes in which flooding is encouraged. It might be possible to apply this concept in a limited fashion to specific reaches of Childs Creek. In concept then, the setback levee could perform similarly to the sediment basin concept described above in Alternative 4.

The area between SR 20 and the Lyman-Hamilton Hwy is populated by residences that are set close to the stream channel in topographically low areas and experience the greatest frequency of flooding. To develop setback levees in this area could require property purchases to make more effective setback levees. For illustrative purposes, we created a conceptual setback levee alignment that tries to reduce the impacts of frequent flooding, maximize the existing floodplain area, and minimize levee length to keep costs as low as possible. This illustrative example was used to evaluate potential project cost. The primary cost differences with other potential setback levee alignments are related to real estate easement purchases. Maintenance of levees and some stream channel dredging would potentially be necessary over time given any setback alignments, but some alignments would require more maintenance and repairs over time.



Conceptual setback levee alignment (purple line) to protect residences that are frequently flooded is shown for illustrative purposes only. Note, this alternative would require voluntary allowances (easements) from private property owners and the feasibility of this alternative depends upon this.

Alternative 7B – ***Concept Illustration for discussion purposes only***

7C. Raise Residences or Perimeter Levees

The raising of residences or creating perimeter levees or elevated fill pads for homes or structures in topographically low areas would allow for the creek to overflow its banks and deposit material on the alluvial fan floodplain to a greater extent than setback levees and have a lower project cost. This would provide a much larger area for storage of material, as well as dramatically increasing the flood conveyance. This option would primarily be useful between SR 20 and the Lyman-Hamilton Highway. According to conversations with local residents, flooding from Child Creek creates flood depths typically between 1 to 3 feet deep and with little velocity, which would mean the construction of a perimeter levee or the raising of a house would not have to be a large modification. This option would not prevent the properties and infrastructure from flooding, but would reduce damage to private homes and outbuilding structures.

8) **Rerouting Childs Creek**

A possible channel alteration to re-establish the historical Childs Creek channel north of SR 20 could be considered. The 1983 debris flow event caused the creek to assume a new path above SR 20 (Figure 5). If the stream was moved back into its previous location or some similar path to the west then the channel could be routed through SR 20 without the need for two 90 degree bends north of SR 20. The presence of the sharp bends decreases the hydraulic capacity of the stream, increases the susceptibility of stream to bank erosion and breakout floods during storm events. However, providing a “straighter” approach would increase the potential sediment conveyance under the SR 20 Bridge and may exacerbate some of the downstream sediment deposition and flooding conditions unless allowances for upstream storage of sediment and water are part of the design.

We additionally identified that potential channel realignment could occur downstream of Lyman-Hamilton Highway in which habitat connectivity to the Skagit River could be improved, but that this did not necessarily address the management objectives at bridges maintained by Skagit County.

A option of linking Childs Creek to the Skagit east of Robinson Road or via Jones Creek stream system to the east of the current alignment was considered infeasible because of infrastructure improvement cost, private property issues, and environmental impacts.

9) **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 and 1970’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 hydrology is recovering as is root strength 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 nine sediment management alternatives were evaluated for their ability to meet the Skagit County project objectives and fit within their fiscal abilities.   In general, we observed that some alternatives provide benefits to only one objective. For example, an alternative that focuses exclusively on management of sediment may not address any of the fisheries objectives. Conversely, an alternative that focuses only on habitat may not adequately address the sediment issues. The alternative or alternatives that best meet more than one objective are ones with mutual benefits and offer some degree of compromise between conflicting objectives.

Of these alternatives that provided mutual benefits, we identified options that were financially viable given our understanding of Skagit County's resources. Table 8 shows the planning level costs of each alternative. For Alternative 7 (setback levees), the most conservative planning level costs for a conceptual alignments is shown in Table 8 in order to provide a high-end range of cost potential since no levee alignment has been defined. Table 9 summarizes the positive and negative aspects of each alternatives.

Table 8: Planning-level costs of the 9 alternatives identified for this management plan. Rationale for the stated planning level costs in Table 8 are provided in Appendix C.

Alternative	Title	Planning Level Costs
1	No Action	$0 Near-term Long-term costs unknown
2	Upper Watershed Sediment Source Control	$2 Million project costs $2 M total maintenance (25-year)
3	Instream Sediment Removal (historic management practice)	$15,000 per year $600,000 ongoing costs (25 year adjusted for inflation)
4	Sediment Basin	$1 M project cost (split with WSDOT) $250,000 maintenance (25 years)
5A	Nicholson Road Abandonment	$50,000 one-time cost
5B	Lyman-Hamilton Road Abandonment	$75,000 one-time cost
6A	Lyman-Hamilton Bridge Raising (using existing structure w/ new footings)	$750,000 one-time cost (if feasible footing designs)
6B	Lyman-Hamilton Bridge Replacement (Raising/ Widening)	$1.5 M one-time project cost
6C	Nicholson Bridge Raising (using existing deck structure with new footings)	$400,000 one-time cost
6D	Nicholson Bridge Replacement (Raising/ Widening)	$500,000 one-time cost
6E	Road lowering at overflow locations	$75,000 one-time cost
7A	Creek-side Levees Alluvial fan apex to Lyman Hamilton Rd.	$1,200,000 project cost (easements, construction, and mitigation) $400,000 maintenance (25-year)
7B	Levee Setback (between creek and residence)	$1.6 M project costs (easements, construction, and mitigation) $200,000 maintenance (25-year)
7C	Raise residences or perimeter levee	$50,000 one-time project cost
8	Childs Creek Channel Relocation (upstream of SR 20 to former alignment)	$200,000 one-time cost
9	Forestry Land Use Management	$20,000 per year (20% FTE County Staff) / $500,000 over 25-year

Table 9: Summary of Positives and Negatives of Sediment Management Alternatives

Alternative	Title	Positives	Negatives
1	No Action	• Low upfront investment	• Increased flooding frequency and magnitude • possible loss of road or bridge • may not improve habitat
2	Upper Watershed Sediment Source Control	• reduced downstream sediment transport • reduced potential and frequency for large events • reduces flooding	• works need to take place on private or state property • will not stop sediment transport • will not manage flooding • expensive construction and maintenance obligation • may increase liability
3	Instream Sediment Removal (historic management practice)	• maintains Childs Creek location and hydraulic conveyance under bridge • reduces flooding • neighbors prefer • may be able to get some help from WSDOT	• Negative impacts to fish habitat • continued maintenance costs • permitability
4	Sediment Basin	• reduces effects of sediment deposition on flooding • a potential willing landowner • reduces maintenance needs at the three bridges • allows for more channel stability • potential reduction in overall impacts to fish habitat could result if maintenance occurred outside of the active channel • may be able to get some help from WSDOT	• Impacts stream temperature and fish • continued maintenance costs • potential eventual depletion of downstream sediment • acquisition necessary • permitability
5A	Nicholson Road Abandonment	• reduction on Skagit County management costs • low traffic impacts	• Stops thru traffic • wouldn't solve other bridges issues

		• reduce flooding impacts from bridge • low impact on fish	• flooding issues remain
5B	Lyman-Hamilton Road Abandonment	• reduction on Skagit County management costs • allows for unimpeded sediment transport • reduce flooding impacts caused by bridge • low impact on fish	• Stop thru traffic on a well-used road • wouldn't solve other SR20 issues • flooding will continue
6A	Lyman-Hamilton Bridge Raising (using existing structure w/ new footings)	• reduces future maintenance needs • increase sediment transport • reduction of flooding • reduced impact on fish	• bridge construction may not allow • high initial cost • bridge is nearing the end of its design life • some dredging may still be needed • some flooding issues will remain
6B	Lyman-Hamilton Bridge Replacement (Raising/ Widening)	• reduces future maintenance needs • increase sediment transport • reduce flooding • reduced impact on fish • Bridge is nearing its live expectance	• high initial cost • some dredging may still be needed? • some flooding issues still
6C	Nicholson Bridge Raising (using existing deck structure with new footings)	• reduces future maintenance needs • increase sediment transport • reduce flooding • reduced impact on fish	• bridge construction may not allow • high initial cost • bridge is nearing its live expectance • some dredging may still be needed? • some flooding issues still
6D	Nicholson Bridge Replacement (Raising/ Widening)	• reduces future maintenance needs • increase sediment transport • reduce flooding • reduced impact on fish • bridge is nearing its live expectance	• high initial cost • some dredging may still be needed? • some flooding issues still
6E	Road lowering at overflow locations	• Low costs • increased sediment transport • reduced overbank flooding	• Increased road closures due to flooding • continued risk for bridge damage • continued need for some dredging

			• potential traffic safety issues
7A	Creek-side Levees	• Reduced flooding of residences during smaller events	• negative channel morphology and fish impacts through channel changes • would not stop need for dredging around bridges • high initial and continued costs • will worsen flooding impacts on larger events
7B	Levee Setback (between creek and residence)	• reduced flooding of residences • allows for stream morphology • allows for habitat formed by natural processes • allows for sediment storage	• less negative channel morphology and fish impacts through channel changes • would not stop need for dredging around bridges • initial and continued costs
7C	Raise residences or perimeter levee	• reduced flooding of residences • low cost • allows for stream morphology • allows for habitat formed by natural processes • allows for sediment storage on the floodplain	• would not stop need for dredging around bridges • continued dredging costs • may not be appropriate use of public funds
8	Childs Creek Channel Relocation	• increase fish passage connectivity and fish habitat (below Lyman-Hamilton Bridge) • increase hydraulic conveyance (above SR 20)	• would not address sediment problem • permitability • may have a high cost and temporary benefits
9	Forestry Land Use Management	• Decreases sediment delivery to the system	• out of jurisdictional control

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 10. The matrix, in Excel format, was provided to Skagit County to allow assessment of the different alternatives for potential changes in costs or benefit.

Table 10: 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	-3	-2	0	4	-1.0
2 - Upper Watershed	1	1	0	0	4	3	0.3
3 - Sediment Removal	1	-3	2	0	1	2	0.0
4 Sediment Basin	3	2	1	-1	4	1	1.2
5A - Nicholson Abandonment	1	0	0	-1	2	0	0.5
5B L.H. Bridge Abandonment	3	0	1	-2	2	0	2.0
6A L.H. Bridge raising	1	0	1	0	3	1	0.5
6B L.H. Bridge replacement	1	0	1	0	4	1	0.4
6C Nicolson Br. Raising	1	0	0	0	3	1	0.3
6D Nicolson Br. Replacement	1	0	0	0	4	1	0.2
7A - Creekside Levees	2	-3	1	0	4	2	0.0
7B - Setback Levee	3	2	2	-2	4	1	1.4
7C - Residential Flood Protection	0	0	1	0	1	0	1.0
8 - Channel Relocation	1	1	1	-1	2	1	1.0
9 - FP Management	0	3	0	0	1	1	1.5
Combined Alternatives							
3, 4, 7B, 8, 9	4	3	2	-1	4	2	1.5

3.2.1 Proposed Conceptual Project

Of the nine alternatives we identified and evaluated, we found that the combining several of the alternatives offered the greatest mutual benefits to Skagit County and the stakeholders and had lower relative costs over time. These combined alternatives are described as the conceptual project below.

3.2.1.1 Conceptual Project Description

A sediment basin north of SR 20, partnering with WSDOT, combined with setback levees, a channel relocation upstream of SR 20, and ongoing forest practices management provide the best overall benefits for the least relative cost. The basin could also allow for some extent of channel realignment in order to create a more hydraulically efficient pathway beneath the highway. The basin size will be dependent upon property negotiations and voluntary willingness; however, the larger the basin area the more effective the long-term management cost savings and flood/sediment retention abilities will be. A setback levee will still be needed to some extent upstream of SR 20 and could be used to define the basin area. The levee could be constructed from suitable material excavated from this basin area. Even with this alternative, some degree of sediment management at the downstream bridges will be necessary, but it is anticipated that the frequency of such maintenance will be dramatically decreased.

3.2.1.2 Planning-level Implementation Costs and Sequencing for Conceptual Project Elements

The costs of estimating the basin are dependent upon the following variables:

- Voluntary willingness of private property owners to allow for easements and easement costs will be a negotiated term
- Size of the basin will be based on allowable area that results from negotiations with private property owners
- Cost-share opportunities with WSDOT could off-set project costs and maintenance costs
- Habitat mitigation and mutually agreed upon maintenance plan with WDFW.

It could be that this alternative becomes unfeasible depending upon the outcome of the discussions with private property owners or WDFW regarding maintenance and mitigation. It should also be noted, that to take advantage of the potential habitat improvements that a basin could offer and developing a long-term maintenance plan that offered both managing entities and habitat managers some level of assurance, these negotiations with WDFW and property owners should occur prior to the commitment of this alternative as a feasible alternative. Costs will have to be evaluated once the constraints and opportunities become more apparent following these discussion. At a minimum, the sediment removal plan may be needed until such time that the larger conceptual project components can be implemented.

Ultimately, as replacement of Lyman Hamilton Highway Bridge becomes necessary, resizing that bridge to allow for more capacity will make additional management improvements. At such time that the Nicolson Road Bridge becomes necessary to replace, we recommend that Skagit County consider abandoning that bridge and removing it from the system. Individuals can make advances in raising their structures or creating small setback levees as they determine necessary; however, this action would be best suited if it involved Skagit County staff technical resources to ensure that no off-site impacts increase as a result of private modifications of topography and flood flow paths.

4 Recommendations

4.1 Summary

The Childs Creek alluvial fan is a dynamic system and sediment transport and deposition will forever be a maintenance and management issue so long as there remains a built environment on the alluvial fan. The dynamic process will include flooding and larger events can create significant disturbances and impacts to the community and infrastructure. This management plan does not address these larger events and disturbances, but rather the more frequent and chronic flooding and sediment deposition problems.

To manage the chronic sediment issues and habitat impacts, we recommend that Skagit County continue to work closely with WSDOT on the development of a basin in the area north of SR 20 as this will provide a benefit to downstream management. It also offers partnership potentials to share in project costs and maintenance. The final design of a project will be realized once all the opportunities and constraints with respects to private property ownership and environmental permitting are revealed. We recommend working closely with WDFW to develop a long-term maintenance program.

In addition to pursuing the active management strategies described above, passive management strategies should be part of the overall management strategy. While management of sediment in the upper watershed does not appear to be a feasible alternative given the scale and degree of long-term instability; supporting and encouraging conservative forest practices in order to reduce the potential impacts is an action that Skagit County could pursue by working with upland land owners. On the alluvial fan, Skagit County can continue to administer the Critical Areas Ordinance and try to minimize risk on the alluvial fan through regulatory controls. Future development proposals on the alluvial fan should consider the hazards and risks that are present and mitigate accordingly.

Through the implementation of any management strategy for a dynamic system, adaptations may be needed as changes to the system, or the regulatory environment, occur. At such time, alternatives currently excluded as not feasible, may become feasible, or alternatives not identified may be needed. Given the ability to look forward in the short-term, changes to sediment removals is one project element that will need ongoing adjustments. In addition, evaluating habitat conditions will also need frequent consideration. Pursuing a monitoring program and periodic review of management practices should be part of the overall management strategy.

5 Closure

This report was submitted by:

State of Washington
Engineering Geologist
1084
Licensed Geologist
Paul David Pittman
EXP. 09·21·2013

Paul D. Pittman, L.E.G.

This version of the Report was produced from an electronic Portable Document File (pdf)
conversion of the original document format
ORIGINAL SIGNED AND SEALED REPORTS ARE ON FILE WITH SKAGIT COUNTY

Statement of Limitations
This document has been prepared by Element for the exclusive use and benefit of Skagit County. No other party is entitled to rely on any of the conclusions, data, opinions, or any other information contained in this document.

This document represents Element Solutions best professional judgment based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the geologic engineering profession currently practicing under similar conditions. No warranty, expressed or implied, is made.

References

DeLaChapelle, J. 2000. Late Holocene aggradational processes and rates for three alluvial fans, Cascade Foothills, Washington. Unpublished M.Sc. thesis, Western Washington University, Bellingham, Washington.

Dragovich, J.D., D.K. Norman, and G. Anderson, 2000. Interpreted geologic history of the Sedro-Woolley North and Lyman 7.5-minute quadrangles, western Skagit County, Washington. 71 p. 1 pl.

GeoEngineers, Inc. 2004. Hansen Creek: Reach 2 Restoration and Sediment Retention Project Report. Prepared for Skagit County Public Works.

Jakob, M. 1996. Morphometric and geotechnical controls on debris flow frequency and magnitude in southwestern British Columbia. Unpublished Ph.D. thesis, University of British Columbia, Vancouver.

Jakob, M., Bovis, M. and Oden, M. (2005), The significance of channel recharge rates for estimating debris-flow magnitude and frequency. Earth Surface Processes and Landforms, 30: 755–766. doi: 10.1002/esp.1188

Lautz, K. and Beall, J. 2005. Site and Reach Assessment Evaluation of Treatment Alternatives: SR 20 MP 76.25 (Red Cabin Creek) Chronic Environmental Deficiency Study. Prepared for the Washington State Department of Transportation.

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.

Miller Consulting. 2002. Hansen Creek Watershed Management Plan.

Northwest Hydraulic Consultants. 2008. Coal Creek Minkler Road Sediment Basin Performance Review and Recommended Refinements. Unpublished report prepared for Skagit County Public Works. 48 pp.

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.

R2 Resource Consultants, Inc. 2008. Comparison of Mouse Creek Bed Profiles After Reconstruction of Bridge #631 and Observations on General Flooding Problems and Potential Actions.

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.

Skagit Watershed Council. 2011. Plan for Habitat Protection and Restoration in the Middle Reach of the Skagit River: Strategies, Treatments, and Priorities. SRFB 08-2132.

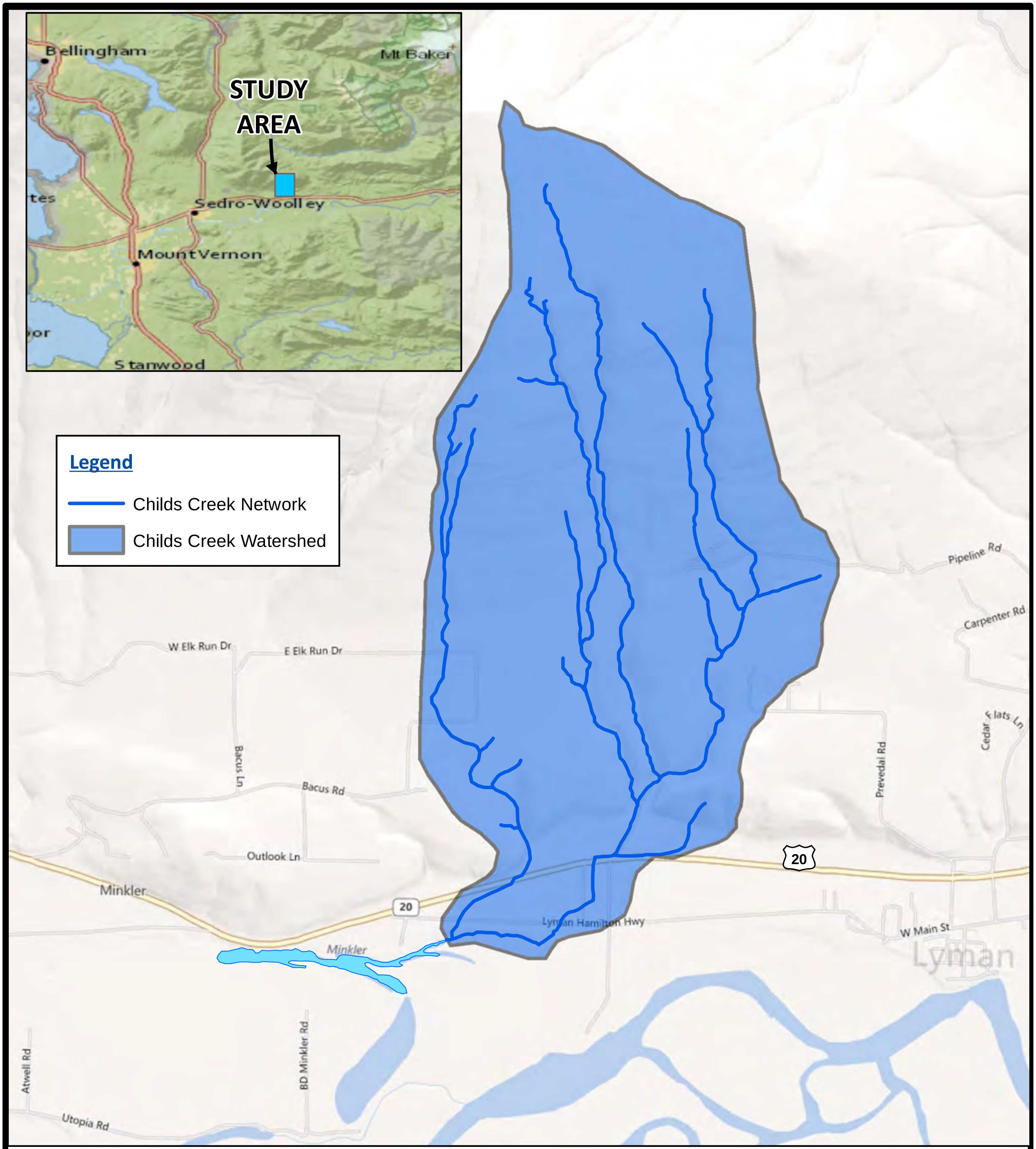
Sumioka, S.S., Kresch, D.L., and Kasnick, K.D., 1998, Magnitude and Frequency of Floods in Washington: U.S. Geological Survey Water-Resources Investigations Report 97-4277, 91 p.

Tabor, R.W., Haugerud, R.A., Hildreth, W., and Brown, E.H. 2003. Geologic Map of the Mount Baker 30- by 60-Minute Quadrangle, Washington, U.S. Geological Survey Geologic Investigations Series I-2660.

Washington Department of Natural Resources, 1994. Hansen Watershed Assessment Unit Assessment Report/Presriptions. Unpublished report dated August 31, 1994.

Waters, T.F., 1995. Sediment in Streams: Source, Biological Effects, and Control. American Fisheries Society, Bethesda, Maryland.

FIGURES



Element Project Number: 2010112

Miles
0 0.25 0.5

Notes:
Inset map from National Geographic

Childs Creek Sediment Management Feasibility Study

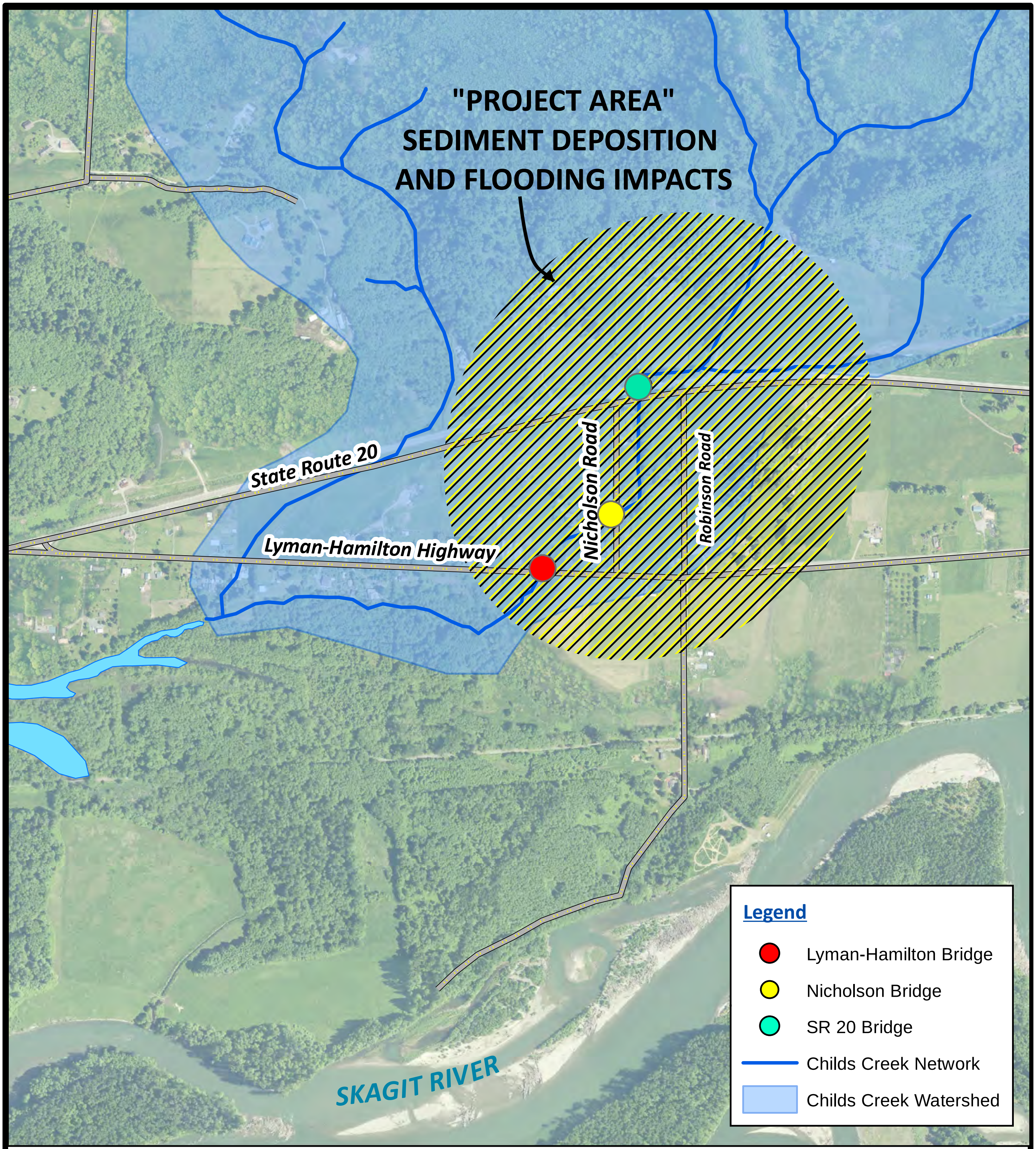
Skagit County, Washington

Date Created: June 15, 2012
Revision Date: July 7, 2012
By: Jeff Ninnemann / Paul Pittman

Vicinity

Figure 1

1812 Cornwall Avenue
Bellingham, WA 98225
info@elementsolutions.org



Element Project Number: 2010112

N

Feet
0 400 800

Notes:
Background 2010 Air Photo

Childs Creek Sediment Management Feasibility Study

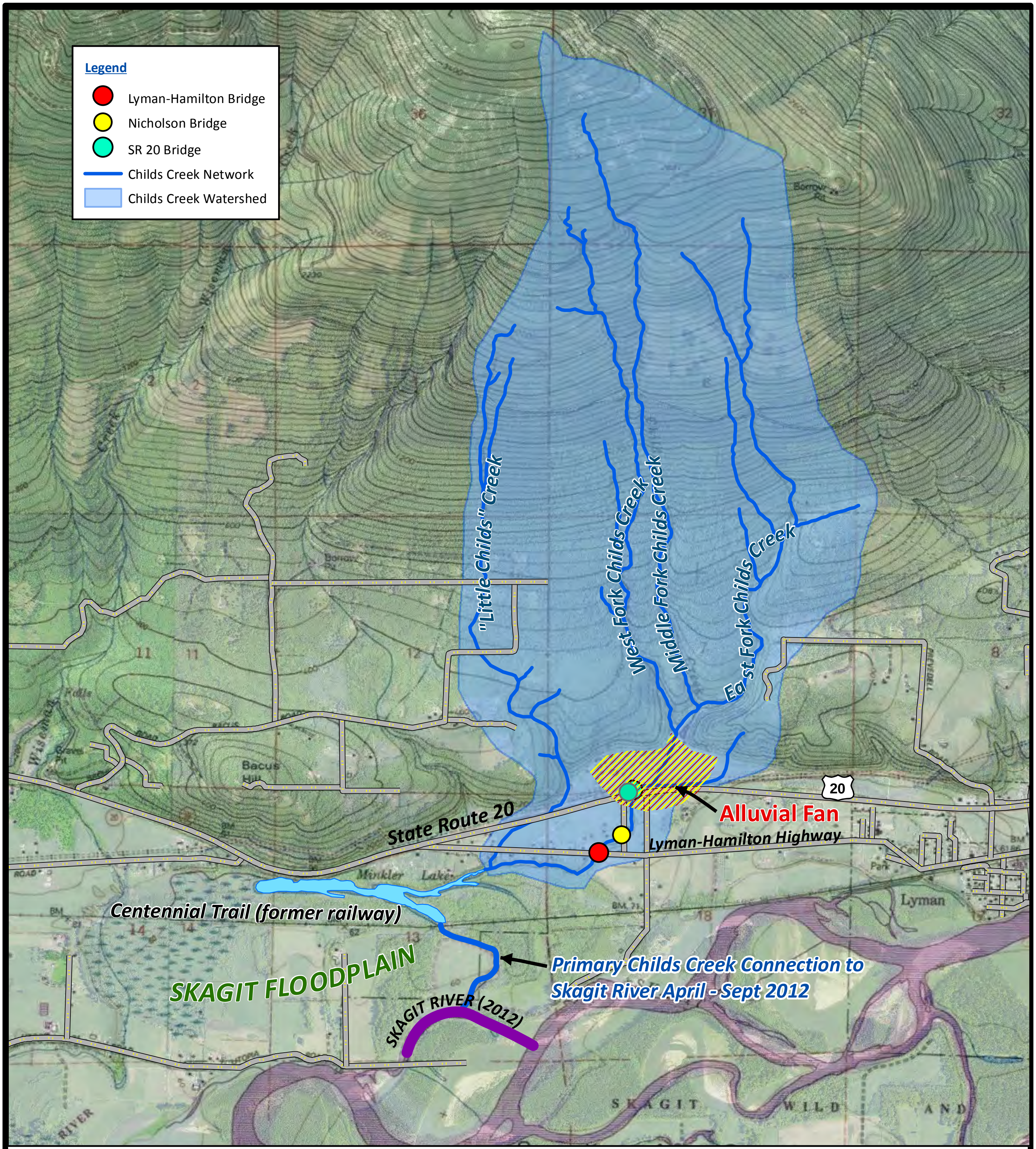
Skagit County, Washington

Date Created: June 15, 2012
Revision Date: July 7, 2012
By: Jeff Ninnemann / Paul Pittman

Project Area

Figure 2

1812 Cornwall Avenue
Bellingham, WA 98225
info@elementsolutions.org



Element Project Number: 2010112

Feet
0 1,000 2,000

Notes:
Background map from Topo USA Topo Maps/USGS
with LiDAR hillshade (USGS) and Skagit County 2011 DOQ

Childs Creek Sediment Management Feasibility Study

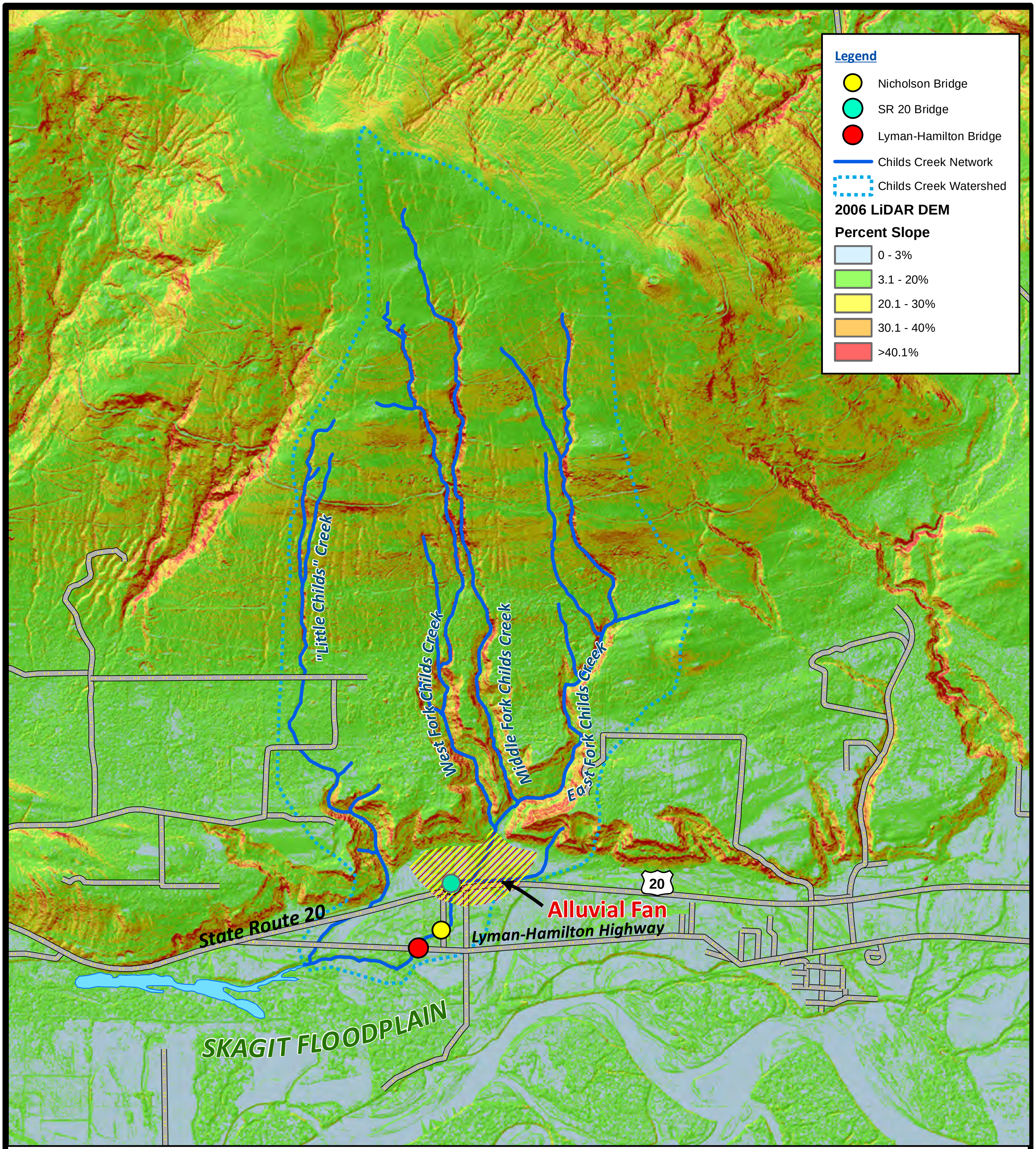
Skagit County, Washington

Watershed Physiography

Figure 3

Date Created: June 15, 2012
Revision Date: Sept 21, 2012
By: Paul Pittman

1812 Cornwall Avenue
Bellingham, WA 98225
info@elementsolutions.org



Element Project Number: 2010112

Feet
0 1,000 2,000

Notes:
Background map from Topo USA
Topo Maps/USGS

Childs Creek Sediment Management Feasibility Study

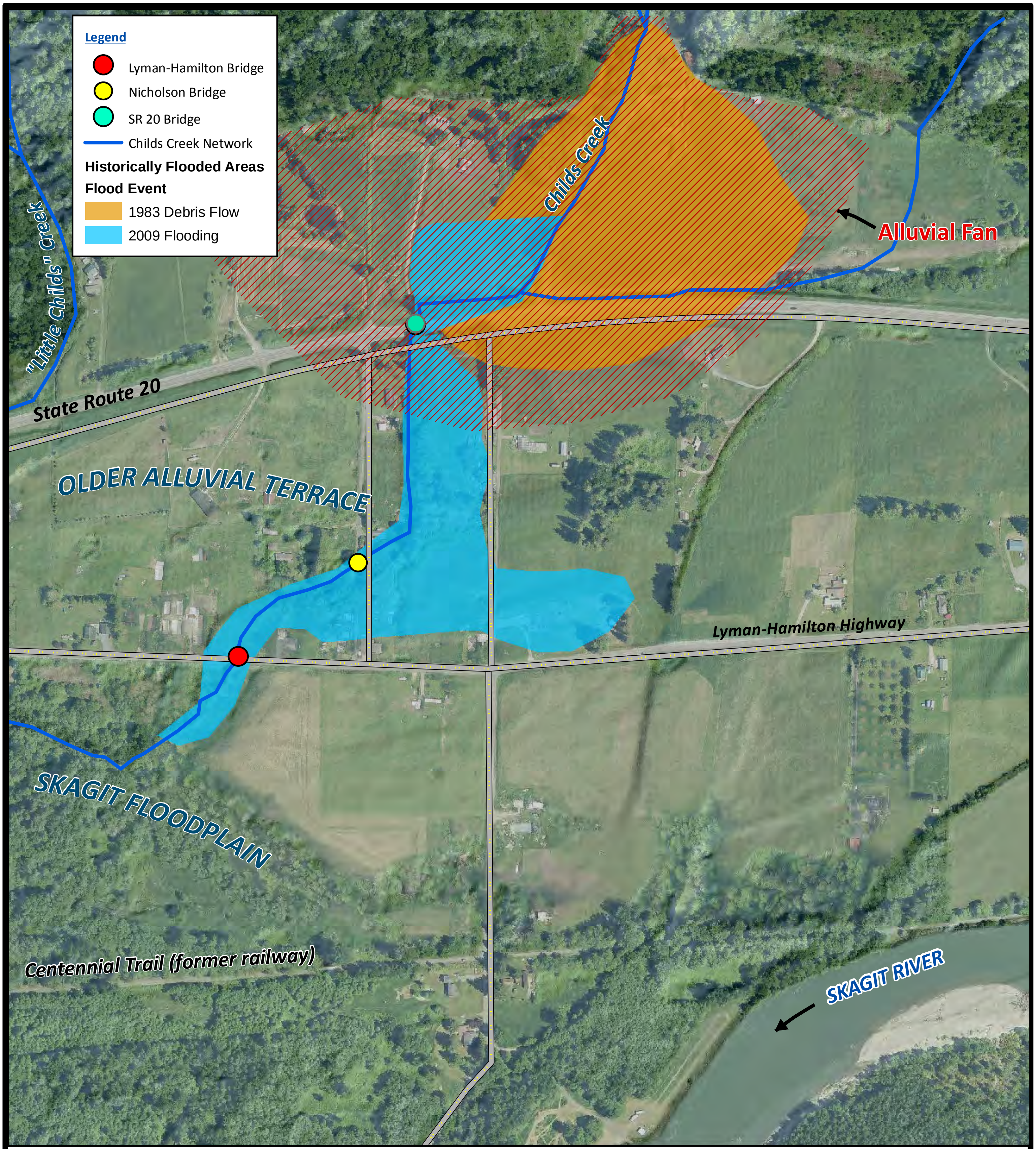
Skagit County, Washington

Date Created: June 15, 2012
Revision Date: July 7, 2012
By: Jeff Ninnemann / Paul Pittman

Watershed Slope

Figure 4

1812 Cornwall Avenue
Bellingham, WA 98225
info@elementsolutions.org



Element Project Number: 2010112

Childs Creek Sediment Management Feasibility Study

Historically Flooded Areas (1983 & 2009)

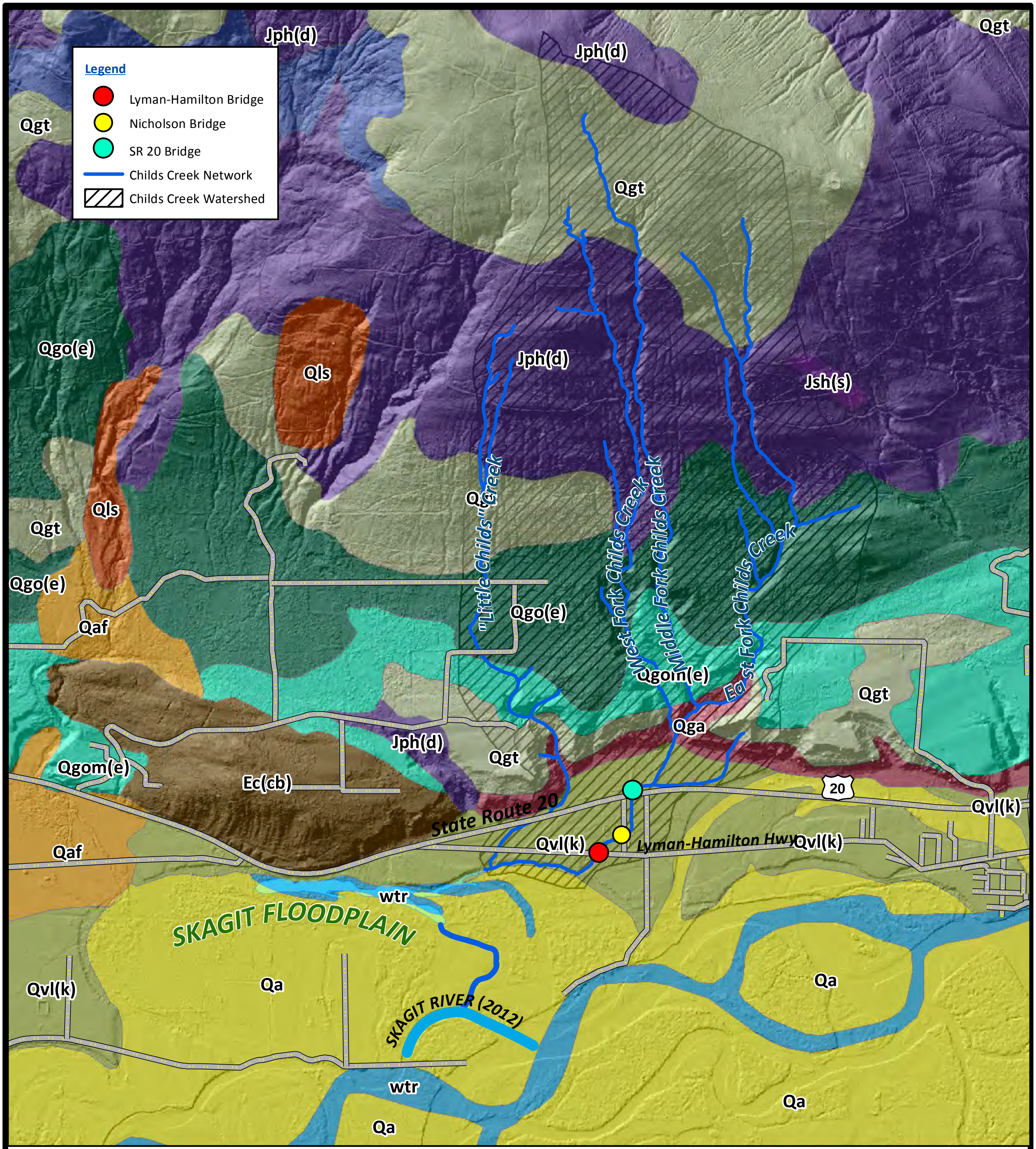
Skagit County, Washington

Figure 5

Notes:
Background map from Topo USA Topo Maps/USGS
with LiDAR hillshade (USGS) and Skagit County 2011 DOQ

Date Created: June 15, 2012
Revision Date: Sept 21, 2012
By: Paul Pittman

1812 Cornwall Avenue
Bellingham, WA 98225
info@elementsolutions.org



Element Project Number: 2010112

Feet
0 1,000 2,000

Notes:
DNR compiled geology (100 k)
with LiDAR hillshade (USGS)

Childs Creek Sediment Management Feasibility Study

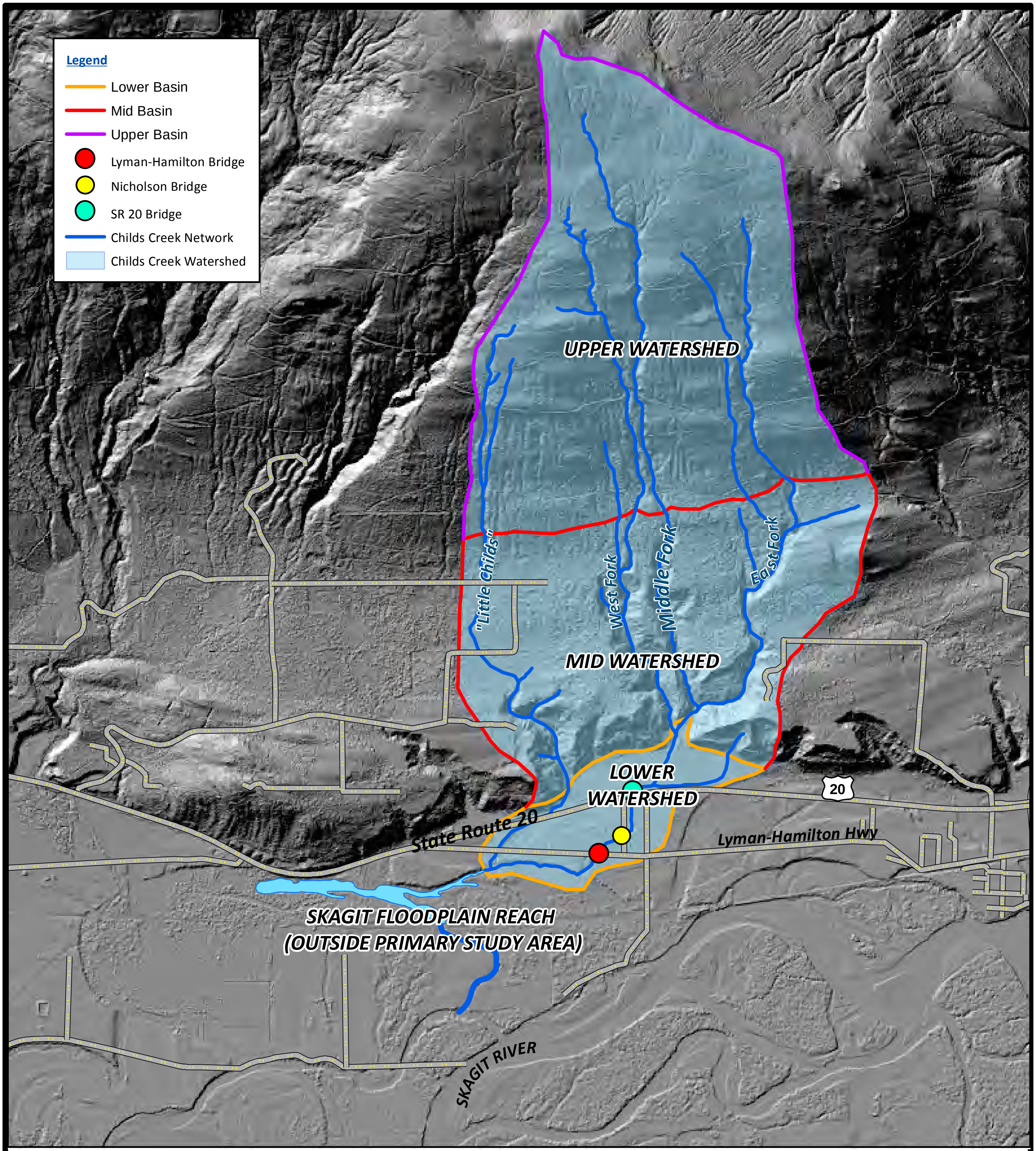
Skagit County, Washington

Date Created: June 15, 2012
Revision Date: Sept 21, 2012
By: Paul Pittman

Watershed Geology

Figure 6

1812 Cornwall Avenue
Bellingham, WA 98225
info@elementsolutions.org



Element Project Number: 2010112

0 1,000 2,000 Feet

Notes:
LiDAR hillshade (USGS)

Childs Creek Sediment Management Feasibility Study

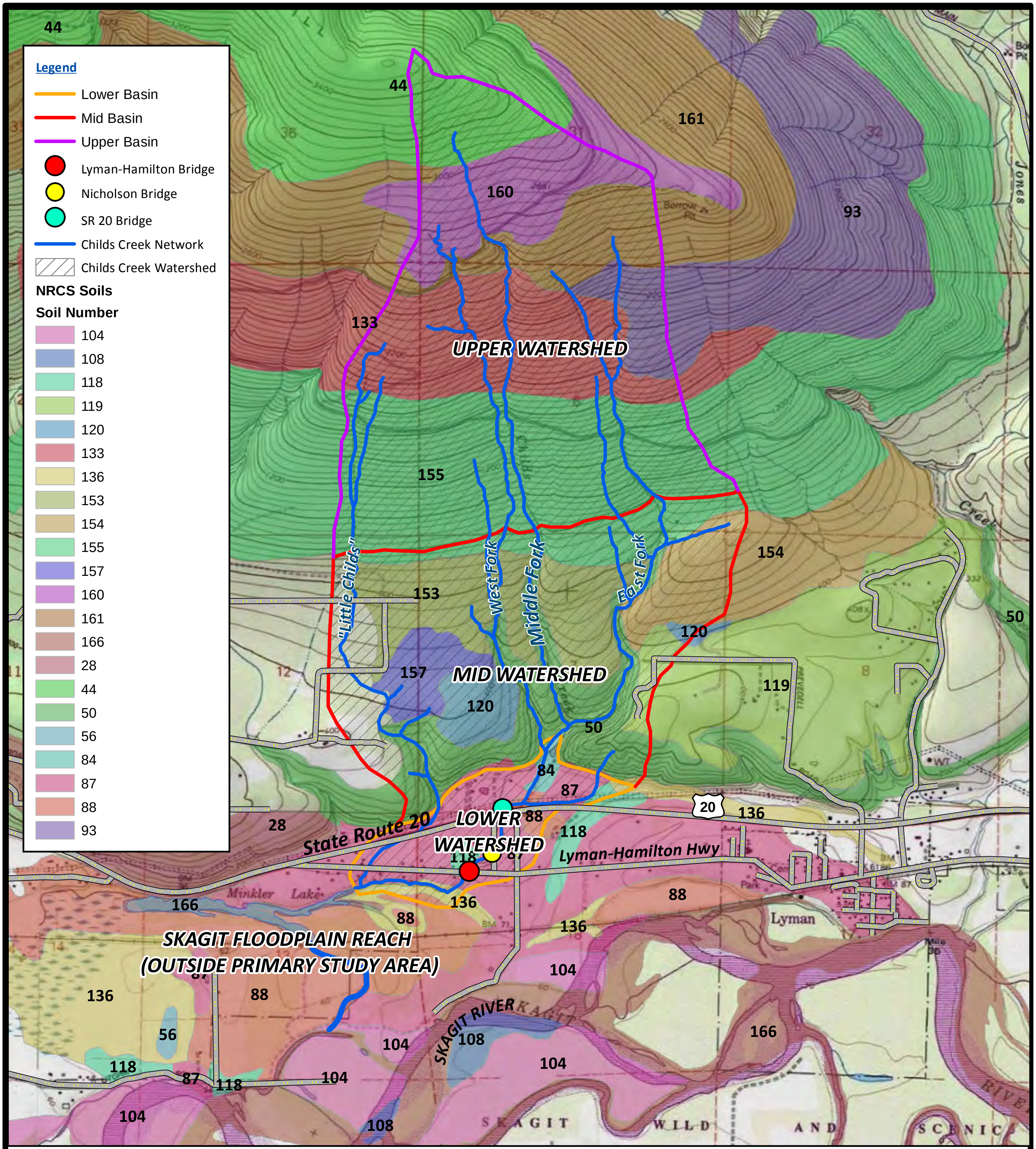
Skagit County, Washington

Date Created: June 15, 2012
Revision Date: Sept 21, 2012
By: Paul Pittman

Watershed Reaches

Figure 7

1812 Cornwall Avenue
Bellingham, WA 98225
info@elementsolutions.org
ELEMENT solutions



Element Project Number: 2010112

Feet
0 1,000 2,000

Notes:
NRCS Soils
USA Topography (USGS)

Childs Creek Sediment Management Feasibility Study

Watershed Soils

Skagit County, Washington

Figure 8

Date Created: June 15, 2012
Revision Date: Sept 21, 2012
By: Paul Pittman

1812 Cornwall Avenue
Bellingham, WA 98225
info@elementsolutions.org

Appendix A – Historic Information

APPENDIX A CONTENTS

1. **1983 DEBRIS FLOW PHOTOGRAPHS**

   NOTE ON HISTORIC PHOTOS
   The following photographs were provided to Skagit County by Mr. Anthony Hamerski, a resident at the apex of the Childs Creek alluvial fan who lived at the site at the time of the January 1983 debris flow. The home shown in the images was damaged in the 1983 event and no injuries were reported as the structure was unoccupied at the time of the event. The 1983 event resulted in a realignment of Childs Creek, the loss of Mr. Hamerski's home and damage to public roads. Mr. Hamerski provided the images to preserve the history of that event. If you are viewing this document in a digital PDF format, the photo sizes were left at large scale to preserve as much detail in the photos as possible. Original photographs are the held with Mr. Hamerski. If you are printing this document from the PDF format, please select 8.5" x 11" page format and format the printing accordingly.

2. **HISTORIC CHILDS CREEK HYDRAULIC PERMIT APPROVALS (HPA) FOR SKAGIT COUNTY (1996-2006)**

   Note: Cover sheets only


OCT

A-24

OCT 83


OCT '83

OCT 83

R-3

OCT 83


OCT 83

Washington
Department of
FISH and
WILDLIFE

HYDRAULIC PROJECT APPROVAL

RCW 77.55.021(10) & (11) - Appeal Pursuant to Chapter

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

Did not dredge

Issue Date: November 15, 2006
Project Expiration Date: November 25, 2006

Control Number: 107384-1
FPA/Public Notice #: N/A

PERMITTEE	AUTHORIZED AGENT OR CONTRACTOR
Skagit County Public Works ATTENTION: Barb Hathaway 1800 Continental Place Mount Vernon, WA 98273 360-336-9400 Fax: 360-336-9369	

Project Name:	Childs Creek bridge dredging
Project Description:	Removal of less than 50 CY of sediment and repositioning of large woody debris from the Lyman Hamilton Road bridge crossing of Childs Creek.

PROVISIONS

1. TIMING LIMITATIONS: The project may begin immediately and shall be completed by November 25, 2006.

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

3. Less than 50 cubic yards of material shall be removed without additional State Environmental Policy Act (SEPA) review.

4. Repositioned large woody material shall be placed downstream of the bridge.

5. Equipment used for this project shall operate stationed on the bridge.

6. The county shall develop an alternative plan to dredging in this location, and implement measures designed for this purpose during the normal work window in 2007. The bridge at this location may need to be raised to allow proper conveyance of the stream and debris associated with it. A separate HPA will be required.

Washington Department of Fish and Wildlife

HYDRAULIC PROJECT APPROVAL

RCW 77.55.100 or RCW 77.55.150

State of Washington
Department of Fish and Wildlife
Region 4 Office
16018 Mill Creek Boulevard
Mill Creek, Washington 98012

DATE OF ISSUE: September 13, 2002

LOG NUMBER: ST-C5902-08

This Hydraulic Project Approval (HPA), which now supersedes all previous HPAs for this project, is a correction of the original HPA issued September 27, 2000, and last modified on May 31, 2001.

PERMITTEE	AUTHORIZED AGENT OR CONTRACTOR
Skagit County Public Works Department ATTENTION: Barbara Hathaway 1111 Cleveland Avenue Mt. Vernon, WA 98273-4215 (360) 336-9400 Fax: (360) 336-9478	Not Applicable

PROJECT DESCRIPTION: Dredge and Remove Approximately 176 Cubic Yards of Stream Gravel from Bridge to 20-feet Downstream and from Bridge to 20-feet Upstream on Childs Creek (Bridge #40151) for Year 2000, and 167 Cubic Yards of Stream Gravel from Same Location for Year 2001 for a Total Removal of 343 Cubic Yards of Stream Gravel, Skagit County

PROJECT LOCATION: Childs Creek Bridge at Milepost 0.5 on Lyman-Hamilton Highway, Skagit County, Washington

#	WRIA	WATER BODY	TRIBUTARY TO	1/4 SEC.	SEC.	TOWNSHIP	RANGE	COUNTY
1	03.0294	Childs Creek	Minkler Lake	NW	17	35 North	06 East	Skagit

NOTE: Due to the Endangered Species Act (ESA), consultations for the removal of gravel from Childs Creek at the Bridge located at Milepost 0.5 on the Lyman-Hamilton Highway needs to be conducted. You may wish to consult with NMFS and USFWS before conducting the proposed work authorized under this HPA.

Future dredging at the bridge shall discontinue for proceeding years from the date of this HPA until a Biological Assessment is provided by permittee, and/or a Comprehensive Study and Plan to determine long term impacts and solutions has been generated and cooperatively approved of between local, state, and federal agencies. It may be deemed necessary that the bridge may need to be removed and replaced with a larger structure, or the existing bridge modified to provide for adequate passage of gravels, convey stream flows for 100-year flood events within the channel migration zone, and enhance the stream channel for fish populations that inhabit this stream.

PROVISIONS

1. **TIMING LIMITATIONS:** The project may begin **June 15, 2001** and shall be completed by **September 30, 2002**, provided:

   a. **Work shall be conducted when stream is not flowing, or is dry in this stream reach.**

   c. **The volume of material to be removed shall not exceed 343 cubic yards.** The material to be removed in 2002 shall be conducted from August 1, 2002 to September 30, 2002 when the stream is dry.

HYDRAULIC PROJECT APPROVAL
RCW 77.55.100 or RCW 77.55.150

Washington Department of FISH and WILDLIFE

State of Washington
Department of Fish and Wildlife
Region 4 Office
16018 Mill Creek Boulevard
Mill Creek, Washington 98012

RECEIVED
JUN 04 2001
SKAGIT COUNTY
PUBLIC WORKS ADMIN.

DATE OF ISSUE: May 31, 2001 **LOG NUMBER:** 00-C5902-07

This Hydraulic Project Approval (HPA), which now supersedes all previous HPAs for this project, is a correction of the original HPA issued September 27, 2000.

PERMITTEE	AUTHORIZED AGENT OR CONTRACTOR
Skagit County Public Works Department ATTENTION: Barbara Hathaway 1111 Cleveland Avenue Mt. Vernon, WA 98273-4215 (360) 336-9400 Fax: (360) 336-9369	Not Applicable

PROJECT DESCRIPTION: Dredge and Remove Approximately 176 Cubic Yards of Stream Gravel from Bridge to 20-feet Downstream and from Bridge to 20-feet Upstream on Childs Creek (Bridge #40151) for Year 2000, and 167 Cubic Yards of Stream Gravel from Same Location for Year 2001 for a Total Removal of 343 Cubic Yards of Stream Gravel, Skagit County

PROJECT LOCATION: Childs Creek Bridge at Milepost 0.5 on Lyman-Hamilton Highway, Skagit County, Washington

#	WRIA	WATER BODY	TRIBUTARY TO	1/4 SEC.	SEC.	TOWNSHIP	RANGE	COUNTY
1	03.0294	Childs Creek	Minkler Lake	NW	17	35 North	06 East	Skagit

NOTE: Due to the Endangered Species Act (ESA), consultations for the removal of gravel from Childs Creek at the Bridge located at Milepost 0.5 on the Lyman-Hamilton Highway needs to be conducted. You may wish to consult with NMFS and USFWS before conducting the proposed work authorized under this HPA.

Future dredging at the bridge shall discontinue for proceeding years from the date of this HPA until a Biological Assessment is provided by permittee, and/or a Comprehensive Study and Plan to determine long term impacts and solutions has been generated and cooperatively approved of between local, state, and federal agencies. It may be deemed necessary that the bridge may need to be removed and replaced with a larger structure, or the existing bridge modified to provide for adequate passage of gravels, convey stream flows for 100-year flood events within the channel migration zone, and enhance the stream channel for fish populations that inhabit this stream.

PROVISIONS

1. **TIMING LIMITATIONS:** The project may begin **June 15, 2001** and shall be completed by **September 15, 2001**, provided:

   a. Work shall be conducted when stream is not flowing, or is dry in this stream reach, or,

   b. A temporary bypass to convey flow around the work area should the stream be flowing shall be installed prior to conducting work, and removed after completion of work.

   c. **176 cubic yards of material shall be removed in 2000; 167 cubic yards of material shall be removed in 2001. The material to be removed in 2001 shall be conducted from August 1, 2001 to September 15, 2001 when the stream is dry.**

HYDRAULIC PROJECT APPROVAL
RCW 77.55.100 or RCW 77.55.150

State of Washington
Department of Fish and Wildlife
Region 4 Office
16018 Mill Creek Boulevard
Mill Creek, Washington 98012

RECEIVED
MAY 30 2001
SKAGIT COUNTY
PUBLIC WORKS ADMIN.

DATE OF ISSUE: May 29, 2001

LOG NUMBER: 00-C5902-06

At the request of, Barbara Hathaway, on April 18, 2001, this Hydraulic Project Approval (HPA), which now supersedes all previous HPAs for this project, is a time extension and change of the original HPA issued September 27, 2000.

PERMITTEE	AUTHORIZED AGENT OR CONTRACTOR
Skagit County Public Works Department ATTENTION: Barbara Hathaway 1111 Cleveland Avenue Mt. Vernon, WA 98273-4215 (360) 336-9400 Fax: (360) 336-9369	Not Applicable

PROJECT DESCRIPTION: Dredge and Remove Approximately 176 Cubic Yards of Stream Gravel from Bridge to 20-feet Downstream and from Bridge to 20-feet Upstream on Childs Creek (Bridge #40151) for Year 2000, and 167 Cubic Yards of Stream Gravel from Same Location for Year 2001 for a Total Removal of 343 Cubic Yards of Stream Gravel, Skagit County

PROJECT LOCATION: Childs Creek Bridge at Milepost 0.5 on Lyman-Hamilton Highway, Skagit County, Washington

#	WRIA	WATER BODY	TRIBUTARY TO	1/4 SEC.	SEC.	TOWNSHIP	RANGE	COUNTY
1	03.0294	Childs Creek	Minkler Lake	NW	17	35 North	06 East	Skagit

NOTE: Due to the Endangered Species Act (ESA), consultations for the removal of gravel from Childs Creek at the Bridge located at Milepost 0.5 on the Lyman-Hamilton Highway needs to be conducted. You may wish to consult with NMFS and USFWS before conducting the proposed work authorized under this HPA.

Future dredging at the bridge shall discontinue for proceeding years from the date of this HPA until a Biological Assessment is provided by permittee, and/or a Comprehensive Study and Plan to determine long term impacts and solutions has been generated and cooperatively approved of between local, state, and federal agencies. It may be deemed necessary that the bridge may need to be removed and replaced with a larger structure, or the existing bridge modified to provide for adequate passage of gravels, convey stream flows for 100-year flood events within the channel migration zone, and enhance the stream channel for fish populations that inhabit this stream.

PROVISIONS

1. **TIMING LIMITATIONS:** The project may begin **June 15, 2001** and shall be completed by **September 15, 2001**, provided:

   a. Work shall be conducted when stream is not flowing, or is dry in this stream reach, or,

   b. A temporary bypass to convey flow around the work area should the stream be flowing shall be installed prior to conducting work, and removed after completion of work.

   c. **176 cubic yards of material shall be removed in 2000; 167 cubic yards of material shall be removed in 2001. The material to be removed in 2001 shall be conducted from August 1, 2001 to September 15, 2001 when the stream is dry.**

HYDRAULIC PROJECT APPROVAL
RCW 77.55.100 or RCW 77.55.150

Washington Department of Fish and Wildlife

State of Washington
Department of Fish and Wildlife
Region 4 Office
16018 Mill Creek Boulevard
Mill Creek, Washington 98012

DATE OF ISSUE: October 20, 2000

LOG NUMBER: 00-C5902-005

At the request of, Barbara Hathaway, on October 19, 2000, this Hydraulic Project Approval (HPA), which now supersedes all previous HPAs for this project, is a time extension and change of the original HPA issued September 27, 2000.

PERMITTEE	AUTHORIZED AGENT OR CONTRACTOR
Skagit County Public Works Department ATTENTION: Barbara Hathaway 1111 Cleveland Avenue Mt. Vernon, WA 98273-4215 (360) 336-9400 Fax: (360) 336-9369	Not Applicable

PROJECT DESCRIPTION: Dredge and Remove Approximately 176 Cubic Yards of Stream Gravel from Bridge to 20-feet Downstream and from Bridge to 20-feet Upstream on Childs Creek (Bridge #40151) for Year 2000, and 167 Cubic Yards of Stream Gravel from Same Location for Year 2001 for a Total Removal of 343 Cubic Yards of Stream Gravel, Skagit County

PROJECT LOCATION: Childs Creek Bridge at Milepost 0.5 on Lyman-Hamilton Highway, Skagit County, Washington

#	WRIA	WATER BODY	TRIBUTARY TO	1/4 SEC.	SEC.	TOWNSHIP	RANGE	COUNTY
1	03.0294	Childs Creek	Minkler Lake	NW	17	35 North	06 East	Skagit

NOTE: Due to the Endangered Species Act (ESA), consultations for the removal of gravel from Childs Creek at the Bridge located at Milepost 0.5 on the Lyman-Hamilton Highway needs to be conducted. You may wish to consult with NMFS and USFWS before conducting the proposed work authorized under this HPA.

Future dredging at the bridge shall discontinue for proceeding years from the date of this HPA until a Biological Assessment is provided by permittee, and/or a Comprehensive Study and Plan to determine long term impacts and solutions has been generated and cooperatively approved of between local, state, and federal agencies. It may be deemed necessary that the bridge may need to be removed and replaced with a larger structure, or the existing bridge modified to provide for adequate passage of gravels, convey stream flows for 100-year flood events within the channel migration zone, and enhance the stream channel for fish populations that inhabit this stream.

PROVISIONS

1. **TIMING LIMITATIONS:** The project may begin **Immediately** and shall be completed by **October 31, 2000**, provided:

   a. Work shall be conducted when stream is not flowing, or is dry in this stream reach, or,

   b. A temporary bypass to convey flow around the work area should the stream be flowing shall be installed prior to conducting work, and removed after completion of work.

   c. **176 cubic yards of material shall be removed in 2000; 167 cubic yards of material shall be removed in 2001**

HYDRAULIC PROJECT APPROVAL

RCW 77.55.100 or RCW 77.55.150

State of Washington
Department of Fish and Wildlife
Region 4 Office
16018 Mill Creek Boulevard
Mill Creek, Washington 98012

DATE OF ISSUE: September 27, 2000

LOG NUMBER: 00-C5902-04

At the request of Barbara Hathaway, this HPA is a time extension and revision change of the previous HPA, and supersedes all previous HPA's issued.

PERMITTEE	AUTHORIZED AGENT OR CONTRACTOR
Skagit County Public Works Department ATTENTION: Barbara Hathaway 1111 Cleveland Avenue Mt. Vernon, WA 98273-4215 (360) 336-9400 Fax: (360) 336-9369	Not Applicable

PROJECT DESCRIPTION: Dredge and Remove Approximately 50 Cubic Yards of Stream Gravel from Bridge to 20-feet Downstream on Childs Creek, Skagit County

PROJECT LOCATION: Childs Creek Bridge at Milepost 0.5 on Lyman-Hamilton Highway, Skagit County, Washington

#	WRIA	WATER BODY	TRIBUTARY TO	1/4 SEC.	SEC.	TOWNSHIP	RANGE	COUNTY
1	03.0294	Childs Creek	Minkler Lake	NW	17	35 North	06 East	Skagit

NOTE: Due to the Endangered Species Act (ESA), consultations for the removal of gravel from Childs Creek at the Bridge located at Milepost 0.5 on the Lyman-Hamilton Highway needs to be conducted. You may wish to consult with NMFS and USFWS before conducting the proposed work authorized under this HPA.

Future dredging at the bridge shall discontinue for proceeding years from the date of this HPA until a Biological Assessment is provided by permittee, and/or a Comprehensive Study and Plan to determine long term impacts and solutions has been generated and cooperatively approved of between local, state, and federal agencies. It may be deemed necessary that the bridge may need to be removed and replaced with a larger structure, or the existing bridge modified to provide for adequate passage of gravels, convey stream flows for 100-year flood events within the channel migration zone, and enhance the stream channel for fish populations that inhabit this stream.

PROVISIONS

1. **TIMING LIMITATIONS:** The project may begin **Immediately** and shall be completed by **October 6, 2000**, provided:
   a. Work shall be conducted when stream is not flowing, or is dry in this stream reach.
   b. Work shall be conducted with weather permitting/ non-raining days.
2. NOTIFICATION REQUIREMENT: The permittee or contractor shall notify the Area Habitat Biologist (AHB) listed below, by FAX or mail, of the project start date. Notification shall be received by the AHB at least three working days prior to the start of construction activities. The notification shall include the permittee's name, project location, starting date for work, and the control number for this Hydraulic Project Approval.

Childs Creek

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 17, 1996
(applicant should refer to this date in all correspondence)
PAGE 1 OF 2 PAGES

10 LAST NAME FIRST: Skagit County Public Works
18 CONTACT PHONE(S): (360) 336-9333 x
1 CONTROL NUMBER: 238 00-C5902-01
19 STREET OR RURAL ROUTE: 1111 Cleveland Ave ATTN: Barbara Hathaway
7
8
9 WRIA: 03.0294
CITY: Mount Vernon
STATE: WA
ZIP: 98273
14
17
12 WATER: Childs Creek
TRIBUTARY TO: Skagit River
11 TYPE OF PROJECT: Dredge at Bridge
13 QUARTER SECTION: NW
SECTION: 17
TOWNSHIP: 35N
RANGE(E-W): 06E
COUNTY: Skagit

TIME LIMITATIONS:
5 THIS PROJECT MAY BEGIN: Immediately- rpv 1
6 AND MUST BE COMPLETED BY: Oct. 15, 1997- prv 1

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

1. ADDITIONAL TIMING LIMITATIONS: Instream work shall be completed by October 15, 1996. Any work remaining shall be done between June 15, 1997, and October 15, 1997. It may be necessary to review the site prior to 1997 work.

2. Work shall be accomplished per plans and specifications submitted to the Washington Department of Fish and Wildlife (WDFW), except as modified by this Hydraulic Project Approval (HPA). These plans reflect design criteria per Chapter 220-110 WAC. A copy of these plans shall be available on site during construction.

3. Work shall be done during a low flow period, preferably when the stream is dry.

4. If the stream is flowing, fish shall be captured and moved upstream of State Route 20 prior to dredging. A fine mesh screen shall be installed across the channel upstream and downstream to prevent fish from entering the work area. Fish rescue shall be coordinated with the Area Habitat Biologist, Kurt Buchanan, at 428-1240. A 5-day notice is requested.

5. If at any time, as a result of the project activities, fish are observed in distress, a fish kill occurs, or water quality problems develop (including equipment leaks or spills), operations shall cease and WDFW, at (206) 775-1311, and Washington Department of Ecology, at (206) 649-7000, shall be contacted immediately. Work shall not resume until further approval is given by WDFW.

SEPA: Exempt - No non-exempt permits required
REGIONAL HABITAT MANAGER - Kurt Buchanan (360) 428-1240
PATROL - Frazier 073 [P3]
APPLICANT - WILDLIFE - READER - PATROL - HAB. MGR. - WRIA

DEPARTMENT OF FISHERIES **DIRECTOR**

Appendix B – Childs Creek Habitat Survey Report

CEDAROCK CONSULTANTS, INC.
Environmental Consulting

STREAM HABITAT REPORT

CHILDS CREEK

Alluvial Fan to Skagit River

Skagit County, Washington

Prepared for:

ELEMENT Solutions
1812 Cornwall Avenue
Bellingham, Washington 98225

Prepared by:

Cedarock Consultants, Inc.
19609 244th Avenue NE
Woodinville, Washington 98077

September 26, 2012

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDIX

Field Data – Excel spreadsheets and raw field notes.

1.0 INTRODUCTION

Skagit County Public Works is considering management alternatives to help alleviate impacts of Childs Creek flooding on the alluvial fan and downstream (Figure 1). These downstream reaches of Child Creek are known fish-bearing waters with use by both resident and anadromous salmonids for spawning and rearing. Because any work involving flow and sediment management has the potential to adversely affect fish habitat, this study was conducted to evaluate existing conditions of fish habitat within the primary sediment depositional areas downstream of the canyon reach (Reach 2). The survey was continued downstream to the Skagit River to help identify any issues in this area (Reach 1) that may also influence fish use of the upper area, and to evaluate potential mitigation opportunities.

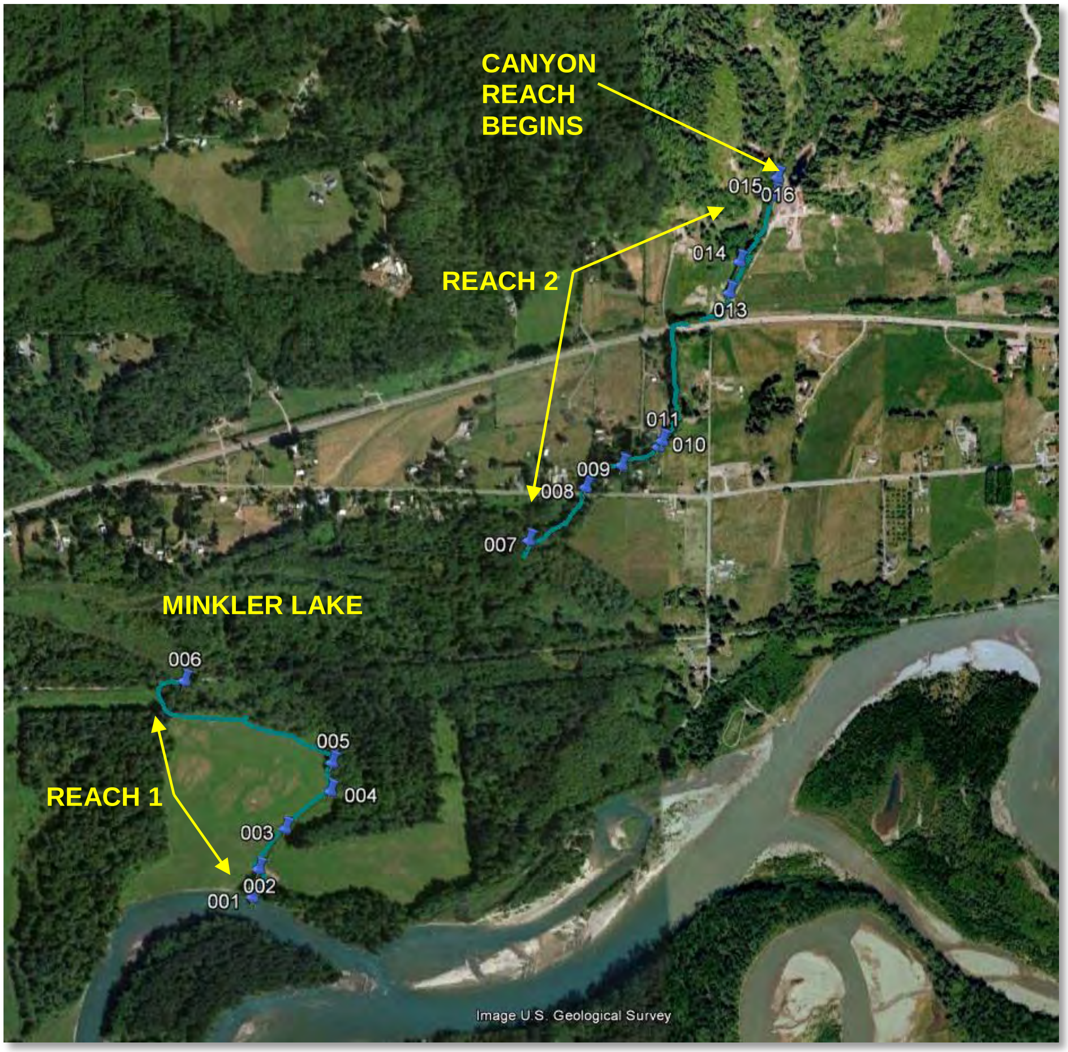


Figure 1. Aerial photo showing lower Childs Creek and fish habitat survey track (GPS waypoint numbers are shown).

2.0 METHODS

Field techniques generally followed guidelines described in Washington Forest Practices Board Manuals (1997 and 2004). Data were recorded on Write-in-the-Rain field sheets and then transferred to Excel spreadsheets. Both are provided in the attached appendix. Specific details are provided below describing or referencing each habitat feature measurement technique.

Childs Creek was walked on September 6, 2012 in an upstream direction while physical channel measurements and habitat observations were made. Distances were measured with a hip chain. Spot locations were identified with GPS points (Figure 1). The survey was divided into two reaches separated by Minkler Lake. The large wetland/open water area that comprises Minkler Lake was not surveyed. The survey of Reach 1 began at the confluence with the Skagit River and continued upstream approximately 2,600 feet (0.5 river miles [RM 0.5]) to the Centennial Trail crossing bridge. Because the channel through this area was generally confined to an entrenched ditch with steep, blackberry confined banks and deep silt/organic substrates, and walking the channel was impossible, most of this reach was observed from the bank. Reach 2 began about 600 feet downstream of the Lyman-Hamilton Highway crossing and continued upstream to the mouth of the canyon reach, a distance of approximately 3,700 feet (0.7 miles). The starting point was selected where very dense vegetation that included Himalayan blackberry made moving down-channel increasingly difficult. And because the channel was dry in this area, and beginning to braid, collecting habitat data was infeasible without a much larger effort.

Habitat units were separated into channel types such as flat water (pools, runs), riffles, and cascades. A number of instream and riparian habitat characteristics were collected within each habitat unit. If the units were longer than about 300-feet, multiple measurements were collected within a unit. Measured variables included length, wetted width, maximum water depth, bankfull width and depth, dominant and sub-dominant substrate, presence of spawning substrates suitable for resident trout and anadromous salmonids, percent flatwater within riffles and cascades, pool formative element, pool maximum and control depths, substrate embeddedness of pool tailouts, percent wood cover of pools, large woody debris counts, riparian vegetation by species, percent shade cover, and water temperature. Photographs were also taken periodically. Additional detail is provided below.

Habitat Units

Habitat units were separated based on channel gradient and minimum size. They were denoted as flat (<0.1 % slope), pools (topographic low points meeting minimum size and residual depth criteria per WFPB 1997), runs/riffles (0.1%<slope<5%), and cascades (step pools with gradient greater than 5 percent. Discrete physical habitat measurements were taken at least once within each habitat unit and every five to ten bankfull widths if the habitat unit length exceeded five times the bankfull width.

Wetted Width and Depth

The channel was flowing at what was likely the summer low level because of recent dry weather. The wetted width was measured once in each habitat unit with a length less than five channel widths in length, and once each 5 to 10 channel widths for longer units. The average width for the longer units was recorded. The maximum depth for each pool was measured using a marked piece of ¾” PVC pipe.

Bankfull Depth and Width

Bankfull depth was measured as the average vertical distance between the channel bed and the estimated water surface elevation required to completely fill the channel to a point above which water would enter the floodplain or intersect a terrace or hillslope (Pleus and Schuett-Hames 1998). Bankfull width was measured as the lateral extent of the water surface elevation perpendicular to the channel at bankfull depth.

Substrate

Substrate was visually examined throughout each habitat unit and a subjective determination made of the dominant and sub-dominant substrate types. Substrate was separated by size according to general salmonid habitat functionality as shown in Table 1.

Table 1. Substrate Categorization

Substrate	Code	Size	General Salmonid Function
Fines/Organics	F	Silts, clays, and organics	Low value. Degrades spawning habitat
Sand	S	<bb’s	Low value
Gravel	G	bb’s to golf balls	Resident trout and coho spawning habitat
Cobble	C	Baseballs to volleyballs	Steelhead and Chinook spawning habitat
Boulder	B	> Basketballs	Forms pools and velocity breaks
Bedrock	R	Solid rock	Low value

Based on Flosi et.al. 1998.

Spawning habitat availability was based on substrate size and minimum spawning site size (Schuett-Hames and Pleus 1996.) Spawning substrate was considered suitable for resident trout use if a patch of substrate dominated by gravel was present over an area in excess of 1 sq.ft. Spawning substrate was considered suitable for anadromous salmonid use if a patch of substrate dominated by gravel or cobble was present over an area in excess of 10 sq.ft.

Percent Flatwater

In many watercourses human influence has significantly altered pool habitat forming factors such as the availability of LWD, and confinement of a channel. In these cases, pools that might have formed in low gradient (flatwater) areas are generally absent. To assess the amount of stream length where pool formation might be improved in the future, and to identify habitat that is otherwise used as low gradient rearing habitat, the percent of flatwater within riffles and cascades is estimated.

Pool Habitat

Because of their importance to fish rearing and spawning habitat, pools are examined in the most detail. Pools are defined using criteria provided in the fisheries module of WFPB (2004). To be considered a pool, the unit must meet minimum size criteria (measured as total area) and maximum depth (measured as residual pool depth) based on bankfull channel width at the unit. Dominant pool formative element is identified as either wood (log or rootwad), bed or bank scour, boulder, or other. Substrate embeddedness of the pool tailout is examined to identify potential use as spawning substrate. The substrate is considered embedded if greater than 25 percent of the interstitial spaces are clogged with fine material (Flosi et.al. 1998). Percent wood cover of pools is estimated as the total percentage of wetted pool area overlain by logs or rootwads.

Large Woody Debris

Pieces of wood found within the bankfull channel width and greater than 6-feet in length and 4-inches in diameter are counted as large woody debris. Notes are taken if logs appeared to have been artificially placed in the channel.

Riparian Condition

Riparian condition including dominant shrubs and trees, and shade coverage was evaluated approximately every 300 feet. If present, the 2 or 3 most dominant shrubs and trees nearest the channel were identified. Percent canopy closure was measured using a spherical densiometer under the procedure described in (Pleus and Schuett-Hames 1998).

Water Quality

Water temperature was measured approximately every 300 feet with a calibrated thermometer.

Photos

Digital photos looking upstream were taken approximately every 300 feet. Additional photos were taken of unusual features.

Fish Migration Barriers

Upstream fish migration barriers were defined as features exceeding the ability of salmonids to pass in an upstream direction. Salmonid passage ability identification generally utilized criteria presented in Powers and Orsborn (1985) and Bell (1991).

3.0 RESULTS

3.1 Habitat Types

3.1.1 Reach 1

Habitat in the lower reach is fairly monotypic and reflects the largely low gradient channelized nature of the watercourse through and along an area of existing pasture (Figure 2). With a few minor exceptions the entire reach consists of flatwater habitat with very little diversity. The reach was flat with barely enough slope to produce any deflection in the water surface. Small exceptions were found at the mouth (Figure 3, Waypoint 001) where the channel opens up to the Skagit River, a small pond formed by an inactive beaver dam (Figure 4, Waypoint 004), a short cobbled reach near an old stream gauge structure (Figure 5, Waypoint 005), and where the channel opens up into the Minkler Lake reach (Figure 6, Waypoint 006). Despite the exceptions, flatwater habitat made up virtually 100 percent of the habitat by channel length and by area.

3.1.2 Reach 2

Habitat classification in Reach 2 was complicated by the lack of surface flow downstream of Waypoint 009 (just downstream of the Nicholson Road crossing). The 1,135 feet of dry channel between Waypoints 007 and 009 was relatively flat and lacked diversity (Figure 7). However, a number of small depressions in the substrate may qualify as pools when the reach contains flow.

The wetted reach contained a total of 25 different habitat units over 2,571 feet. Pool and flatwater areas were observed in equal frequency with 12 instances of each. One riffle/cascade was found at the upper end of the study reach as the mouth of the canyon was reached. Pools made up only 11 percent of the habitat by channel length and 13 percent by surface area. Flatwater habitat made up 88 percent of the habitat by channel length and 86 percent by area (Figure 8). Riffle habitat made up 1 percent of the habitat by channel length and by area.

A total of 12 pools were identified in this reach for a pool frequency of 24.6 pools/mile (Figure 9). Logs were the primary formative element for five (42%) pools. Bed scour as a result of constriction or around bends in the channel caused four (33%) pools and the remaining 3 pools (25%) were formed by scour around boulders.

3.2 Channel Morphology

3.2.1 Reach 1

Wetted width for the channel (not including extremes at the mouth and Minkler Lake) averaged 11.3 feet with an average maximum (thalweg) water depth of 2.3 feet. Exceptional widths were measured at the confluence with the Skagit River (24-feet), and where the channel opened up into Minkler Lake (65-feet). Measurements were not made of the single pool formed at the beaver dam (Waypoint 004) due to access issues (very deep silts and dense blackberry).

Bankfull width averaged 25 feet (range of 22 to 200 feet) and bankfull depth averaged 7 feet (range of 4 to 9 feet).

3.2.2 Reach 2

Wetted width for the portion of channel with continuous flow averaged 7.6 feet with an average maximum (thalweg) water depth of 0.5 feet. Wetted width for pools averaged 9.3 feet, for flatwater averaged 6.1 feet, and for the riffle averaged 6.0 feet. Maximum depth for pools averaged 1.6 feet with the average pool tailout at 0.3 feet. Wetted stream depth throughout the channel was not measured but on average was estimated to be about a third of the depth of the pools or about 0.5 feet. Bankfull width averaged 22 feet (range of 15 to 35 feet) and bankfull depth averaged 3 feet (range of 2 to 4 feet).

Figure 2. Reach 1 - pasture area

Figure 3. Reach 1 – mouth at Skagit River

Figure 4. Reach 1 – beaver dam

Figure 5. Reach 1 – cobble reach

Figure 6. Reach 1 – nearing Minkler Lake

Figure 7. Reach 2 – dry channel area

Figure 8. Reach 2 – flat water area

Figure 9. Reach 2 – typical shallow pool

3.3 Substrate Condition

3.3.1 Reach 1

Substrate throughout the reach consisted almost entirely of deep silt/organic materials. This made walking the channel difficult as it was not unusual to sink one to two feet into the mud before a more solid surface was reached. One exception was noted at Waypoint 005 where a cobble bedded system was observed for approximately 100 feet (Figure 5). The source of the cobble was not found. The channel reaches upstream and downstream are bedded in deep silt. No bank source of this larger material was observed in this area. Of note was the presence of a large standpipe type stream gauge on the bank near the middle of the cobbled area (approximately 1,280 feet upstream from the mouth).

3.3.2 Reach 2

Gravel was the dominant substrate over 79 percent of the reach (by length) with sand being dominant over 20 percent of the reach (primarily in the pools). The distribution of gravel didn’t change much from beginning to end of the survey. The downstream-most reach was dominated by sand, as were virtually all pools. But gravel was dominant everywhere else.

Sub-dominant substrate was more variable and coarsened in an upstream direction. While sand was the leading sub-dominant substrate covering 41 percent of the reach, this occurred almost exclusively downstream of SR-20. From the highway upstream, cobble was the leading sub-dominant substrate covering 38 percent of the reach as a whole. Very fine material was sub-dominant over 18 percent of the reach entirely within the first 575 feet at the downstream end.

3.4 Large Woody Debris

3.4.1 Reach 1

Approximately 25 pieces of large woody debris were observed in a jam at the confluence of the Skagit River and Childs Creek (Figure 3). Another single log was observed a short distance upstream. No additional wood was observed upstream to the Centennial Trail.

3.4.2 Reach 2

A total of 39 pieces of LWD were counted throughout this reach. Most (80%) was concentrated in the 700-foot reach downstream of SR-20 where evidence of artificial log placement was encountered (e.g. cabling and anchoring). Six pieces were counted in the dry reach downstream of the Lyman-Hamilton Bridge.

3.5 Fish Migration

3.5.1 Reach 1

Figure 10. Partially plugged culvert (RM 0.04)

No absolute fish migration barriers were noted in this reach. Potential temporary or partial barriers were noted at three locations:

1. A moderate sized woody debris jam is located at the confluence with the Skagit River (Figure 3). At the observed flow rate in the Skagit River, the two waterbodies (Skagit River and Childs Creek) were at the same surface water elevation and upstream passage was unimpeded. If the Skagit River were to drop several feet for some reason, passage up the very steep bank and through the logs could prove difficult.
2. A culvert under a dirt road is located at Waypoint 002 (RM 0.04), 200 feet upstream of the confluence (Figure 10). The culvert is roughly 4-feet in diameter, at grade (flat), and for the most part appeared to be open. However, a moderate amount of small woody debris has accumulated against the upstream end restricting flow. Given the amount of debris across the road and evidence of scour, it is apparent that the debris causes a restriction at times beyond which the flow seeks alternative pathways. If water cannot pass downstream through the culvert during these periods of blockage, it is possible that fish cannot pass upstream. Water was passing downstream on the survey date so the condition is not permanent.
3. A small beaver dam is located at Waypoint 004, approximately 1,050 feet upstream of the confluence (Figure 4). The dam did not appear to be currently active based on the absence of new material. Water was flowing over the dam and dropping a foot or two

into the channel downstream. While the dam might block some fish, at some flows, the drop was not high, and alternative migration pathways appeared to be present.

None of the obstacles that were encountered present complete or permanent migration blockages. However, each of them could present physical barriers under some conditions.

3.5.2 Reach 2

No potential fish migration barriers were noted with the exception of the dry channel reaches during the summer. All culverts and bridges appeared to be completely open and passable and there were no natural or anthropogenic obstructions.

3.6 Riparian Function

3.6.1 Reach 1

The channel begins in a small grove of mature deciduous trees located immediately adjacent to the Skagit River. The area is heavily impacted by cattle grazing with few shrubs or smaller trees. The understory where present is dominated by Himalayan blackberry and reed canarygrass. Canopy closure was measured at 26 percent. Within 200 feet upstream, the tree canopy layer is gone and riparian vegetation consists almost entirely of reed canarygrass with scattered Himalayan blackberry on steep banks (Figure 2). Both banks have been fenced to preclude cattle grazing. This reed canarygrass-dominated condition continues upstream to about the beaverdam located at Waypoint 004 (1,050 feet upstream). Two canopy closure measurements in this reach both recorded 0 percent cover.

From Waypoint 004, the channel enters a relatively mature deciduous forest dominated by alder. Dense reed canarygrass still covers much of the both banks. A canopy closure measurement near Waypoint 005 recorded 99 percent cover. The forested reach continues upstream to Minkler Lake where the channel opens up into a broad marsh.

3.6.2 Reach 2

Reach 2 contains good riparian shading despite having a somewhat narrow total vegetated width along both banks (Figure 8). A total of 11 canopy closure measurements found an average closure of 93 percent with a range between 75 and 100 percent. Most of the canopy was provided by mature trees with dense underlying riparian shrubs.

Himalayan blackberry was the most common of the shrub and trees species encountered showing up in 100 percent of the vegetation survey plots. Salmonberry was second (88%) and red alder was third (75%). Various other species (thimbleberry, cottonwood, willow, huckleberry, Indian plum, butterfly bush and red-osier dogwood) were all observed at frequencies below 25 percent. Reed canarygrass was ubiquitous at varying densities throughout the channel but was not tallied.

Large conifers were observed at a few locations south of SR-20 but were not immediately adjacent to the channel. The potential for future recruitment of these trees is low.

3.7 Water Quality

3.7.1 Reach 1

Ambient air temperature during the survey date was very warm ranging between 24 ^{o}C and 32 ^{o}C (75 ^{o}F and 90 ^{o}F) as measured at Marblemount.

Water temperature was measured four times in Reach 1 with a range between 11.5 ^{o}C and 15.5 ^{o}C. Temperature in Minkler Lake was 15.5 ^{o}C but cooled rapidly after entering the densely shaded forested reach. Temperature increased again upon exiting the forest and passing through the pasture. While heating occurred, the temperature did not exceed 15.5 ^{o}C before reaching the Skagit River.

3.7.2 Reach 2

Water temperature was measured six times in Reach 2 with a range between 14.5 ^{o}C and 17.0 ^{o}C. Temperature was warmest near SR-20 but this reading (2:30pm) also coincided with the peak reported air temperature. While air temperature stayed warm past 4:00pm, the water temperature cooled 2 ^{o}C as the canyon mouth upstream was approached.

4.0 DISCUSSION

Fish habitat quality in the surveyed reach is evaluated using criteria from Best Available Science references applicable to Washington State salmonids (e.g. NMFS 1996, WFPB (1997), and Ecology 2002). Current condition of key habitat forming elements and pathways are described below and summarized in Table 2. Fish rearing and spawning habitat conditions are also described with a summary provided in Table 3.

4.1 Water Quality

Water temperature is generally considered to be properly functioning for salmonids when it is between about 15 ^{o}C and 17^{o}C. Colder temperatures are preferred by native char such as bull trout. Temperatures were recorded during one of the hottest days of the year, and after a significant period without rainfall and can be expected to represent a fairly worst case scenario. With an observed range between 11.5 ^{o}C and 17.0 ^{o}C, it appears that temperature is properly functioning for the maintenance of rearing habitat in Childs Creek.

These low water temperatures were observed despite high air temperatures and a relatively narrow riparian buffer. This indicates that the high level of stream shading observed is effective. There may also be a significant groundwater temperature influence as a result of hyporheic flow through the thick substrate layer. Observed temperatures in the range of 11 and 12 ^{o}C are often a result of sub-surface flow rather than simple shading.

Table 2. Current Condition of Key Habitat Forming Elements and Pathways

Habitat Function	Existing Conditions	Condition Rating
Water Quality	Water temperature recorded between 11.5 °C and 17.0 °C on a hot summer day	**Properly functioning**
Habitat Access	Only one potential blockage noted at a culvert located 200 feet upstream of mouth	**At risk**
Habitat Elements		
Substrate	Dominated by gravel but with high sand embeddedness in many locations	**At risk**
Large Woody Debris	Low LWD counts at 0.01 pieces per foot	**Not properly functioning**
Pool Frequency	Both reaches have very low pool frequencies	**Not properly functioning**
Pool Quality	No deep pools; very little cover	**Not properly functioning**
Off-Channel Habitat	Highly constrained channel with no off-channel other than Minkler Lake	**Not properly functioning**
Refugia	Small shallow pools, low LWD counts, and no off-channel habitat	**Not properly functioning**
Channel Condition and Dynamics	Excessive sediment inputs, reduced LWD inputs, channelization	**Not properly functioning**

Table 3. Current Condition of Salmonid Habitat

Habitat Function	Existing Conditions
Summer Rearing	Moderate to low quality based on long dry reaches, low pool frequencies, poor pool quality, and very shallow water depths.
Winter Rearing	Moderate to low quality based on low pool frequencies, poor pool quality, low LWD counts, high embeddedness, and absence of off-channel and refuge habitat.
Spawning Habitat	Ranges from low to good quality in an upstream direction. Poor quality areas are limited by high silts and sand abundance in the flatter reaches. Good quality areas are primarily near and above SR-20 and are best suited to resident trout and smaller salmon (coho and pink).
Migration	Fish movement throughout the survey reach appears to be relatively unobstructed most of the year. One potential blockage noted at a culvert located 200 feet upstream of the mouth. Dry reaches during the summer limit fish movement between Minkler Lake and Nicholson Road.

4.2 Habitat Access

Habitat access is considered to be properly functioning when no man-made barriers are present that inhibit upstream or downstream fish passage. In the reach of Childs Creek that was examined, all of the manmade stream crossings with the possible exception of the culvert 200 feet upstream of the confluence were passable without issue at all normal flows. The culvert was not examined in detail but it is possible that it inhibits passage under some flow conditions and wood load rates. Habitat access is considered at risk due to the potential blockage.

4.3 Habitat Elements

4.3.1 Substrate

Substrate is considered to be properly functioning when it is dominated by gravel and cobble with low embeddedness. Reach 1 is a naturally very low gradient system downstream of the Minkler Lake area where gravel and cobble would not naturally dominate. As such, the silt bedded system should probably be considered naturally functioning.

Reach 2 is more responsive to sediment supply/discharge because of the higher gradient and location further up on the alluvial fan. Gravel is the dominant substrate throughout this reach with long pool/riffle complexes where both trout and salmonids preferring smaller substrate sizes would be expected to spawn. The high level of sand downstream of SR-20 results in a relatively high embeddedness, especially on the lower reaches downstream of the Lyman-Hamilton Highway. The level of embeddedness reduces spawning habitat quality in this area and these sections would be considered at risk or not properly functioning. Upstream of SR-20 the level of embeddedness is less and habitat quality is relatively good. Substrate condition upstream to near the end of the survey where the gradient suddenly increases and a step-pool or cascade habitat type begins would be considered properly functioning. Substrate beginning at the cascade habitat type is dominated by larger cobbles and boulders in small patches unsuitable for salmonid spawning.

4.3.2 Large Woody Debris

Large woody debris is considered to be properly functioning when there are greater than 2 pieces per channel width or approximately 0.1 pieces per foot in this area of Childs Creek. The counts in both Reach 1 and Reach 2 were well below this level at a loading of only 0.01 pieces per foot. The vast majority of this wood was encountered at the confluence of Reach 1 and the human-enhanced section or Reach 2. Virtually everywhere else wood loading was near zero. Large woody frequency is considered not properly functioning.

4.3.3 Pool Frequency

Pool frequency is considered to be properly functioning for a channel with less than a two percent grade when pools are observed at a rate of approximately 60 per mile. Reach 1 contains only a single pool at the beaver dam. Reach 2 has a pool frequency 24.6 pools/mile. Both reaches would be considered not properly functioning for pool frequency. The absence of downed trees and other woody debris, along with channelization, likely have a significant effect on pool frequency in both areas.

4.3.4 Pool Quality

Pool quality is considered to be properly functioning when the pools are greater than 3 feet deep, contain cold water, and have good cover (woody debris or large boulders). No pools greater than 3-feet were found and percent cover average only 6 percent. Pool quality would be considered very poor or not properly functioning.

4.3.5 Off-Channel Habitat

Off-channel habitat is used by fish to escape high winter flows and by some species for both summer and winter rearing. Off-channel habitat quality is considered to be good when backwaters are present in places and they contain good cover and complexity. The only area that contained backwater habitat was Minkler Lake. No other backwaters were observed. It appears most likely that any historic backwaters have been cut off and filled. Small levees and other bank management has prevented new off-channel habitat from forming. Off-channel habitat availability would be considered very poor or not properly functioning in both Reach 1 and Reach 2.

4.3.6 Refugia

Refugia provides habitat where fish can go during unusual events. This could be thermal refugia during warm periods, deeper pools during low flow periods, and off-channel area or large boulders during large flood events. Refuge habitat helps preserve populations or sub-populations during catastrophic events. Refuge habitat is considered to be properly functioning when it is present, and sufficient in size, quality, and connectivity. The metric is relatively subjective.

Some refugia is available with respect to periods of low flow where a few isolated pools were noted and had low water temperatures. These pools were small and no fish were observed. Other types of refugia were absent. Refugia availability would be considered very poor or not properly functioning in both Reach 1 and Reach 2.

4.4 Channel Condition and Dynamics

Channel condition is considered to be properly functioning when the channel form is unconstrained by anthropogenic features and free to develop naturally, but without evidence of unusually high rates of channel change that might be due to frequent flooding, excessive sediment supply, or lack of riparian buffer stabilization.

The Childs Creek channel has been heavily influenced by human activity in the watershed including excessive sediment inputs, reduced LWD inputs, channelization, riparian buffer width and composition changes, and stream crossings. Many of these changes currently influence channel function and fish habitat. Development on the floodplain in particular has constrained the ability of the channel to move in the area between the canyon reach and Lyman-Hamilton Highway. Much of Reach 1 has been ditched. Channel condition and dynamics would be considered not properly functioning in both Reach 1 and Reach 2.

4.5 Summer Rearing

Summer rearing in the two reaches is limited by long dry reaches, low pool frequencies, poor pool quality, and very shallow water depths. Despite these limitations, high numbers of juvenile coho and young resident trout were observed in Reach 2. Fish were likely being crowded into all available habitat by the very low flow conditions observed in the late summer. Good water quality, including low water temperatures, provides summer refuge during this season. Overall, summer rearing habitat is considered to be moderate to low quality in this reach.

4.6 Winter Rearing

Winter rearing is limited by low pool frequencies, poor pool quality, low LWD counts, high embeddedness, and absence of off-channel and refuge habitat in many areas. Channelization and low wood frequency are significant factors limiting winter habitat. Refuge habitat is available in Minkler Lake. The lack of significant migration barriers means any fish flushed downstream into Minkler Lake or the Skagit River can recolonize Childs Creek after significant storm events.

4.7 Spawning and Incubation

Spawning and incubation habitat quality varies based primarily on channel gradient. An abundant sediment supply containing a high proportion of gravel to sand-sized material is delivered from the upper basin. With the coarser material naturally depositing in the upper reaches of the alluvial fan-based channel, spawning habitat quality is highest in this area. Poor quality areas downstream are limited by high quantities of silts and sand. Good quality areas are primarily near and above SR-20 and are best suited to resident trout and the smaller species of salmon like coho and pink.

4.8 Potential Impacts

No specific project has been proposed at this time. Potential significant adverse effects from in-channel work in Childs Creek are listed here for consideration during project design.

- Changes in hyporheic flow can influence water temperature. Existing low summer water temperatures that provide refuge for a large number of fish upstream of Nicholson Road may be highly sensitive to changes in sediment supply.
- Spawning habitat quality is currently highest upstream of SR-20. Any channel changes in this area will have the greatest effect on spawning in Childs Creek.

4.9 Mitigation Opportunities

Potential mitigation opportunities noted during the habitat survey are listed here. The list is not comprehensive, nor have any of the options received any level of detailed consideration. The list is provided solely as a starting point for further consideration.

- The culvert located 200 feet upstream of the Skagit River could be replaced with a small bridge.
- LWD or large boulder addition could provide significant benefit in some areas. Logs placed in the reach immediately downstream of SR-20 currently have little effect in creating pools. Gradient and sediment supply influence pool formation near wood

and boulders and need to be considered in more detail before placement of additional logs or boulders.

- Several low bridges affect debris and sediment transport.
- Periodic removal of Himalayan blackberry will benefit native plant species.

5.0 REFERENCES

Bell, M. C. 1991. Fisheries handbook of engineering requirements and biological criteria. U.S. Army Corps of Engineers, Portland, OR.

Flosi, G. and five coauthors. 1998. California salmonid stream habitat restoration manual. Third edition, California Department of Fish and Game, Inland fisheries division, Sacramento, CA.

Northwest Indian Fisheries Commission. 1994. Timber Fish and Wildlife ambient monitoring program manual, habitat unit survey module. TFW-AM9-94-001.

Pleus, A.E. and D. Schuett-Hames. 1998. TFW monitoring program methods manual for reference point survey. TFW-AM9-98-002. DNR #104. May 1998. 90 pp.

Powers, P. D. and J. F. Orsborn. 1985.Analysis of barriers to upstream fish migration, an investigation of the physical and biological conditions affecting fish passage success at culverts and waterfalls. Prepared by Washington State University, Dept. of Civil and Environmental Engineering for the Bonneville Power Administration, Portland, Oregon. 120 p.

Schuett-Hames, D., and A. Pleus. 1996. Literature review and monitoring reccommendations for salmonid spawning habitat availability. TFW Report TFW-AM-9-96-002. Olympia, WA.

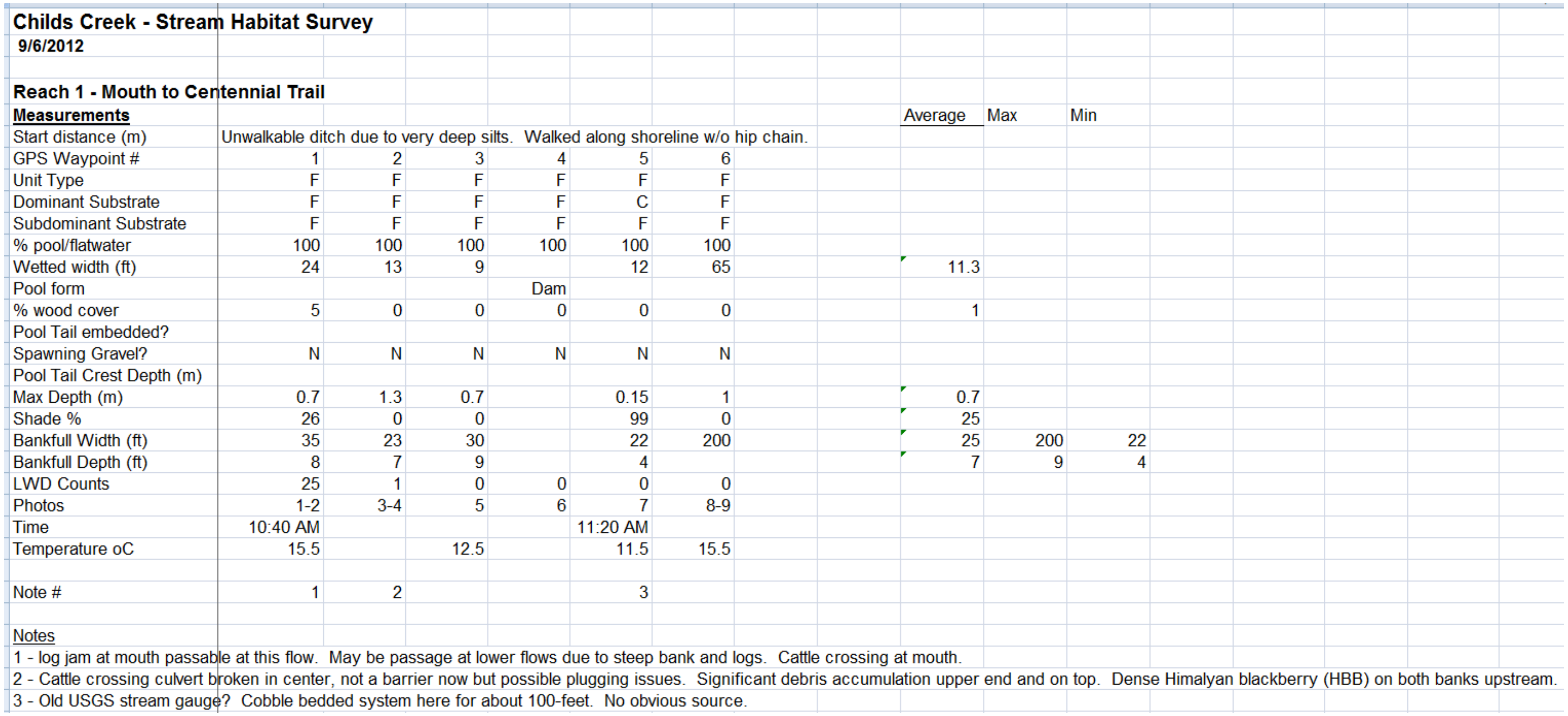
Washington Forest Practices Board. 1997. Board manual: standard methodology for conducting watershed analysis, Version 4.0. Washington Department of Natural Resources, Forest Practices Division. Olympia.

Washington Forest Practices Board. 2004. Board manual: standard methods for identifying bankfull channel features and channel migration zones, Section 2. Washington Department of Natural Resources, Forest Practices Division. Olympia.

APPENDIX

FIELD DATA

Excel Spreadsheets
Raw Field Notes



Childs Creek - Stream Habitat Survey
9/6/2012

Reach 1 - Mouth to Centennial Trail

Measurements							Average	Max	Min
Start distance (m)	Unwalkable ditch due to very deep silts. Walked along shoreline w/o hip chain.								
GPS Waypoint #	1	2	3	4	5	6			
Unit Type	F	F	F	F	F	F			
Dominant Substrate	F	F	F	F	C	F			
Subdominant Substrate	F	F	F	F	F	F			
% pool/flatwater	100	100	100	100	100	100			
Wetted width (ft)	24	13	9		12	65	11.3		
Pool form				Dam					
% wood cover	5	0	0	0	0	0	1		
Pool Tail embedded?									
Spawning Gravel?	N	N	N	N	N	N			
Pool Tail Crest Depth (m)									
Max Depth (m)	0.7	1.3	0.7		0.15	1	0.7		
Shade %	26	0	0		99	0	25		
Bankfull Width (ft)	35	23	30		22	200	25	200	22
Bankfull Depth (ft)	8	7	9		4		7	9	4
LWD Counts	25	1	0	0	0	0			
Photos	1-2	3-4	5	6	7	8-9			
Time	10:40 AM				11:20 AM				
Temperature oC	15.5		12.5		11.5	15.5			
Note #	1	2			3				

Notes

1 - log jam at mouth passable at this flow. May be passage at lower flows due to steep bank and logs. Cattle crossing at mouth.
2 - Cattle crossing culvert broken in center, not a barrier now but possible plugging issues. Significant debris accumulation upper end and on top. Dense Himalyan blackberry (HBB) on both banks upstream.
3 - Old USGS stream gauge? Cobble bedded system here for about 100-feet. No obvious source.

Reach 2 - Upstream of Minkler Lake to Canyon Reach																						
Measurements																						
Measured distance (m)	0	100	175	200	300	310	346	374	0	11	15	45	51	128	132	187	192	212	217	261	268	310
Actual Distance (m)	0	100	175	200	300	310	346	374	390	401	405	435	441	518	522	577	582	602	607	651	658	700
Actual Distance (ft)	0	328	574	656	984	1017	1135	1227	1279	1315	1328	1427	1446	1699	1712	1893	1909	1975	1991	2135	2158	2296
Habitat Unit Length (ft)	328	246	82	328	33	118	92	52	36	13	98	20	253	13	180	16	66	16	144	23	138	26
GPS Waypoint #	7			8	9			10	11													
Unit Type	Dry	Dry	Dry	Dry	Dry	Dry	P	F	F	P	F	P	F	P	F	P	F	P	F	P	F	P
Dominant Substrate	S	S	S	G	G	G	G	G	G	G	G	G	G	G	G	S	G	G	G	S	G	S
Subdominant Substrate	F	F	F	S	S	S	S	S	S	S	S	S	S	S	S	G	S	S	S	G	C	G
% pool/flatwater								50	50		80		70		90		50		50		60	
Wetted width (ft)							5	4	3	8	4	7	5	6	6	9	4	11	8	10	6	7
Pool form							Bed			Log		Bed		Log		Log		Log		bed		Boulder
% wood cover							0			5		0		30		5		5		0		0
Pool Tail embedded?							N			N		N		N		Y		N		in culvrt		N
Spawning Gravel?	R	R		R			R		R/A	R/A	A/R	R/A	R/A	R	A/R	R	A/R	R	R	R	A/R	N
Pool Tail Crest Depth (m)							0.05			0.05		0.10		0.10		0.10		0.10		in culvrt		0.10
Max Depth (m)							0.4			0.3		0.4		0.5		0.7		0.5		0.7		0.65
Shade	100		82	99	95								99				95					
Bankfull Width (ft)	30	16		20	20				15				17				19					16
Bankfull Depth (ft)		2		2	2				2				3				3					2
LWD Counts	3		3			0	0					1	9	4	12	2	3	1		0	0	
Photos	1	2	3	4	5				6			7	8				9		10	11		12
Time	12:45 PM				1:23 PM				2:00 PM									2:30 PM				3:10 PM
Temperature oC					14.5				16.0									17.0				16.5
Note #	4	5	6	7	8	9	10		11				12				13			14		

Notes

4 - Dry, not even damp;100% sand and silt; 100% shade with huckleberry, salmonberry, alder, HBB; appears to be long flat water with embedded pools; OHW depth about 1-foot
5 - salmonberry, alder, HBB
6 - Lyman-Hamilton Highway Bridge
7 - salmonberry, thimbleberry, alder, cottonwood, HBB
8 - Surface water starts here with isolated pool; water 1" below bed surface.
9 - steady surface flow starts here.
10 - Nicholson Bridge 346-351; 364m pool with 40+ 3-6" res trout and coho.
11 - walked around a 16m section with impenetrable HBB thicket.
12 - dense fish (1-3/lin ft) observed everywhere upstream of here; LWD cabled to stream channel upstream to SR-20;
13 - salmonberry, thimbleberry, alder, HBB, willow, Indian plum
14 - SR-20 culvert at 261m - flat box with no passage issues; N end turns 90 deg with nice deep pool
15 - Willow, cottonwood, HBB, salmonberry @335m; old RR car bridge at 415m; alder, salmonberry, HBB, butterfly bush @ 450m
16 - red-osier dogwood, alder, HBB, salmonberry; photos of fish
17 - grade increasing suddenly
18 - end at confluence with trib to west. Grade increasing again to step pools and cascades.

Reach 2 - Upstream of				SR-20						
Measurements										END
Measured distance (m)	318	373	380	575	583	617	620	728	733	740
Actual Distance (m)	708	763	770	965	973	1007	1010	1118	1123	1130
Actual Distance (ft)	2322	2503	2526	3165	3191	3303	3313	3667	3683	3706
Habitat Unit Length (ft)	180	23	640	26	112	10	354	16	23	
GPS Waypoint #			13	14	15					16
Unit Type	F	P	F	P	F	P	F	P	R	
Dominant Substrate	G	S	G	G	G	G	G	B	C	
Subdominant Substrate	C	G	C	S	C	S	C	S	B	
% pool/flatwater	70		25		20		10		0	
Wetted width (ft)	6	10	8	11	10	13	9	14	6	
Pool form		Boulder		BED		LOG		Boulder		
% wood cover		0		0		30		0		
Pool Tail embedded?		N		Y		Y		N		
Spawning Gravel?	A/R	N	A/R	A/R	A/R	R	A/R	R	R	
Pool Tail Crest Depth (m)		0.10		0.10		0.10		0.1		
Max Depth (m)		0.4		0.4		0.5		0.4		
Shade	96		96	75	93				97	
Bankfull Width (ft)			35	35	22				16	
Bankfull Depth (ft)			3	3	3				4	
LWD Counts			0	0	1				0	
Photos			13	14-16	17				18	
Time				3:40 PM					16:10	
Temperature oC				15.0					15.0	
Note #		15		16	17					18

(1)

CEDAROCK CONSULTANTS

Fish Habitat & Biological Reconnaissance Survey

Stream Childs Crk

Segment # 1

Date 9/6/12

Recorder CGef

Start location description Mouth @ Skagit WP#1 RR @ Centennial Trail

Unit Data						Bridge						
Start distance (m)	WP-1 0	WP-2	WP-3	4	005	006						
Unit type	F	F	F	F		F						
Unit number	1		Ditch	B.Dam								
Dominant substrate	F	F	F	F	C	F						
Subdominant substrate	F	F	F	F	F	F						
% pool/flatwater	100	100	100	100	100	100						
Wetted width (ft)	24'	13'	9'		12	65'						
Note #					5							
End distance (m)												
Pool Data												
Pool Former	grade	grad	–	Dam	grad	grad						
% wood cover	50	0	0	0	0	0						
Pool tail Embedded (y/n)	–		–									
Spawning gravel Present (A, R, A/R, N)	N	N	N	N	A?	N						
Tail crest depth (ft)												
Max. depth (~~ft~~) M	0.7	1.2	0.7		0.15	2.0						
Fish Observations												
Fish species												
Shade = 16/17/24/44 **Ancillary Data**												
Distance Shade	WP-1	0 0 0 0	0 0 0 0		96 96 94 93	00 00						
Time	10:40				11:20							
Water temperature	15.5		12.5		11.5	19.5						
Bankfull width (ft) / Depth	35/8	23/7	30/9		22/4	200						
LWD Count / Key Pieces	25	1	0	0	0	0						
Photos	1/2	3/4	5	6	7	8-9						

Notes Log Jam @ mouth, passable @ this flow, may be issue @ lower flow in Skagit
Cattle crossing @ mouth
WP-2: Culvert not a barrier now, ~~open clear~~ but partially plugged. ~~but~~ Appears to plug periodically based on debris accumulation upstream and on top of crossing. Culvert separated.
#5 – Cobble bed from bank deposits – isolated patch w/ gravel for 100' then back to silt

(2)

CEDAROCK CONSULTANTS **Fish Habitat & Biological Reconnaissance Survey**

Stream CHILDS CR

Segment # 2

Date 9/6/2012

Recorder CLH

Start location description

200

Unit Data												
Start distance (m)	007	100m	175	200	300	310	346	374	0	11	15	45
Unit type	Dry	Dry	—	—			P	R	R	P	R	P
Unit number												
Dominant substrate	S	S	[illegible]	G			G	G	G	G	G	G
Subdominant substrate	F	F		S			S	S	S	S	S	S
% pool/flatwater	-	-					50%	50%		80%		
Wetted width (ft)	-						5'	4'	3'2"	8'	4'	7'
Note #				WP08	WP09							
End distance (m)			183	300			374	400 WP10	11	15	45	51
Pool Data												
Pool Former							Bed			Log		Bed
% wood cover							0			5		0
Pool tail Embedded (y/n)							N			N		N
Spawning gravel Present (A, R, A/R, N)	R-	R-		R			R		R/A	R/A	M/R	A/R
Tail crest depth ~~(ft)~~							0.05			0.05		0.1
Max. depth ~~(ft)~~							0.4			0.3		0.4
Fish Observations												
Fish species		Sun 2	Sun	14.5 0.10 →			2-4" 100+ trout	100s Coho	100s 2"	30+	50	20
SHADE	100%	5/5, 2/10	0/0 2/0									
Ancillary Data												
Distance	0	100m		200					0			
Time	12:45				1:20				2:50			
Water temperature	Dry	Dry			14.5				16.0			
Bankfull width (ft)/dpth	~30'/	16/2		20/2	20/2				15/2			
LWD Count / Key Pieces	3/0		3			0	0					1
Photos	1	2	3	4	5				6			7

Notes 007 Dry - not even damp 100 Sand, silt 100 shade huckle, salmonberry, Alder Hazelberry. Long riffle w/ embedded pools. OHW depth ~1'
100m - Alder, salmonberry, HBB 200m Alder, Ctwd, salmonberry, Thimble HBB
300m - patches of water start, here 1' below bed in pools
310m - steady flow Nicholson/Bodie 346-351/ 364m - 40+ 4-5" trout
400m - Impenetrable blackberry. Stopped & called crew.

CEDAROCK CONSULTANTS **Fish Habitat & Biological Reconnaissance Survey**

2

Stream CHILDS CR	Segment # 2	Date 9/6/2012	Recorder CGH
Start location description			

Unit Data												
Start distance (m)	57	128	132	187	192	212	217	261	268	310	318	377
Unit type	F/R	P	F/R	P	F/R	P	F/R	P	F/R	P	F/R	P
Unit number												
Dominant substrate	G		G	S	G	G	G	S	G	S	G	S
Subdominant substrate	S		S	G	S	S	S	G	C	G	C	G
% pool/flatwater	70		90		50		50		60		90	
Wetted width (ft)	54'	6'	6'	9'	4'	11	8'	10'	6'	7'	6"	10'
Note #	1											
End distance (m)	128	132	187	192	212	217	261	268	310	318	377	380
Pool Data												
Pool Former		Log		Log		Log		O		O Boulder		O Boulder
% wood cover		30		5		5						
Pool tail Embedded (y/n)		N		Y		N		?		N		N
Spawning gravel Present (A, R, A/R, N)	R/A	R	A/R	R	A/R	R	R	R	A/R	N	A/R	N
Tail crest depth ~~(ft)~~ m		0.1		0.1		0.1		?		0.1		0.1
Max. depth ~~(ft)~~ m		0.5		0.7		0.5		0.7		~~0.4~~ 0.65		0.4
Fish Observations												
Fish species	100's	20	100s	100s				50+	lots	lots	—	—
Ancillary Data										WP12		
Distance										335		
Time						2:30				3:10		
Water temperature						17.0				16.5		
Bankfull width (ft) / depth	17/3'				15/3'					16/2'		
LWD Count / Key Pieces	~~20~~ 9	4	12	2	3	1		0	0			
Photos	8				9		10	11		12		

Notes 100m Sun 0,0 1,1 ① Place LWD @ upper end.
200m Shn 0,0 6,1 Alder, Willow Schmb, thimble, IPlum HBB.
261m SR-20 culvert weir spring
261 - Started upstream (N) end of SR-20 culvert - ~~pool~~ pool @ 90° turn
335m - 0,0,5,12, Sun

(4)

CEDAROCK CONSULTANTS

Fish Habitat & Biological Reconnaissance Survey

Stream Childs Cr	Segment #	Date 5/6/2011	Recorder CGH

Start location description

Unit Data												
Start distance (m)	380	575	583	617	620	728	733					
Unit type	F/R	P	F/R	P	F/R	P	R					
Unit number												
Dominant substrate	G	G	G	G	G	B	C					
Subdominant substrate	C	S	C	S	C	S	B					
% pool/flatwater	25%		20%		10%		0					
Wetted width (ft)	8'	11'	10'	13'	9'	14'	6'					
Note #												
End distance (m)	575	583	617	620	728	733	740					
Pool Data												
Pool Former		O		Log		Boulder						
% wood cover		O		30%		O						
Pool tail Embedded (y/n)		Y		Y		N						
Spawning gravel Present (A, R, A/R, N)	A/R	A/R	A/R	R	A/R	R	R					
Tail crest depth (ft)		0.1		0.1		0.1						
Max. depth (ft)		0.4		0.5		0.4						
Fish Observations							Sun					
Fish species	2tr	—	—	—	—	—	7,2 8,2					
Ancillary Data	WP13	14	15				WP16					
Distance	450	575	700				740					
Time	Sun 4,5	3:46	Sun 4,18				4:10					
Water temperature	3,4	15,0	7,2				15.0					
Bankfull width (ft) /Depth	35/3	35/3	22/3				16/4					
LWD Count / Key Pieces	0	0	1				0					
Photos	13	14	17				18					

Notes willow, (trout), HBB, Salmonberry @ 335m 415m RR car bridge
450m Alder SB HBB, ButterflyBush – 575m ROD, Alder, HBB, Salm B,
Photos 15&16 fish 3" @ WP14 WP 15 (next to house – grade increasing
Sun 31,50,8,6

Appendix C – Planning-level Project Costs

Historic and Future Costs

Table C-1: Historic (1983-2010) estimated damage costs (public costs only) adjusted to 2011 dollars using the Bureau of Labor Statistics Consumer Price Index (CPI) values

Maintenance Event	***cost****	***Inflation Adjustment***	
1983	*$100,000*	$226,000	*($2011)*
1991	*$20,000*	$33,000	*($2011)*
1996	*$10,000*	$14,000	*($2011)*
2000	*$15,000*	$20,000	*($2011)*
2010	*$15,000*	$15,000	*($2011)*
	TOTAL (1983-2010)	**$308,000**	*($2011)*

Average Annual Damages: $11,500 ($2011)

Table C-2: Future Repair Cost Estimate (*status quo* dredging maintenance program)
This method uses the "average annual damages" calculated above at $11,500/year and adjusts for future dollars using an inflation rate of 3.4%/year based on historic CPI average (1981-2010) and presented as 5 year running sums in year-appropriate adjusted dollars)

Year	***Estimated 25-year Cumulative Repair Costs****	***Adjusted for 3.4% CPI***
2015	$61,500	(est. $2015)
2020	$72,750	(est. $2020)
2025	$86,000	(est. $2025)
2030	$101,500	(est. $2030)
2035	$120,000	(est. $2035)
TOTAL	~$440,000	(est. $2035)

*Repair and maintenance costs are estimates based on assumptions of frequency and scope of routine dredging, staff time, permitting, and mitigation costs. Actual records for repair and damages were unavailable.

**This estimate does not includes the replacement of Lyman-Hamilton Bridge at Childs Creek, which is not scheduled to occur within the 25-year projection

Table C-3: Estimated Expenses for Sediment Management Alternatives

Alternative # - Title	*Planning-Level Cost to Implement and Maintain*
#1 No Action	• No expenses • Eventual loss of road and/or bridge, costs uncertain
#2 Upper Watershed Sediment Source Control	• Initial construction of small sediment catches or debris jams (access and delivery of materials, material costs, labor, design and permitting costs) = $2,000,000 for 40 structures* *Note: It is unknown if this number of structures would adequately capture enough sediment to provide benefit to the project reach. The structures are temporary in nature and benefits are temporary as they stop arresting sediment transport once filled. • Yearly maintenance of sediment traps = $50,000/year; $2 M 25-year cumulative total adjusting for inflation of 3.4 percent
#3 Instream Sediment Removal	• Yearly sediment removal $11,500 ($2011) • Mitigation (restoration) for each dredging event estimated to be 30% total project cost ($11,500 x 1.3 = $14,950 Year-1 annual costs) • $575,000 Year-25 maintenance totals
#4 Sediment Basin	• Initial costs include acquisition, site grading, levees, vegetation, design and permitting = $1,000,000* *Note: construction costs dependent upon the size of the facility and real estate purchase needs. • Maintenance will be needed, but rate is dependent upon the rate of sediment input and size of facility. For these planning level estimates, it is assumed that maintenance will occur on a decadal scale and will be $100,000 per maintenance activity, or estimated to be $250,000 at year 25.
#5A Nicholson Road Abandonment	$50,000 one-time cost
#5B Lyman-Hamilton Road Abandonment	$75,000 one-time cost
#6A Lyman-Hamilton Bridge Raising (using existing structure w/ new footings)	$750,000 one-time cost (if feasible footing designs and reusable bridge deck)
#6B Lyman-Hamilton Bridge Replacement (Raising/Widening)	$1.5 M one-time project cost based on using two pre-prefabricated 3-sided spans (40-ft each span) and fill. Similar costs were recently incurred on a bridge of similar design in Whatcom County.
#6C Nicholson Bridge Raising (using existing structure w/ new footings)	• $400,000 one-time cost (if feasible footing designs and reusable bridge deck)
#6D Nicholson Bridge Replacement	• $500,000 one-time cost based on using one pre-prefabricated 3-sided spans (40-ft) and fill. Similar costs were recently incurred on

(Raising/Widening)	a bridge of similar design in Whatcom County.
#6E Road lowering at overflow locations	• $75,000 one-time engineering, permitting and construction costs
#7A Creek-side Levees	Assumes 3000 lineal feet of levee at $250/lineal foot for construction (fill and armoring) plus easements, design, permitting, and mitigation = $1,200,000 • $400,000 maintenance (25-year at $10,000 year one annual maintenance cost)
#7B Levee Setback (between creek and residence)	Assumes 3000 lineal feet of levee at $250/lineal foot for construction (fill and armoring) plus easements acquisition, design, permitting, and mitigation = $1,600,000 • $200,000 maintenance (25-year at $5,000 year one annual maintenance cost)
#7C Raise residences or perimeter levee	• $50,000 one-time project cost for elevating 3 homes on new foundations
#8 Childs Creek Channel Relocation	• 1000 lineal feet of channel at $200 lineal foot to construct
#9 Forestry Land Use Management	• $20,000 / year for 20% FTE County Staff • $500,000 per year at a pay increase of 1.2% (below CPI)