Technical Memorandum

To: Chris Woelfel – Seattle City Light

From: Ed Zapel

Date: June 21, 2019

Subject: Ross Lake Debris Disposal Study –Final Report

1 Introduction

Ross Dam, owned by Seattle City Light, impounds the upper Skagit River, creating a reservoir that stretches to the Canadian border. The upper Skagit River originates in the Cascade Range of British Columbia, with most of the contributing watershed draining the middle portion of the range within 50 miles of the US border. The watershed above Ross Dam on the US side is entirely contained within the North Cascades National Park. On the British Columbia side, lands are owned by the government of British Columbia, some private holdings, and Native Reserves. During winter flood events, the watershed contributes a significant volume of woody debris to the upper reservoir at the head of Ross Lake. Generally, prevailing winds on the reservoir tend to push the debris to toward the head of the reservoir. This debris is collected from the reservoir when it is at its highest spring time level and stored in large accumulations contained within floating log booms, or 'bags.' Project staff collect and contain the debris to prevent it from reaching Ross Dam where it can become an operational issue. Floating debris is also removed from the reservoir to reduce navigation hazards to recreational boaters. The historical practice of burning the debris each year has been curtailed over the past two decades, and the debris has continued to accumulate within the debris containment areas as project crews clear the lake of debris each year. However, the continued accumulation of debris is considered by project staff to represent an eventual undesirable operational constraint on the project, in that it will become increasingly difficult to contain the debris successfully within the present bag sites.

2 Purpose and Need

The purpose for this study is to identify various alternatives for disposing of the stored debris at the north end of Ross Lake, and to evaluate means of disposing of the annual debris input to the lake. Alternatives should range from simple burning of the debris at the usual collection sites, as has been the historical practice, to transporting of all the debris to the south end of Ross Lake, then transporting it below Gorge Dam to release it back into the Skagit River. Development and evaluation of these alternatives should include determination of the types of equipment used to manage and handle the debris, and estimates of the labor and capital costs associated with managing the debris. Additionally, this study evaluates the suite of alternatives within a decision matrix designed to aid Seattle City Light in making a management decision on the preferred means of managing the debris. The preferred debris management method will likely be considered in future FERC permitting discussions with the agencies during consultation.

This study is intended to support SCL's planning efforts to examine short-term and long-term alternatives for addressing the present and future accumulation of woody debris on Ross Lake. SCL is particularly interested in alternatives that can make use of the accumulated debris in a sustainable way, and to continue to make sustainable use of future debris accumulations. The natural debris generated by the upper Skagit River served a valuable function in the lower river below the three SCL dams by enhancing aquatic habitat and inducing healthy changes to channel morphology in localized reaches of the river. Basin-wide, the Skagit River has not benefitted from the natural transport of woody debris from the upper Skagit watershed to the river reaches below the SCL dams.

3 Background

Prior to development or refinement of various alternatives for debris disposal, SCL provided the Consultant team with historical information and data to provide background on the Ross Lake project operation and historical treatment of debris. This information consisted of the following items:

- Records of previous debris disposal methodology and debris amounts estimated by SCL staff in current storage area as well as annual estimates of production in future
- Photographs of the current debris accumulation and characteristics
- Project drawings, figures and maps for Ross and other Skagit River projects to establish existing road access, and identify facilities at projects that could be used for debris handling
- Existing hydrologic information and reservoir rule curve to establish area from which debris is annually recruited
- Interviews with other dam owners and literature search to explore debris disposal methods used elsewhere

3.1 Project Vicinity and Debris Management Areas

Most of the floating woody debris enters the lake during the spring freshet season in response to higher tributary flows resulting from snow melt. Additional debris enters the lake during floods. Typically, the debris collects in the upper end of the reservoir, as prevailing winds tend to push the debris north on the surface of the lake. Project crews have historically contained the debris in two primary locations in the upper half of the reservoir, one near the northernmost end of the western shore of the lake directly across from the National Park Service's Hozemeen Landing building complex, and the second at Dry Creek about 10 miles south on the east shore. The north end of the lake is accessible via about 35 miles of gravel road (Silver Skagit Road) from Canada Highway 1 near Hope, B.C. US Highway 20 does not come any closer than about a third of a mile from the Ross Dam site as the crow flies, and no roads connect to the dam from public highways. However, Highway 20 overlooks Ruby Arm of the lake about 1.5 miles upstream from the dam. Figures 3.1 through 3.3 below illustrate the general proximity of

Ross Lake to available access roads, the existing debris storage areas, and the Ruby Arm skyline access pullouts.

Figure 3.1. General Map of Ross Lake and Proximity to Access Roads

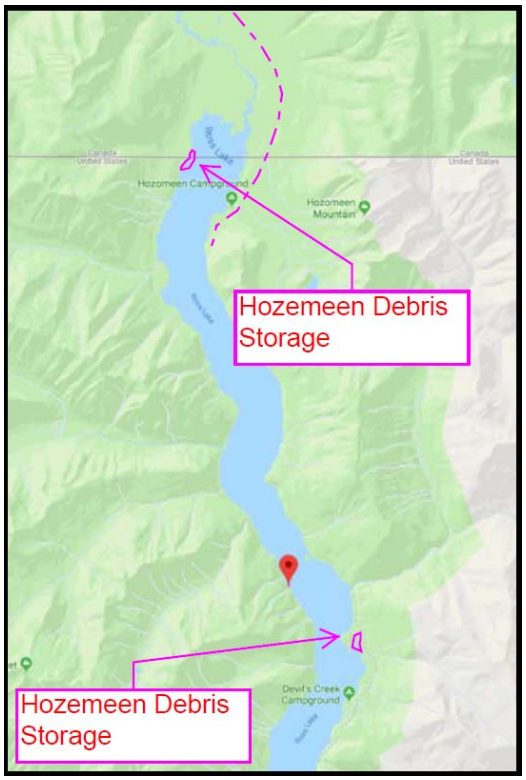


Figure 3.2. Existing Debris Storage Pens in north half of Ross Lake

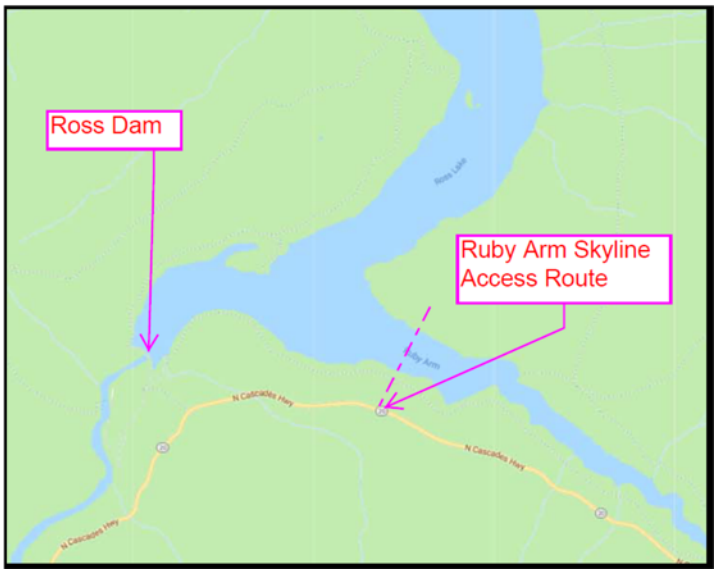


Figure 3.3. Ruby Arm Skyline Hwy 20 Access Locations and proximity to Ross Dam

The primary containment boom consists of a large log boom pen floating along the west shore line, with a double 'gate' boom serving as a kind of fence to hold the bulk of the debris behind the main boom and a smaller pen area at the entrance into which SCL crews move new debris, then close the 'gate' and then open the larger pen and push the debris from the outer pen into the larger pen along the shoreline. The second, and smaller, containment area is located on the east shore of the lake about ten miles downstream from Hozemeen at the Dry Creek embayment where it is also contained by a log boom (Figure 3.2 above). This second containment area is managed to try to blanket the shoreline with debris to prevent invasive vegetation species from colonizing the embayment, and is not proposed for removal at this time.

3.2 Woody Debris Characterization and Volume

Estimates by Seattle City Light (SCL) staff suggest that there is currently between 43,000 and 45,000 cubic yards of woody debris in accumulated storage at the head of the reservoir at the 'bag' site across the lake from Hozemeen Landing. Annual average additional accumulation has been estimated at about 1500 to 6,000 cubic yards per year. For this analysis, we assume that dry debris ranges from 600 to 900 lbs per cubic yard. Inspection of the debris trapped in the Hozemeen suggests that, of the estimated 40,000+ cubic yards of woody debris, approximately 96% (38,400+ yd^3) is small limbs, bark, sticks, and other minor debris. Approximately 2.5% (1,000+ yd^3) of the stored debris is comprised of larger limbs, tops, and small trunks of trees, just 1% (400+ yd^3) of the stored debris appears to be comprised of intact root wads that may be suitable for habitat elements, and only 0.25% (100 yd^3) of the stored debris is comprised of marketable logs. This translates to just 5 to 6 log truck loads of merchantable timber, and the quality of these logs is poor, given their exposure the elements for several years. Aside from the cedar logs, most are likely not marketable to sawmills due to this exposure. Table 3.1 below provides a summary of woody debris estimates by volume and type. Photo 3.1 below illustrates the typical woody debris captured in the Hozemeen debris storage pen area.

Table 3.1 Stored Debris at Hozemeen holding storage pen and truck load volume

	Volume of Stored Debris				
Debris Type	(% of Total)	(yd^3)	(tons)	# of Truck Loads	(yd^3 equiv. per truck)
Marketable Logs	0.25%	112.5	51	5.6	20
Habitat Root wads	1.00%	450	203	18.0	25
Marketable Chip wood	2.50%	1,125	506	25.0	45
Hog Fuel (all the rest)	96.25%	43,313	1,950	963	45

Photo 3.1. Hozemeen Storage Pen Woody Debris (typical)

Estimates of the average annual additional contribution of woody debris from the watershed above Ross Dam range from about 1,500 to 6,000 cubic yards. Based on discussions with SCL right-of-way crews, observation of the type, size, and characteristics of the existing stored debris, we assumed that the new debris might consist of up to 87% small trash, limbs, bark, and other floating debris. Additionally, we estimated that up to 10% of the annual new debris might consist of larger limbs and tops or smaller trunks with solid wood of low quality. We also estimated that new usable root wads (for habitat restoration work) would likely comprise up to 2.5% of the total volume, given that the root wads would be a fresh state rather than decayed, as is the stored debris. And lastly, we estimated that up to about 0.5% of the total volume might be

comprised of merchantable timber, or roughly 1.5 log truck loads. Table 3.2 below provides a summary of annual new woody debris estimates by volume and type.

Table 3.2 New Annual Debris Volume by Type

	Volume of New Debris				
Debris Type	(% of Total)	(yd^3)	(tons)	# of Truck Loads	(yd^3 equiv. per truck)
Marketable Logs	0.50%	30	13.5	1.5	20
Habitat Root Wads	2.50%	150	68	6.0	25
Marketable Chip wood	10.0%	680	306	13.3	45
Hog Fuel (all the rest)	87.0%	5,220	2,350	116.0	45

3.3 Historical Debris Management

Historically, SCL has hired contractors to burn most of the debris on the shoreline in the Hozemeen debris pen as the reservoir level retreats in the late summer and fall and the debris comes to rest within the large open area. However, for the past decade or more, SCL has not disposed of this debris, and the total volume of stored debris has increased significantly. Occasionally, the log boom breaks and part of the stored debris escapes back into the lake, where SCL crews must work diligently to capture it and move it back to the pen, repairing the log boom each time. At least once in the past, the log boom has been damaged by Canadian crews retrieving larger salvageable logs from the boom.

Current debris management practice has been to simply capture the debris and continue to feed it into the existing (and enlarging) boom pens at Hozemeen and Dry Creek. However, the size of these pens, especially the Hozemeen boom, makes it increasingly difficult to keep the boom intact and contain the debris. Natural decomposition occurs relatively slowly at the site and there is limited space available there for additional debris. SCL right-of-way crews managing the debris capture operations have characterized the ability to successfully move floating rafts of debris up or down the length of the reservoir as very difficult without losing a significant amount of the captured debris in transit.

SCL crews currently move some of the typical annual debris load that makes its way to the forebay area of the dam to the Diablo Dam reservoir by truck via the boat access ramp located adjacent to the left abutment of Ross Dam over the short isolated access road connecting the Ross reservoir to the Diablo reservoir. However, they currently move less than 150 dump truck loads (8 – 10 yd^3 each) over this route annually. Additionally, this debris must be removed from the Diablo Dam forebay and transported via truck from there to the Newhalem headquarters processing yard or dumped back into the river downstream of Gorge Dam. Typically, this debris consists only of the detritus that is contributed by tributaries within the lower third of the reservoir. The debris from the main stem and the several upper creeks generally remains in the upper end of the reservoir, as prevailing winds tend to push it north. Without handling machinery on the shoreline at the upper Hozemeen storage pen, SCL crews are unable to concentrate the debris to any greater degree than simply pushing it into tight bunches with the work boats.

3.4 Debris Management Constraints

There are physical and temporal constraints on management of woody debris, both the accumulated stored debris, and the anticipated additional new debris deposited annually into the lake. Each constraint precipitates its own particular considerations which necessitates differing approaches, as described below.

3.4.1 Road Access

The most prominent factor in the flexibility of potential debris management alternatives is the lack of direct road access to the Ross Lake reservoir from the U.S. side of the international border. The lack of U.S. access to roads connected to the reservoir greatly complicates and hinders potential transport of woody debris from the reservoir to downstream reaches of the Skagit River or to markets for wood products.

3.4.2 Fluctuating Reservoir Elevation

Of nearly equal importance is the limited accessibility of the Hozemeen debris pen storage area to floating debris management equipment, which can only be attained when the lake level is at its near maximum. Other locations that might be accessible at lower reservoir elevations do not have significant area for debris storage or processing on ground flat enough for safe working conditions, or are not available due to restrictions on use of National Park lands surrounding the reservoir. The significant fluctuation in reservoir elevation throughout the typical year practically limits effective debris capture and movement to the few spring months when the reservoir is full. Figure 3.4 below illustrates the varying reservoir elevation of Ross Lake.

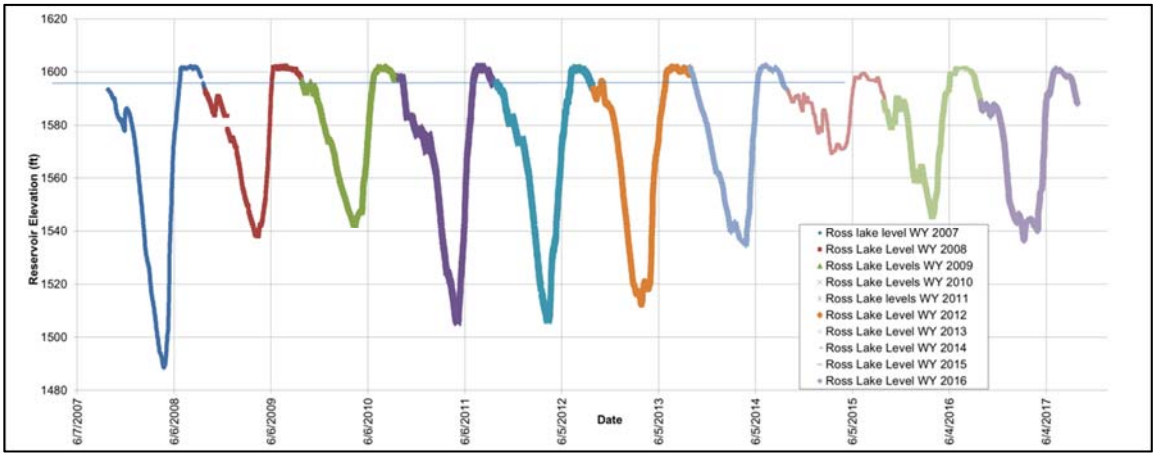


Figure 3.4 Typical Ross Lake Elevation Variation (2007 – 2017)

3.4.3 Seasonal Weather Constraints

Ross reservoir is accessible from the Canadian side by road during the late spring, summer, and autumn months only. During winter, the gravel Silver-Skagit Road is not regularly maintained, and snow removal is infrequently achieved, if at all. Highway 20 is closed once snowfall begins in earnest below Diablo Dam, and the access pullouts on the north shoulder of Highway 20 adjacent to Ruby Arm and the steep grade to Diablo Dam would be unsafe for use as landing areas for skyline operations and transport

routes for extracting woody debris from the reservoir except when the roadway is not affected by snow.

3.4.4 Proximity to National Park Service Lands

Ross Lake is completely encircled by National Park lands, which severely limits the ability to create a new road access route to the reservoir shoreline through which debris could be managed using on-road equipment. In addition, the uses allowed on National Park lands around the reservoir perimeter are limited. Noise, air, and sight line pollution is generally not permitted, and activities that might disturb the environment around the lake are typically restricted to narrow time windows when human and endangered animal use is at its minimum. These windows typically conflict with the available windows in which the debris storage areas are accessible to floating equipment and wood processing equipment that might be used to process and sort the debris into useful products.

3.4.5 Conflicts with Recreational Use of Ross Lake

The relatively pristine and popular Ross Lake is heavily used for recreational activities, including boating, hiking, backpacking, and fishing. Recreational use tends to peak when the lake is at its highest levels in the summer and fall, which falls at the same time as debris management activities that are in high gear to respond to annual spring freshet-borne debris inputs to the lake.

3.4.6 Distance to Potential Markets for Wood Products

In addition to the considerable limitations on physically extracting the woody debris from Ross Lake, the road distance to markets for nearly all wood products is significant. It is nearly 70 miles from Ross Lake to the nearest larger community (Sedro Woolley) where processed wood products might be readily consumed, and even further to larger markets. The volume of merchantable timber that is estimated to be available for extraction from Ross Lake annually is relatively small, and the quality of the saw logs that might be produced is poor. As such, it is likely to be more profitably marketed to small private sawmills and processing businesses than to large mills in Everett and in LaConner.

3.4.7 Labor Costs

Labor Costs for each handling method were based on values provided by SCL and from local logging and construction wage rates. Table 3.3 below provides estimated labor costs for various activities associated with the debris clearing operations.

Table 3.3 Labor Costs

Labor Rates	Fully Loaded Rate ($//hr)
Seattle City Light Crews	
Lineman	$152.00
High Lead Logging Contractor	
choker setter	$108.50
foreman	$170.50
yarder operator	$155.00
equipment operator	$139.50

3.4.8 Equipment Selection and Costs

The various equipment considered for this study are identified in the description of each handling method in Section 4 below, and summarized in Tables 3.4 and 3.5 below.

Table 3.4 Estimated Costs for Handling and Processing Equipment

Trash and Debris Handling Equipment							
Floating Plant	**Existing Project Equipment?**	**New?**	**Used?**	**Rental?**	**Rental Cost ($$/week)**	**Purchase Cost**	**Mfr/Model**
Barge - modular 8' x 24' modules	NO	YES	YES	YES	N/A	$5,000.00	(www.boats.com)
Tugboat - Skagit Project tug	YES	N/A	N/A	N/A	N/A	N/A	N/A
Tugboat - Used small tugboat (diesel 150 Hp)	NO	NO	YES	NO	N/A	$75,000.00	(www.boats.com)
Workboat - Aluminum 20 foot	YES	N/A	N/A	N/A	N/A	N/A	N/A
Handling Equipment							
Excavator - 10 ton, barge transportable	NO	YES	YES	YES	$2,500.00	N/A	many
Excavator - 25 ton, land transportable	NO	YES	YES	YES	$5,000.00	N/A	many
Truck - 10 yd3 dump	YES	N/A	N/A	N/A	N/A	N/A	many
Misc Equipment							
Burn Boxes (25 yd^3 capacity) - Air Burner	NO	YES	YES	NO	N/A	$120,864.00	S-220 Air Burner
Debris Bins (5 yd^3 capacity)	NO	YES	NO	NO	N/A	$5,000.00	estimate
Power Generation Equipment							
Syngas converter	NO	YES	NO	NO	N/A	$100,000.00	estimate
Syngas engine-generator (150 kW GE Waukesha)	NO	YES	NO	NO	N/A	$125,000.00	GE product
Steam Power Generator - Air Burner 100 kW	NO	NO	YES	NO	N/A	$800,000.00	PGV220 Air Burner

Table 3.5 High Lead Logging Equipment Selection

	Yarder Systems										
			Debris bins + logs		Make/Model						
	Skyline Yarder Considerations	Logs and rootwads only (weight - lbs)	and rootwads (weight - lbs)		Koller K507 Tower Truck Mounted	Koller K702 Tower Track Mounted	Madill 172	Madill 071	Thunderbird TSY255	Skagit 737	Berger Mark 6
1	Capacity Requirements/ Line Pull	2500	7500		9,480 lbs ave drum	17,640 lbs ave drum	10,000 lbs ave drum	10,000 lbs ave drum	20,000 lbs ave drum	120,000 lbs ave drum	250,000 lbs ave drum
2	Type of Yarder System (motorized carriage, north bend, etc.)										
2a	Motorized Carriage?	yes	yes		yes	yes	yes	yes	yes	yes	yes
2b	North Bend? (to move mainline laterally)	possibly	no		yes	yes	yes	yes	yes	yes	yes
2c	Swing Yarder	yes	yes		no	no	no	no	yes	no	no
2d	Highlead? (does not fully suspend load)				yes	yes	yes	yes	yes	yes	yes
2e	Live Skyline? (Fully suspends load)				no	no	yes	yes	yes	yes	yes
2f	Standing Skyline? (Fully suspends load)				no	no	yes	yes	yes	yes	yes
3	Barge or no barge required?	no	yes		yes	yes	yes	yes	yes	no	no
4	Permanent Facilities (tailhold, etc.)	yes	yes		no	no	no	no	yes	yes	yes
5	Tower Height	at least 50 feet at Hwy20	at least 50 feet at Hwy 20		49	49	70	70	50	90	110
6	Intermediate Support/s needed?	maybe	yes		yes	yes	yes	yes	yes	no	no
7	Clearing of Skid Trail Required?	maybe	yes		yes	yes	yes	yes	yes	no	no
8	Drum Line Capacity (Skyline)				3400 ft of 3/4"	2550 ft of 7/8"				7,500 ft of 1-1/4"	10,000 ft of 1-3/4"
9	Maximum Yarding Distance (approx)				800 ft	1,200 ft	1,500 ft	1,500 ft	1,800 ft	4,000 ft	5,000 ft
10	Price (USED)				$250,000	$375,000	$100,000	$125,000	$500,000	$250,000	$400,000

3.4.9 Market Value of Product Mix

Various suppliers and buyers of products that are anticipated to be produced from processing and marketing of the available and incoming new woody debris were investigate as part of this study. Though transportation to market was not estimated, since the distance to real markets could not be known for this study without more thorough investigation than can be obtained from readily available sources, the market value can be used to generally gauge the potential for financial returns that might be obtained. Table 3.6 below provides a summary of the market value of the various wood products that can be created from the woody debris at Ross Lake.

Table 3.6 Market Value of Wood Products

Product	Volume per Truck (yd3)	Price per unit ($/yd3)	Price Year	Price quote Supplier	Location
Hog Fuel	45	$26.00	2018	DeJong Sawdust and Shavings	Redmond, WA
Clean Play Chips	45	$80.00	2018	DeJong Sawdust and Shavings	Redmond, WA
Bark - medium 1-1/2"	45	$60.00	2018	DeJong Sawdust and Shavings	Redmond, WA
Product	Volume per truck (ton)	Price per unit ($/ton)	Price Year	Price quote source	
Pulp	18	$25.00	2017	Inland Forest Management	
Product	Volume per truck or trlr (MBf)	Price per unit ($/Mbf)	Price Year	Price quote source	
(USA)					
Marketable logs - Doug fir short saw 12-24'	1.800	$400	2018	Fritch Mill	Snohomish, WA
Marketable logs - Doug fir long saw 26-40'	3.000	$600	2018	Fritch Mill	Snohomish, WA
Marketable logs - WRCedar short saw 12-24'	1.800	$600	2018	Fritch Mill	Snohomish, WA
Marketable logs - WRCedar long saw 26-40'	3.000	$900	2018	Fritch Mill	Snohomish, WA
Marketable logs - Hemlock short saw 12-24'	1.800	$300	2018	Fritch Mill	Snohomish, WA
Marketable logs - Hemlock long saw 26-40'	3.000	$400	2018	Fritch Mill	Snohomish, WA
(Canada)	(cubic meter)	($Can/cubic meter)			
Marketable logs - Doug fir short saw 12-24'	5.063	$115	2018 (Can)	Coastal BC Log prices Madison Report	Vancouver, BC
Marketable logs - Doug fir long saw 26-40'	8.438	$160	2018 (Can)	Coastal BC Log prices Madison Report	Vancouver, BC
Marketable logs - WRCedar short saw 12-24'	5.063	$242	2018 (Can)	Coastal BC Log prices Madison Report	Vancouver, BC
Marketable logs - WRCedar long saw 26-40'	8.438	$242	2018 (Can)	Coastal BC Log prices Madison Report	Vancouver, BC
Marketable logs - Hemlock short saw 12-24'	5.063	$88	2018 (Can)	Coastal BC Log prices Madison Report	Snohomish, WA
Marketable logs - Hemlock long saw 26-40'	8.438	$82	2018 (Can)	Coastal BC Log prices Madison Report	Snohomish, WA
Product	Volume per truck (yd3)	Price per unit ($/yd3)	Price Year	Price quote source	
Rootwads - various spp.	30	$40	2016	Rainier Wood Recyclers	North Bend, WA
Product	Volume per truck (ton)	Price per unit ($/ton)	Price Year	Price quote source	
Biochar	5	$2,000	2018	AgraTerra OR Canadian AgriChar	Maple Ridge, BC

4 Description of Methods / Alternatives

The 10 Primary Handling Methods considered in this study included the following basic methods of handling and disposal of the woody debris, starting with the least complex and ending with the most complex and costly.

- Method 1 – Stack wood debris into stable piles for eventual decay on shore.
- Method 2 – Simple open burning, which was the historical method.
- Method 3 – Burning of debris in air curtain burn boxes to minimize environmental pollution.
- Method 4 – Separation and processing of suitable wood debris into boiler hog fuel or mulch
- Method 5 – Processing suitable wood debris into compressed wood waste briquettes
- Method 6 – Processing suitable wood waste into compressed sawdust pellets
- Method 7 – Syngas or biomass-powered electrical generation for remote facilities, such as the Hozemeen NPS building complex
- Method 8 – Towing debris down the lake in booms or on barge
- Method 9 – Skyline lift to road-accessible locations from reservoir (including chokers, grapple, or bins)
- Method 10 – Multiple load transfer from Ross Dam forebay to trucks to Diablo Lake to Diablo Dam forebay boat ramp to Highway 20 (the primary method used presently to move debris out of Ross Dam forebay area)

Detailed description and discussion of each Primary Handling Method is provided below, with estimated capital cost and labor hours estimated to implement. Figures and photographs to describe these Primary Handling Methods are included.

4.1 Method 1 – Stack Wood Debris into Stable Piles for Decomposition

The very simplest method of debris management is to pile the wood into large piles on the shoreline with sufficient volume and mass above high water line to attain stability. Practically, this would require some sorting to place the finer materials above the water line where they would not be recaptured by wind and wave action to scatter into the lake again. High quality logs suitable for replacement debris booms would be saved for project use or moved across the lake to Hozemeen for sale to Canadian customers. To accomplish this method would require land-based wood debris handling equipment, such as a log loader or excavator with thumb. This equipment would need to be barged in at high water or else walked across the lake bed and river when the reservoir level declines in late summer or early fall. The approximately 9 acres occupied by the loose accumulation of debris at the north end of Ross Lake in the existing storage pen could accommodate up to perhaps 5 times the amount of stored debris currently present.

Natural decay would decompose the base layers of debris over perhaps 30 years, causing the piles to settle over time. Each year's new debris would be stacked atop the old piles as it is corralled from the lake. Total CO_2 emissions would be identical to that of burning, as decomposition generates the same emissions. Photograph 4.1 illustrates the techniques and equipment typically used to stack wood debris.

Photo 4.1. Excavator stacking brush piles

This method assumes about 3 weeks to stack the accumulation of stored debris in large piles by 3 project staff (SCL's current FTE's assigned to this work). Given that the additional new debris arriving each year is estimated to be about 1/7 of the existing stored debris volume, we might expect the annual labor effort would be about one week, counting the time to move machinery in to the site and back out again. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and stacking can only occur after lake level has dropped and debris is accessible by land-based equipment. The machine would possibly have to remain on the west side of the lake for up to 6 months at a time if barged to the site, but could also be hauled in from Canada and walked across the lakebed or on mats if the ground is dry and stable enough. Project staff have suggested that they would likely rent a machine in Canada and could park it on the west side for 6 months out of the year.

Given the limited area available for stacking wood debris on the east shore at the Hozemeen Landing area identified by SCL staff as suitable for processing debris, we expect that this alternative would only be practical in the existing debris storage pen area.

Capital or rental equipment costs to accomplish Method 1, as well as approximate labor hours and costs, and total for the existing volume of stored debris and annual new debris are captured in Table 4.1 on the following page.

Table 4.1. Method 1 Stacking for Natural Decomposition Capital or Rental Equipment and Labor Costs

	Time	Rental Excavator Costs	Labor Hours	Labor Costs	Total
Rate or Units	(weeks)	(at $1000/day)	(man-hours)	(at $152/hr)	
Existing Stored Debris Management (45,000 yd^3)	3	$15,000	360	$54,720	$69,720
Annual Debris Management (6,000 yd^3)	1	$5,000	120	$18.240	$23,240

4.2 Method 2 – Open Burning

This method is similar to the historical practice of open burning the wood debris on the west shore of the lake at the existing debris storage pen area exercised by SCL in the past. Practically, this alternative would be comprised of allowing sufficient time for the debris to dry out (perhaps a month or two), sorting debris, recovering high quality logs suitable for project use as replacement debris boom logs or moved across the lake to Hozemeen landing for sale to Canadian customers, and piling debris as burning occurs. Burning would be enhanced with the use of brush fans to maintain high air injection to the burn piles to keep the emissions at minimal levels. To accomplish this method would require land-based wood debris handling equipment, such as a log loader or excavator with thumb. Total CO_2 emissions would be identical to that of stacking the debris and allowing natural decomposition to occur. Photograph 4.2 illustrates the techniques and equipment typically used to stack and burn wood debris.

Photograph 4.2 Excavator stacking and burning brush with brush fans

Method 2 assumes it would require about 4 weeks to burn the accumulated stored debris in piles with brush fans by 3 project staff, plus additional time to move logs to Hozemeen Landing for sale or secured for project use. Ash could be either left to decay or collected and hauled down the lake on light work barge to Ross Dam for recovery and disposal. Total volume of ash remaining following clean and complete burning of debris would be expected to be about 1% to 3% of the total volume of the original debris (i.e. about 450 to 1350 cubic yards). The debris collection can only practically occur during high lake level, but processing and burning can only occur after lake level has dropped and debris has dried out and is accessible by land-based equipment. The log loader or excavator to be used for debris handling would need to be barged in at high water or else walked across the lake bed when the reservoir level declines in late summer or early fall. The machine would possibly have to remain on the west side of the lake for up to 6 months at a time if barged to the site. Project staff have suggested that they would likely rent a machine in Canada and could park it on the west side for 6 months out of the year.

Alternatively, the stored debris could be transferred across the lake over the course of several years to the Hozemeen Landing work area identified by SCL staff, where it would

be sorted and burned each year until the accumulated volume was eliminated, and thereafter the annual debris would be processed and burned at Hozemeen Landing. The excavator or log loader machine could be readily transported directly to the work area by road from Canada. Figure 4.1 illustrates the potential work area at Hozemeen Landing, and Photograph 4.3 shows this area exposed at high lake level.

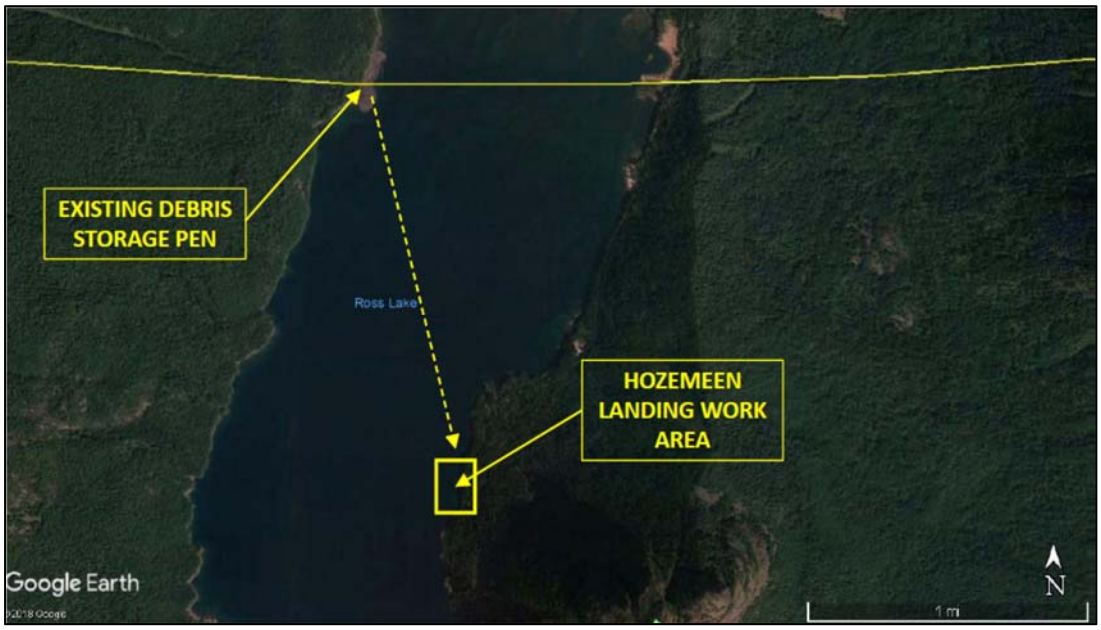


Figure 4.1. Hozemeen Landing Work Area

Photograph 4.3. Hozemeen Landing Debris Processing Work Area

Capital or rental equipment costs to accomplish Method 2, as well as approximate labor hours and costs, and total for the existing volume of stored debris and annual new debris are captured in Table 4.2 on the following page.

Table 4.2. Method 2 Open Burning Capital or Rental Equipment and Labor Costs

	Time	Rental Excavator Costs	Labor Hours	Labor Costs	Total
Rate or Units	(weeks)	(at $1000/day)	(man-hours)	(at $152/hr)	
Existing Stored Debris Management (45,000 yd^3)	4	$20,000	528	$80,256	$100,256
Annual Debris Management (6,000 yd^3)	1	$5,000	120	$18,240	$23,240

4.3 Method 3 - Burning of Debris in Air Curtain Burn Boxes

This method takes advantage of new developments in clean burn technology to incinerate woody debris at high temperatures with very minimal emissions through the use if forced air through a confined burn volume. Air curtain burn boxes utilize a small diesel (or biodiesel) engine to generate high pressure air within a refractory-lined burn box in which the air is recirculated and particulates and combustion gases are consumed thoroughly. In addition, Air Curtain burn boxes can be fitted with a cogeneration system to generate electrical power of between 100 kW and 1 MW from the incineration of debris; more discussion on cogeneration is provided in Method 7. Though the State of Washington has not to date permitted this clean burn technology, studies elsewhere has shown this technology to be considerably cleaner and releases far less emissions than open burning. In addition, the small amount of fuel consumed by the fan blower engine is a fraction of the amount of fuel required to process and grind or chip debris using other methods. The total CO_2 footprint of decomposition or burning of the debris is identical, as both processes generate the same emissions. However, Air Curtain burn boxes also produce Biochar (a useful soil amendment) as a byproduct of combustion.

This method would use the same equipment as stacking or open burning of debris, but with the addition of trucked-in or barged-in air curtain burn boxes. Photograph 4.4 illustrates an air curtain burn box manufactured by Air Burner LLC in the process of incinerating debris. Note the minimal smoke emissions compared to open burning.

Photograph 4.4 Air Curtain LLC Series 200 Fan Driven Burn Box incinerating woody debris (5-7 tons per hour capacity ~15 yd^3/hr)

Method 3 assumes each burn box could incinerate up to about 15 cubic yards per hour, or about 120 cubic yards per 8-10 hr day. To incinerate all 45,000 cubic yards of existing stored debris would require about 375 days for a single burn box, and the average annual additional debris would require about 50 days for a single burn box. To make the process more efficient, a single rented excavator hauled down from Canada could feed up to three burn boxes, hence the process might require as much as 125 working days to burn all the accumulated existing debris with three boxes, and about 17 to 20 days to burn the average annual additional debris. The current SCL crew could feed up to three burn boxes with existing staff assigned for the work, assuming all debris is moved across the lake to the Hozemeen Landing work area for burning. For efficiency and lowest total cost, we have included 3 burn boxes and the total labor hours needed to eliminate all the stored debris assuming all 3 SCL staff are working to feed all 3 burn boxes. The Air Curtain burn boxes are not available for rent, and would have to be purchased, at a cost of about $120,000 each. Annual maintenance and repair costs are not available. Air curtain burn boxes can burn wet debris as well without waiting for it to dry, which enables this process to occur at nearly any time the debris storage area is accessible. Ash could be either left to decay or collected and hauled down the lake on light work barge to Ross Dam for recovery and disposal.

Alternatively, the stored debris could be transferred across the lake over the course of several years to the Hozemeen Landing work area identified by SCL staff, where it would be sorted and burned each year in a single burn box until the accumulated volume was eliminated, and thereafter the annual debris would be processed directly at Hozemeen Landing.

Capital or rental equipment costs to accomplish Method 3, as well as approximate labor hours and costs, and total for the existing volume of stored debris and annual new debris are captured in Table 4.3 on the following page.

Table 4.3. Method 3 Air Curtain Box Burning Capital or Rental Equipment and Labor Costs

	Time	Purchase Cost of Burn Boxes	Rental Excavator Costs	Labor Hours	Labor Costs	Total
Rate or Units	(weeks)	($120k each)	(at $1000/day)	(man-hours)	(at $152/hr)	
Existing Stored Debris Management (45,000 yd^3)	25	$360,000 for 3	$125,000	3,000 (assuming 3 burn boxes)	$456,000	$941,000
Annual Debris Management (6,000 yd^3)	4	First cost of burn boxes is already captured	$20,000	480	$72,960	$92,960

4.4 Method 4 – Separation & Processing of Debris into Boiler Hog Fuel

This method is most suited to wood debris that has no higher value than for boiler hog fuel or rough mulch, and cannot be processed into pulp- or chip-quality material, or processed into compressed sawdust pellets or fuel briquettes. Similar to Methods 1 through 3 above, processing of debris would require an excavator or log loader to feed a hog fuel grinder or chipping machine. Given the large size and weight of the tub grinder or chipper machine necessary to accomplish this work, it is unlikely that it could be accomplished on the west shore of the lake on the softer soils within the footprint of the existing stored debris pen. A more suitable location where the machine could be trucked directly into the work site would be preferred, such as the Hozemeen Landing work area identified above. For greatest economy, given the portable nature of the grinding equipment, it is most advantageous to locate the machines nearest the debris, as the processed mulch takes up much less volume than the loose debris, and transport of the finished mulch is aided by volume reduction.

All debris would need to be transferred across the lake at high water where SCL crews and boats could bag up and tow the debris to the east shore. Total CO_2 emissions would be considerably higher than that for burning or natural decomposition, as the very high horsepower requirements of grinding or chipping equipment necessitates very large diesel engines to power the machine (greater than 750 Hp), which consume about 7 to 10 times more fuel than brush fans or air curtain burn boxes per ton of debris (Burn box ~25 gallons per 100 tons vs. tub or drum grinder about 180 gallons per 100 tons). Photograph 4.5 and 4.6 illustrate the equipment typically used to feed and grind wood debris into hog fuel.

Photo 4.5. Excavator feeding debris into tub grinder (Duratech)

Photo 4.6. Excavator feeding debris into drum grinder (CBI/Terex Industries)

This method assumes about 6 to 8 weeks by a 3-person SCL crew to move debris across the lake to Hozemeen, process the debris, and load onto trucks or bins to be transported either into Canada or barged down the lake for disposal. The debris transfer across the lake to Hozemeen can only practically occur at high lake level, but processing could be conducted at Hozemeen across a wide range of lake levels if debris has already been moved across the lake. Large tub or drum grinders produce as much as 100 tons per hour; hence about 5 weeks of that time would be just for grinding, with the remaining 3 weeks consumed in incrementally moving debris across the lake for continuous processing. Handling and processing each new year's additional debris would likely take about 2 weeks.

Hauling of hog fuel into Canada is assumed to be by point-of-sale directly to customers at Hozemeen and is not assumed to be a cost to SCL or a labor expenditure by SCL project crew for disposal. Barging and tug or push boat or container equipment and labor costs for barging are not included here (see Method 8 for barging costs).

Tub or drum grinder rental costs are only roughly estimated. Capital or rental equipment costs to accomplish Method 4, as well as approximate labor hours and costs, and total for the existing volume of stored debris and annual new debris are captured in Table 4.4 on the following page.

Table 4.4. Method 4 Boiler Hog Fuel Production Capital or Rental Equipment and Labor Costs

	Time	Rental Cost of Tub or Drum Grinder	Rental Excavator Costs	Labor Hours	Labor Costs	Total
Rate or Units	(weeks)	($7500/month + $1,800/day O&M)	(at $1000/day)	(man-hours)	(at $152/hr)	
Existing Stored Debris Management (45,000 yd^3)	8	$15,000 rental + $72,000 O&M	$40,000	960	$145,920	$272,920
Annual Debris Management (6,000 yd^3)	2	$3750 rental + $18,000 O&M	$10,000	240	$36,480	$68,230

4.5 Method 5 – Processing Wood Debris into Compressed Briquettes

This method is most suited to wood debris that has lower value than chip- or pulp-quality, but cannot be processed into fine sawdust for pellet production due to contaminants. The debris would be sorted and the higher quality material processed into chips, sawdust, and small particles, then dried and compressed into fuel logs. Most briquette manufacturing machines rely on relatively high quality, contaminant-free wood feedstock material to successfully produce fuel logs. Only a small proportion of the debris stored in the existing pen at the north end of the lake is suitable for this use, and would be largely confined to the volume of marketable Chip wood and marketable logs only. Root wads and other debris possesses too many contaminants to process through the machines into briquettes. Processing of debris would be similar to Methods 1 through 4 above, and would require an excavator or log loader to feed the chipping machine to prepare the feedstock. Given the large size and weight of the chipper machine and the stable foundation necessary to set up and operate a briquette manufacturing machine to accomplish this work, the west shore storage pen area is unsuitable for this purpose. A better location would be the east shore Hozemeen Landing work area identified above. All debris would need to be transferred across the lake at high water where SCL crews and boats could bag up and tow the debris to the east shore. Total CO_2 emissions would be considerably higher than that for burning or natural decomposition or the tub grinder for hog fuel, as the very high horsepower requirements of fine chipping equipment necessitates very large diesel engines to power the machine (more than 750 Hp). In addition, since not all the debris can be processed into briquette manufacturing machine feedstock, the remainder would have to be processed into hog fuel or burned for disposal. Photograph 4.7 and 4.8 illustrate the equipment typically used to chip and feed wood debris feedstock into briquette machines for conversion to fuel logs.

Photograph 4.7 High-quality Wood Debris Chipping Machine (Peterson)

Photograph 4.8 Wood Chip Briquette Manufacturing Machine (CF Nielsen)

This method assumes a similar amount of time by a 3-person SCL crew to move debris across the lake to Hozemeen (about 6 to 8 weeks), sort and process the debris into feedstock for portable briquette machines or hog fuel (or burning), and load finished product onto trucks headed to Canada or onto a barge headed down the lake to Ross Dam or Ruby Arm. The same lake level constraints apply to debris processing, sorting, and disposal as for Methods 1 through 4 above. Portable containerized briquette manufacturing machines cannot process more than about 2 to 3 tons per hour of finished product per machine. At this processing rate, the estimated volume of 557 tons of chip-quality wood debris (about 1237.5 yd^3, or 2.75% of the total) currently held in the upper lake pen would require 4 weeks to process into finished product. Since the quality of new additional annual debris is expected to be higher, the volume of new annual debris that could be processed into briquettes is estimated to be about 320 tons (about 710 yd^3), or about 10.5% of the total. Thus, annual debris transfer and processing into briquettes would require about 2 weeks. Neither barge transport nor truck hauling to market are included in this discussion (see Method 8 below for barge transport discussion).

Capital or rental equipment costs to accomplish Method 4, as well as approximate labor hours and costs, and total for the existing volume of stored debris and annual new debris are captured in Table 4.5 on the following page.

Table 4.5. Method 5 Briquette Manufacture Capital or Rental Equipment and Labor Costs

	Time	Purchase Price of Briquette Machine	Rental Cost of Chipper	Rental Excavator Costs	Labor Hours	Labor Costs	Total
Rate or Units	(weeks)	($$)	($7500/month + $1,800/day O&M)	(at $1000/day)	(man-hours)	(at $152/hr)	
Existing Stored Debris Management (45,000 yd^3)	8	$100,000	$15,000 rental + $72,000 O&M	$40,000	960	$145,920	$372,920
Annual Debris Management (6,000 yd^3)	2	(first cost is already recovered)	$3750 rental + $18,000 O&M	$10,000	240	$36,480	$68,230

4.6 Method 6 – Processing Wood Debris into Compressed Pellets

This method is most suited to wood debris that has chip- or pulp-quality and can be processed into fine sawdust-sized chips for pellet production with minimal to no contaminants. Hence, only a small proportion of the debris stored in the existing pen at the north end of the lake is suitable for this use, and it consists of only the marketable saw logs, and the chip and pulp logs that are clean and free of stones and other debris. Root wads would possess contaminants that would damage the chipping and pelletizing equipment. The dried debris would be sorted and the higher quality material processed into small chips, sawdust, and small particles using either a very high quality chipping machine or a combination of chipping machine and hammer mill, then compressed into pellets in pressing machines similar to the larger briquette machines in Method 5 above. Most pellet manufacturing machines can only process high quality, contaminant-free wood feedstock material to successfully produce pellets, such as mill-run sawdust.

Similar to Methods 1 through 5 above, processing of debris would require an excavator or log loader to feed the chipping machine to prepare the feedstock, and might also require a closed pond or dip tank to wash dirt and stones from the debris prior to feeding into the chipping machine. The large size and weight of the chipper machine and the stable foundation necessary to set up and operate a pellet manufacturing machine to accomplish this work would make the west shore storage pen area unsuitable for this purpose. Hence, the east shore Hozemeen Landing work area identified above is recommended for setup and operation of the processing equipment. All debris would need to be transferred across the lake at high water where SCL crews and boats could bag up and tow the debris to the east shore. Total CO_2 emissions would be considerably higher than that for burning or natural decomposition or the tub grinder for hog fuel, as the very high horsepower requirements of fine chipping equipment necessitates very large diesel engines to power the machine (more than 750 Hp). In addition, since not all the debris can be processed into pellet manufacturing machine feedstock, the remainder would have to be processed into hog fuel or burned for disposal. Photograph 4.9 and 4.10 illustrate the equipment typically used to chip and feed wood debris feedstock into pellet machines for conversion.

Photograph 4.9 High-quality Wood Debris Chipping Machine (CBI/Terex Industries)

Photograph 4.10 Wood Pellet Manufacturing Machine (Amisys)

This method assumes a similar amount of time by a 3-person SCL crew as Method 5 above to move debris across the lake to Hozemeen (about 6 to 8 weeks), sort and process the debris into feedstock for portable pellet machines, with the remainder ground into hog fuel (or burned). Two machines would likely be necessary to process the material, a chipping machine to reduce the debris to smaller size, followed by a hammer mill to reduce it further to adequate size range for the pelletizing machine. Finished pellet product would be loaded onto trucks headed to Canada or onto a barge headed down

the lake to Ross Dam or Ruby Arm. The same lake level constraints apply to debris processing, sorting, and disposal as for Methods 1 through 5 above. However, portable, containerized pellet manufacturing machines cannot process more than about 2 to 3 tons per hour of finished product per machine. At this processing rate, the estimated volume of 557 tons of chip-quality wood debris (about 1237.5 yd^3, or 2.75% of the total) currently held in the upper lake pen would require 4 weeks to process into finished product. Since the quality of new additional annual debris is expected to be higher, the volume of new annual debris that could be processed into briquettes is estimated to be about 320 tons (about 710 yd^3), or about 10.5% of the total. Thus, annual debris transfer and processing into pellets would require about 2 weeks. Neither barge transport nor truck hauling to market are included in this discussion (see Method 8 below for barge transport discussion).

Capital or rental equipment costs to accomplish Method 6, as well as approximate labor hours and costs, and total for the existing volume of stored debris and annual new debris are captured in Table 4.6 on the following page. Note that a pelletizing mill is considerably more expensive than a briquette manufacturing machine.

Table 4.6. Method 6 Pellet Manufacture Capital or Rental Equipment and Labor Costs

	Time	Purchase Price of Pelletizing Machine	Rental Cost of Chipper and Hammer Mill	Rental Excavator Costs	Labor Hours	Labor Costs	Total
Rate or Units	(weeks)	($$)	($12,500/month + $2,500/day O&M)	(at $1000/day)	(man-hours)	(at $152/hr)	
Existing Stored Debris Management (45,000 yd^3)	8	$750,000	$25,000 rental + $100,000 O&M	$40,000	960	$145,920	$1,060,920
Annual Debris Management (6,000 yd^3)	2	(first cost is already recovered)	$6,2500 rental + $25,000 O&M	$10,000	240	$36,480	$77,730

4.7 Method 7 – Syngas or Biomass Generation for Electrical Power

Synthetic gas or simple biomass power generation is an old concept that has been used for more than a century to generate power. All sawmills after the advent of the steam age used waste wood as feedstock for boilers providing the steam to generate electric power or reciprocating engine power to operate the sawmill. Most sawmills still use their waste wood product for boiler feedstock (hog fuel, sawdust, and trimmings) to generate electrical power to run the mill, and heat to operate drying kilns. Synthetic gas was first developed and produced in commercial quantities by Germany beginning in the early 1930's, but interest in the technology faded with the ready availability of cleaner burning petroleum based fuel that did not create toxic smoke emissions. However, since synthetic gas requires that the wood be converted to fuel gas through low-oxygen burning, emissions are quite high unless secondary treatment can be applied. There are no commercial manufacturers of synthetic gas production equipment in the United States. There are, however, several combustion engine manufacturers in the United States and abroad that produce combustion engines that can burn biogas from a variety of sources, including sewage, landfill gas, anaerobic digesters, natural gas, and synthetic wood gas. Byproducts of the fuel gas generation process includes biochar, an agricultural soil amendment product that enhances water uptake and plant growth.

We have no information on the average electrical demand presented by the Hozemeen complex, but based on the size of the complex and the number of buildings, we estimate the demand to be less than 100 kW of electric power, assuming heat is provided by wood burning appliances. If heat and electrical power is to be provided by the Syngas generator, we estimate total load to be between 100 and 200 kW, with the higher demand occurring in winter. A single gas generator unit is capable of supplying this entire demand quite readily.

Biomass generation is readily available with either a steam boiler system (not considered here given its large size and expense) or a small compact unit that is combined with the burn box system described in Method 3 above. Air Burners, LLC builds cogeneration units that attach to their Class 200 Burn Box a small heat exchange and thermal expansion electrical generation (via circulating heated transfer liquid exchanging heat to water and a low temperature and low pressure steam generator). Both Waukesha and Jenbacher produce engines capable of burning biogas and synthetic gas created by waste wood, with the smallest unit rated at about 150 kW. However, as stated above, there are no known manufacturers of wood gas generator units in the U.S, and as such it would have to be custom designed and manufactured. In addition, any custom designed or manufactured synthetic wood gas generation system would require grinding of the wood waste into uniform feedstock quality and size (hog fuel grinder). The Air Burner system does not require processing of the wood waste, and can be a byproduct of their existing BurnBox system with an attached add-on. No prices were available for the power generation add on unit, but the sales representative stated that a used 1MW unit could be obtained for under $100,000.

Since the BurnBox system add on represents a simpler, and importantly, readily available power generation system, we considered this instead of a synthetic wood gas

generation system. Total CO2 emissions from this type of system are no greater than with the air curtain burn box system described in Method 3 above, since there would be no need for additional processing or grinding systems Photograph 4.11 shows an Air Burner burn box coupled to a power generation system. Figure 4.2 shows a Waukesha gas engine generator, while Figure 4.3 shows a Jenbacher gas generator system.

Photograph 4.11 Portable Biomass and Debris Air Curtain Burning System (Air Burners, LLC)

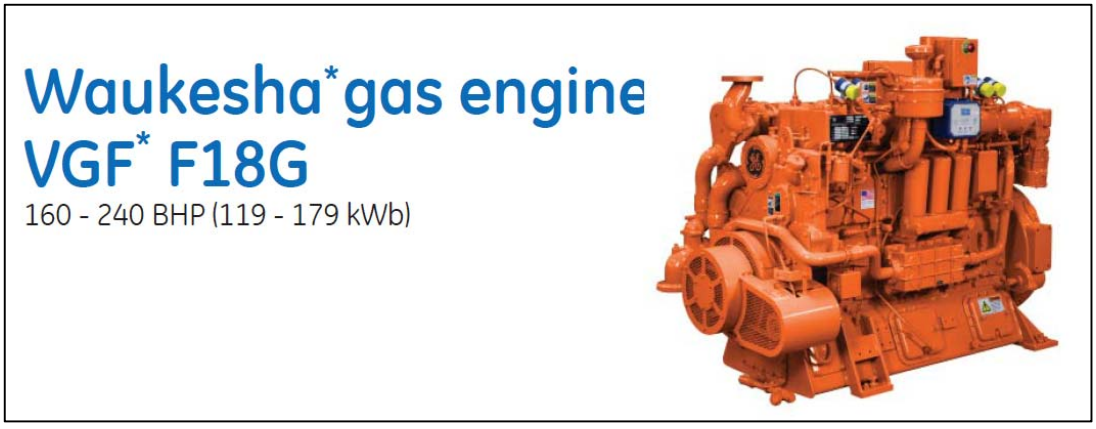


Figure 4.2 Waukesha BioGas-Fueled Generator

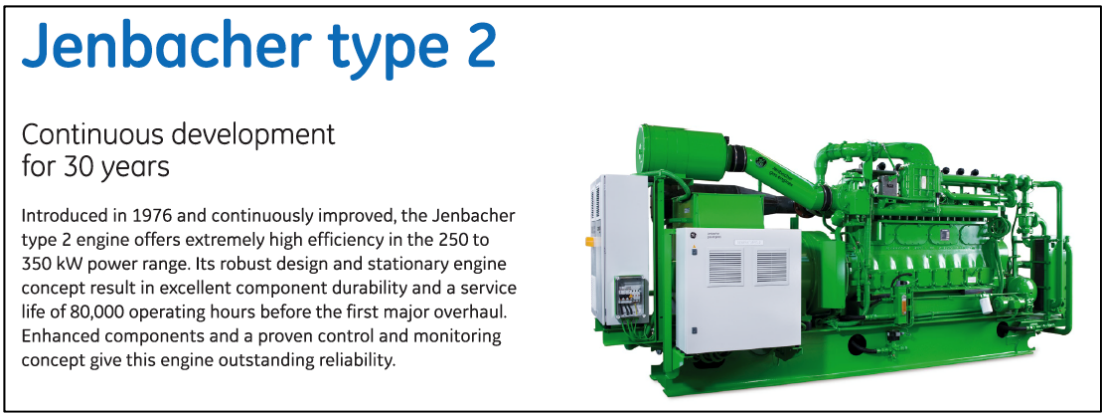


Figure 4.3 Jenbacher BioGas-Fueled Generator

This method was analyzed a bit differently from the others above, as the biogas generation for the Hozemeen complex would be merely a byproduct of the debris disposal, utilizing only a fraction of the available debris. This would require creating a storage area for debris near the building complex, and the purchase of a machine to feed debris into the syngas generator or the air curtain burn box thermal power plant. However, the demand for woody debris is assumed to be continuous throughout the year. In this case, since a syngas (i.e. wood gas) generation system is not commercially available, our attention focused on utilizing an air curtain burn box to process debris on a continual basis to provide for the year-round electrical power demand presented by the Hozemeen building complex.

The labor estimate and cost to implement this Method 7 is distinctly different from that of the other Methods, in that the generation of electrical power is assumed to occur over the course of an entire year, consuming debris on a continual basis, and implemented largely by National Park Service staff housed at the Hozemeen complex. The labor to separate and process the existing debris stockpile into appropriate uses is assumed to be conducted by SCL crews, but instead of disposing of all the debris, an annual supply of sufficient fuel for the electrical generation system at Hozemeen would be reserved and stacked in storage near the generation facility. Hence, the time, labor and equipment needed by SCL staff to process the existing and new annual debris is assumed to be identical to Method 3 described above.

Generation of 100 to 200 kW of electrical generation requires about 100 to 200 cords of wood, assuming a conversion efficiency of about 75% and discounting for wood quality, this annual total is between 800 and 1,000 cubic yards of woody debris per year. The remainder of the debris would be processed and disposed by other means.

Labor costs to accomplish the debris processing and storage activities of Method 7 are assumed to be the same unit price (per yd^3) as Method 3, or about 1 week. Additional labor costs on the part of NPS staff to fuel the syngas or thermal generation systems is not included in this analysis. The capital cost of purchasing the additional power generation module for the Air Burner PowerGen system is estimated based on the quote obtained from Air Burner LLC for the used 1MW power plant. New prices were not provided by Air Burner LLC. The summary costs for Method 7 are captured in Table 4.7 on the following page.

Table 4.7. Method 7 SynGas or Thermal Electrical Generation from Woody Debris for Hozemeen Complex Capital or Rental Equipment and Labor Costs

(NOTE: These costs are ONLY for processing and dry storage of fuel wood for generation. Remaining debris disposal costs are NOT included.)

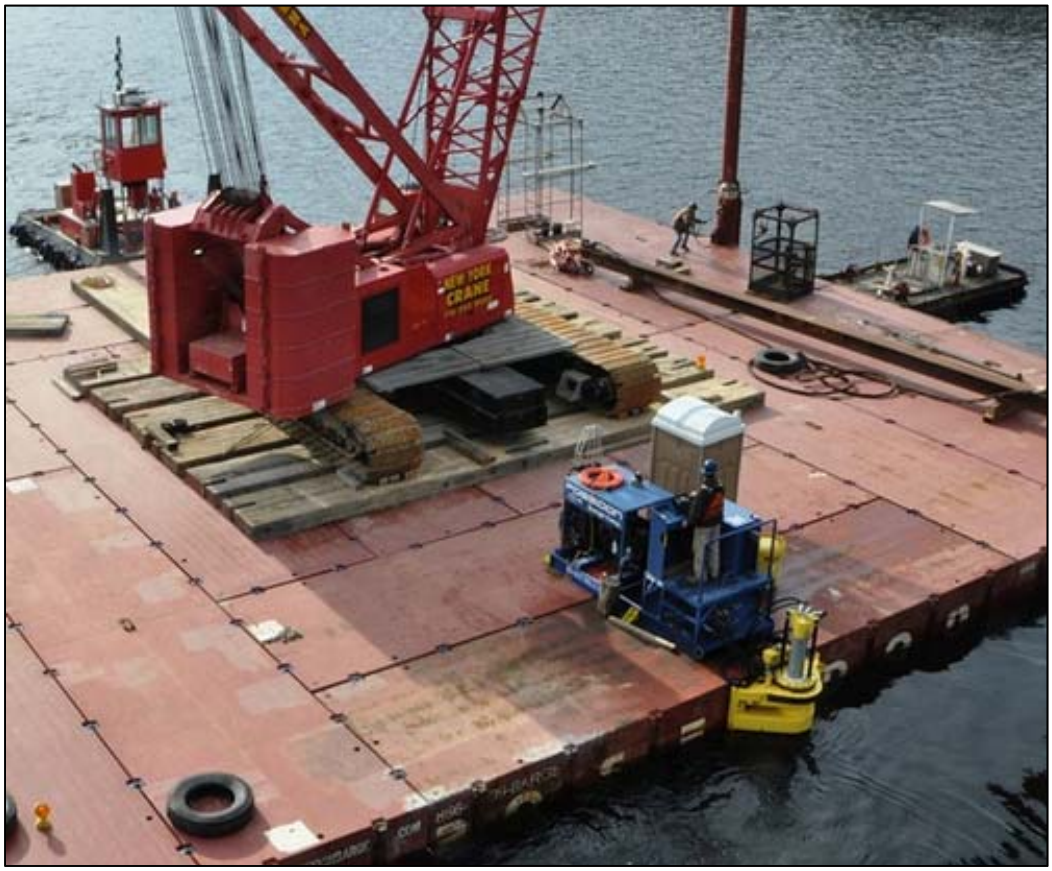
	Time	Purchase Price of Used PowerGen System	Rental Excavator Costs	Labor Hours	Labor Costs	Total
Rate or Units	(weeks)	($$)	(at $1000/day)	(man-hours)	(at $152/hr)	
Annual Woody Debris Consumption Storage (900 yd^3)	1	$100,000	$5,000	120	$18,240	$123,240

4.8 Method 8 – Towing or Barging Debris to Ross Dam or Ruby Arm

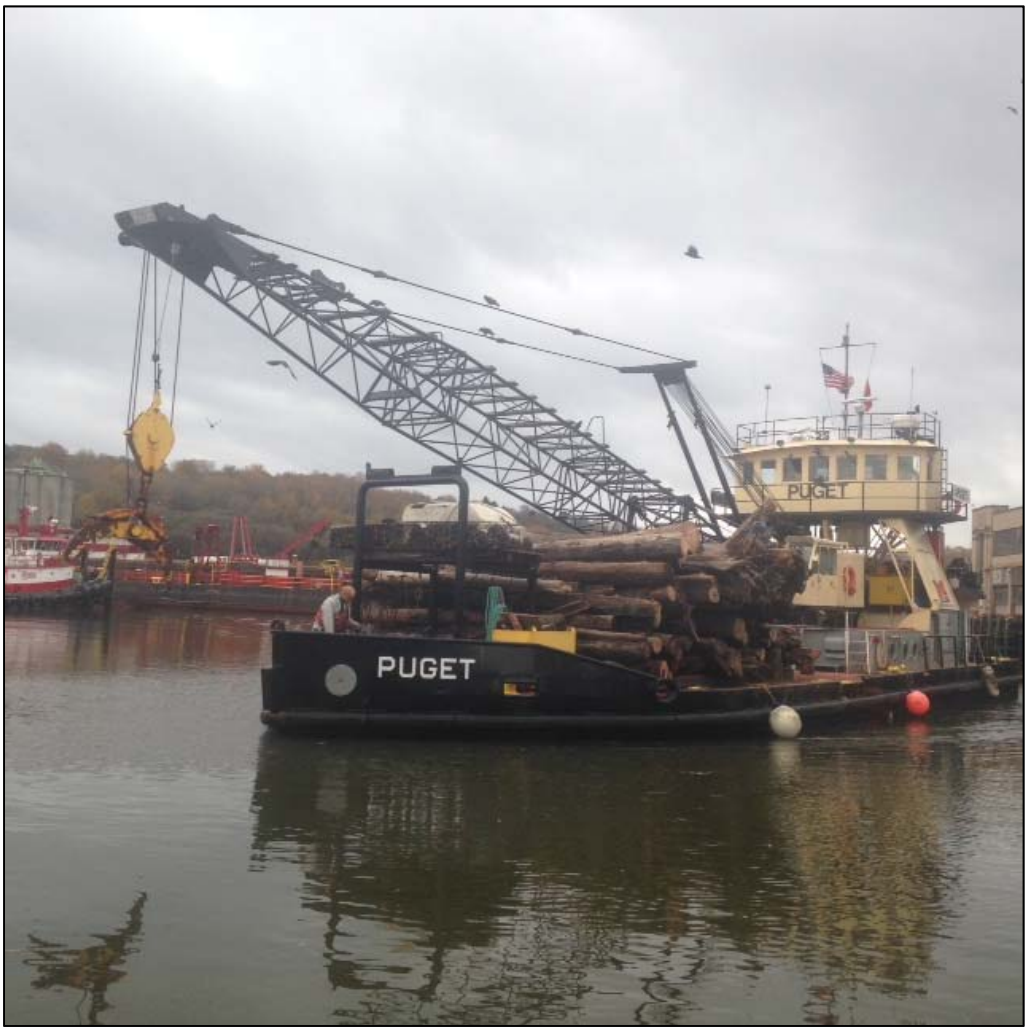
This method can be accomplished with SCL's current crew and equipment, or with the addition of a small tugboat and barge to better contain and more effectively move the debris and prevent re-entrainment into the lake arising from winds or currents encountered during the trip down the lake. SCL crews have indicated that towing small debris down the lake in booms results in loss of as much as 50% of initial boom volume by the time the raft reaches Ross Dam, requiring recapture and repeat of the towing work. Unless processing of the woody debris into bulk volume and hauling in containers on a barge is accomplished, the SCL crew has estimated that simple raft towing might require as much as 30 days of continuous work annually to move, recapture, move again, and isolate the debris at the lower end of the lake. Barging of the stored volume of debris in containers requires processing into boiler hog fuel, marketable logs, root wads, or other value-added products at the existing storage pen site.

For the purposes of evaluating barging or towing of debris, we assumed that barging or towing of debris was merely the means of moving the debris from the upper end of the lake to Ross Dam and vicinity, and was independent of the degree of processing that was accomplished in the upper lake storage area. For all debris other than logs and possibly large root wads, SCL crews suggested that barging of containerized or binned debris would be the only practical way to control and contain debris efficiently for the long trip down the lake. Hence, the costs involved for moving debris down the lake are provided in terms of the time required to tow only logs and root wads down the lake via towed booms, or the time required to move all smaller debris down the lake via barge in containers or bins on the deck of the barge. All barging is assumed to require the purchase of a moderate sized barge (assume modular barge assembled at Ross Dam) and the purchase of a small tug boat (150 Hp diesel). Photograph 4.12 shows a typical small inland water tugboat of the size range required to tow a 250-ton capacity barge (about 48 ft x 72 ft modular barge constructed of 8 ft x 24 ft pontoons) from the upper end of the lake to Ross Dam vicinity. Photograph 4.13 show a typical modular barge assembly used on inland water construction projects. For additional reference, Photograph 4.14 shows a tug/workboat combination watercraft designed specifically for the purpose of removing debris from the water and hauling it to a disposal site.

Photograph 4.12 Small Tugboat for Inland Waterway Work



Photograph 4.13 Modular Barge System for Inland Waterway Work



Photograph 4.14 USACE Seattle District 'Puget' Debris Removal Boat

This method assumes about one day to assemble each boom and secure it to the tow boat, and about 8 to 10 hours to make the loaded 21-mile trip down the lake (about 2-3 knots). The return trip to the upper storage pen could be accomplished in about half that time, with the next boom secured and ready for towing when the tug returned. Each boom is assumed to hold up to about 1000 yd^3 of debris, covering about ½ acre in size. Hence, towing all of the marketable logs, habitat root wads, and chip-suitable larger debris from the existing stored woody debris volume of a about 1700 yd^3 (Table 3.1) would require about 2 round trips.

For the barge, we assumed a loading time to place up to 250 tons (500 yd^3) of processed debris in 25 yd^3 bins of about 1 day. Barging of the loaded bins to Ross Dam is assumed to require about 8 to 10 hours. Unloading of the barge and the return trip to the upper debris storage pen could be accomplished in about a day, resulting in a round trip cycle time of about 3 days. Hence, barge transport of all the existing stored small woody debris might require as much as 270 working days, or about 1 year of full time effort. Barging of each new year's annual debris volume might require as much as 36 working days, or about a month and a half. Capital and labor costs to accomplish Method 8 are captured in Table 4.8 on the following page.

Table 4.8. Method 8 Towing/Barging Woody Debris to Ross Dam Capital or Rental Equipment and Labor Costs

	Time	Purchase cost of used tugboat	Purchase cost of used modular barge system	Rental Excavator Costs	Labor Hours	Labor Costs	Total
Rate or Units	(weeks)		($5,000 each 8 ft x 24 ft, 18 needed)	(at $1000/day)	(man-hours)	(at $152/hr)	
Towing Logs and Root Wads from Existing Stored Debris (1,700 yd^3 only)	1.5	$75,000	N/A	$7,500	180	$27,360	$109,860
Towing Logs and Root Wads from Annual Debris (860 yd^3 only)	1	first cost covers	N/A	$5,000	120	$18,240	$23,240
Barging Small Debris from Existing Stored Debris (43,313 yd^3)	52	$75,000	$90,000	$260,000	6240	$948,480	$1,373,480
Barging Small Debris from Annual Debris (5,220 yd^3)	6.5	first cost covers	first cost covers	$32,500	780	$118,560	$151,060

4.9 Method 9 – Skyline Lift Debris from Ruby Arm to Highway 20 Pullouts above Ross Lake

This method likely cannot be accomplished with SCL's current crew and equipment, as the equipment is highly specialized. However, contract crews and equipment can be readily hired from the surrounding area, as high lead logging is still conducted frequently in the general area. SCL has identified the Ruby Arm area, immediately below two highway pullouts on Highway 20, as the best locations for assembling a skyline and tower system for high lead operations of this type. For the assessment of Method 9 for debris handling, we have assumed contracted crews and equipment, and establishment of permanent tail holds and guy line anchors to utilize these two pullout areas above Ruby Arm. We assume that the high lead system would be assembled each year to extract debris from the reservoir and disassembled again when the work is completed, much like typical high lead logging equipment.

The two highway pullouts have sufficient space to position a skyline tower yarder, a log loader, excavator, or other machine for handling and loading loose debris or bins of debris, and truck loading. However, given the confined space, the need for overhead guy lines to secure the tower safely, the highway would need to be closed during this operation. Approximate alignments for the skyline arrangement for positioning the yarder at either of the two pullouts was roughly determined in the field, and these are shown in Figures 4.4 and 4.5 below. One or more permanent anchors would have to be constructed on the point of land on the opposite side of Ruby Arm to provide a secure tail hold. These could consist of large anchor bolts drilled and grouted into the bedrock, or a mounted concrete block anchored into the bedrock. To string the skyline each year would require that the skyline be stored somewhere near the shoreline on the opposite side of Ruby Arm, or a light straw line be pulled up the mountain each year with which the large skyline could then be drawn up to the tail hold. Weathering of the skyline would necessitate regular replacement if it was to be left outside. Photograph 4.15 shows a typical large yarder tower in use for logging. A similar equipment mix would be expected for Method 9 as described.

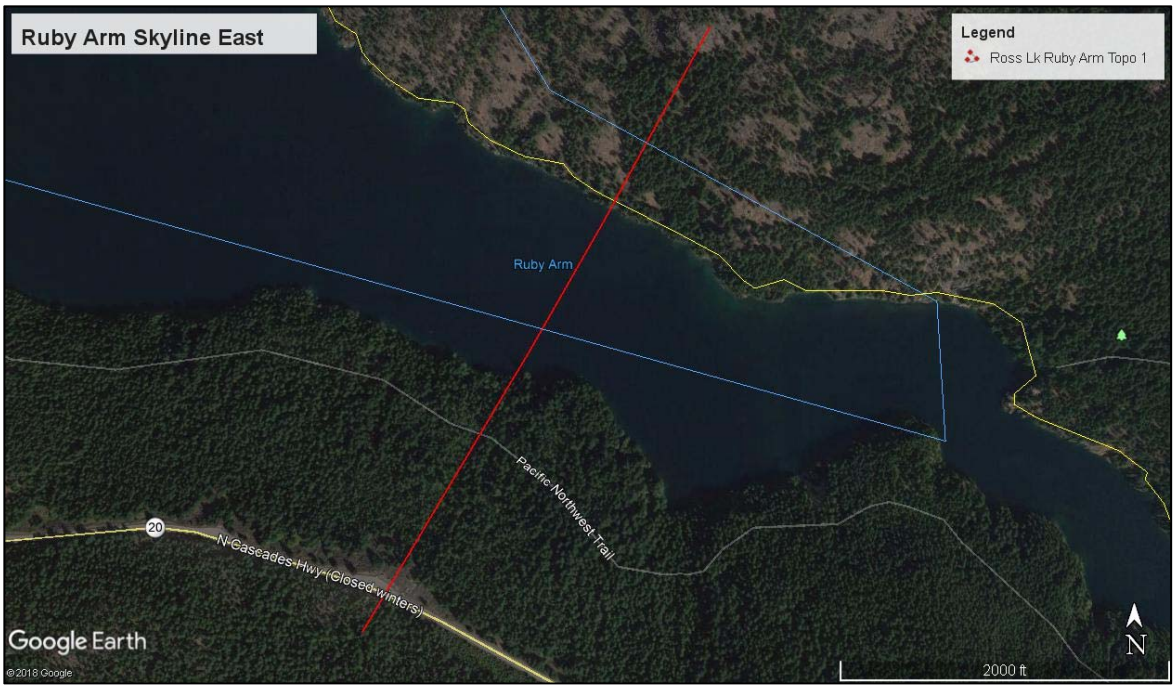


Figure 4.4 Ruby Arm Skyline Alignment from east Highway 20 Pullout

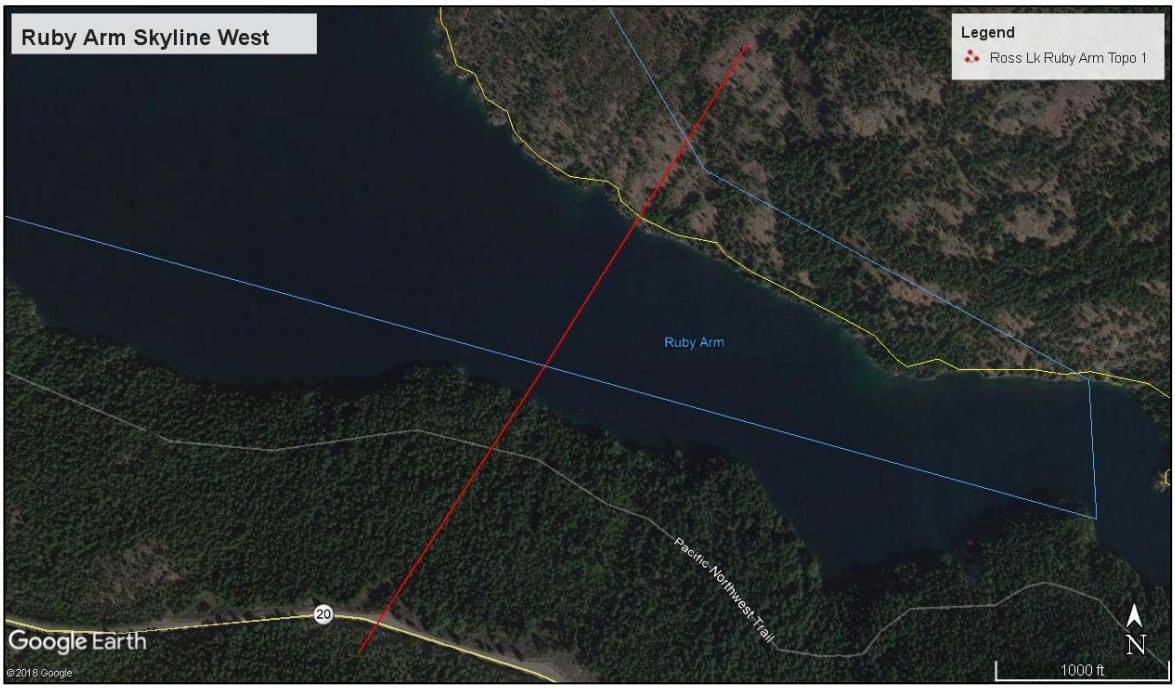


Figure 4.5 Ruby Arm Skyline Alignment from west Highway 20 Pullout

Photograph 4.15 Berger Yarder with 110-foot Tower

Though detailed evaluation of impacts to the existing vegetation along the alignment of a proposed skyline system was well beyond the scope of this study, it should be noted that the nature of skyline operations are such that debris will eventually become scattered below the line. In addition, the need to slack and tighten the skyline with every load lifted from Ruby Arm up to the Highway 20 pullout area will necessitate the removal of selected trees and trimming of limbs that might interfere with the skyline operations. A permanent scar on the native vegetation will develop over time with repeated use, though no significant land damage should occur unless repeated loads are dropped or come into contact with the ground during the operations. Heavier loads will inevitably contact the ground through much of their transit up the slope, as the skyline cable tension cannot be safely increased enough to fully suspend the load along the entire path. Figure 4.6 below illustrates the typical catenary developed by suspended load passing along the length of a skyline cable. Photograph 4.16 shows typical skyline skid trail vegetation scars on the slope under the lifting line.

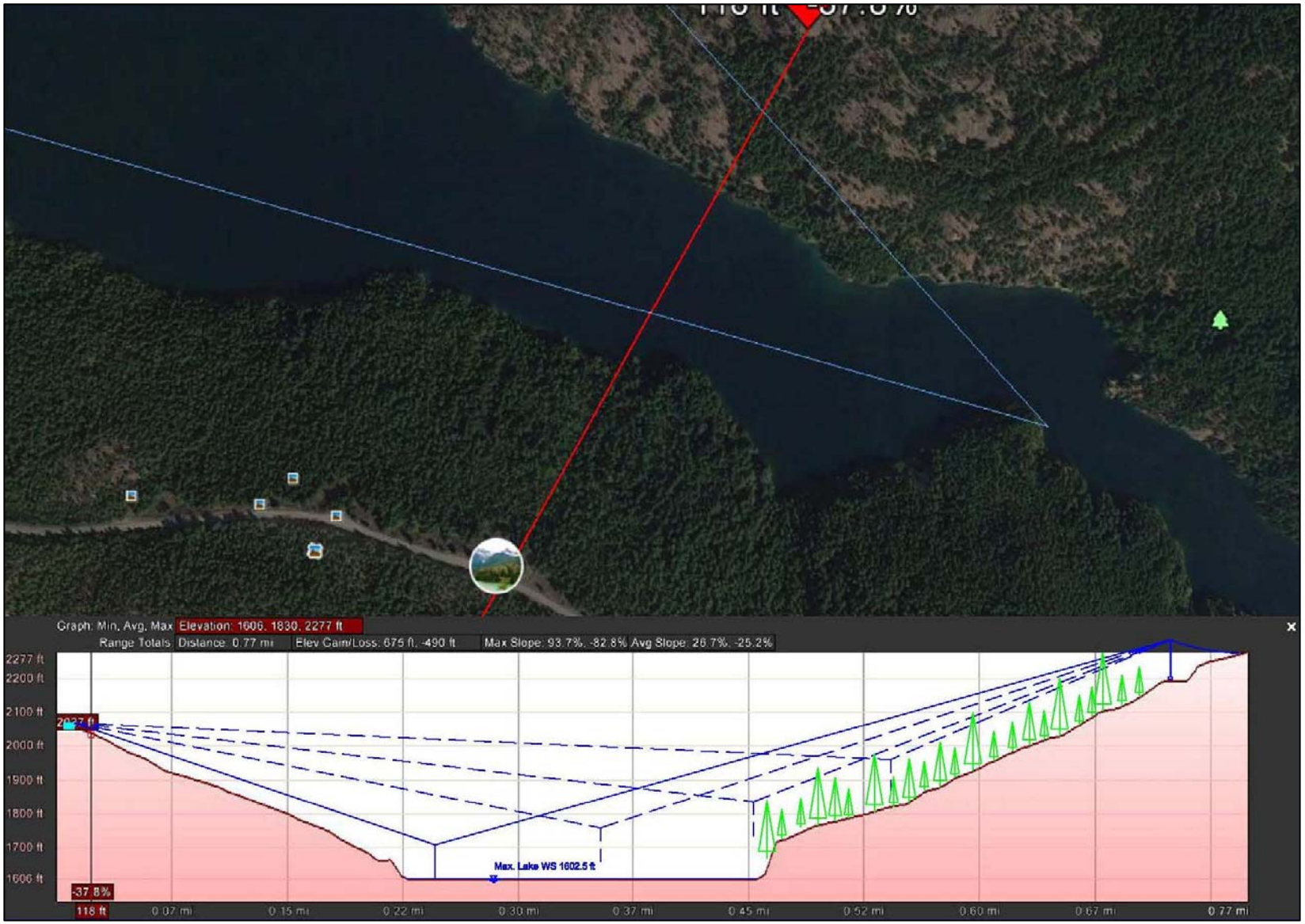


Figure 4.6 East Option Skyline Catenary (typical with load) Showing Impacted Skid Trail

Photograph 4.16 Typical Skyline Skid Trail Vegetation Scars following Operations

Capital and labor costs to accomplish Method 9 would include contract costs for skyline operations crews to assemble and disassemble the skyline, help process and load debris at the upper lake storage pen site, and help tow barge loads to Ruby Arm. Contract crews would manage the landing area and hauling of the debris. The production rate of a skyline operation would demand more than SCL crews can supply each day. Costs and time expenditures here do not include processing of debris, booming up logs and root wads (covered in Method 4 above), or loading and transporting by barge or towed (Method 8). Handling machinery such as an excavator at the upper lake storage pen area, chipper and grinder rental costs, and barge or tugboat costs are not included here, but are covered in Method 4 and Method 8 above. Assume skyline crew is required for two weeks @$5,000/day plus $25,000 mob and demob. The debris collection can only practically occur during high lake level, but processing can continue until stockpile at Hozemeen is gone. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water to attach chokers to each log in turn, but from the barge deck for bins. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees. Daily production of logs and root wads would be as much as 15 log truck loads or more, while bins could be moved as quickly as 20 per hour (about ½ of a barge load). Volume of processed debris moved by this method could be as much as 500 yd^3 per hour, provided bins were properly designed and were of optimum size and weight. Set up and tear down would be at least several days.

Table 4.9 below provides a summary of the production expected from a skyline operation and the labor costs associated with both the contract crew and SCL crew. The labor costs assume that no excavator or other handling machinery would be required to be supplied by SCL, and all debris would be attached to the skyline lifting equipment from the water.

Table 4.9 Method 9 Skyline Lift of Debris from Ruby Arm to Highway 20 Capital or Rental Equipment and Labor Costs

	Time	Contract Labor Hours	Contract Skyline System Costs	SCL Labor Hours	Total Contract + SCL Labor Costs	Total
Rate or Units	(weeks)	(assume 4 men on skyline + 8-10 additional men on 2 addtl tug crews and processing debris)	($5,000/day plus $25,000 for mob and demob)	(assumes processing, loading, and lake transit time not included)	(at $152/hr)	
Skyline Operation to Lift Existing Stored Debris Logs, Root Wads of Bins only (1,700 yd^3 logs and root wads only + up to 43,313 yd^3 processed binned debris)	2	1080	$100,000	240	$200,640	$300,640
Skyline Operation to Lift Annual Debris (860 yd^3 logs and root wads only + up to 5,220 yd3 processed binned debris)	1.5	552	$87,500	180	$111,264	$198,764

4.10 Method 10 – Multiple Load Transfer from Ross Dam to Diablo Reservoir to Diablo Access Road

This method is the same procedure SCL crews currently employ to remove debris from the forebay and near vicinity of Ross Dam, but expanded to include additional debris collected from the upper end of the lake. Currently, SCL crews extract as many as 150 dump truck loads of debris from the forebay annually (about 1200 yd^3) via the boat launching ramp near the left abutment of the dam. Debris is collected using the workboats, boomed, and towed to the boat ramp area, where it is loaded into trucks and hauled the short distance down below the dam and offloaded onto a waiting barge for transport down the Diablo reservoir to the Highway 20-accessible public boat launch above the right abutment of Diablo Dam. It is loaded onto trucks and hauled away from disposal or for deposit back into the Skagit River below Gorge Dam. Due to the difficulty and time expense of collecting and towing all debris (discussed in Method 9 above), including small debris, from the upper end of the lake all the way down to Ross Dam, SCL crews currently do not move debris down the lake from the upper storage pen area.

Method 10 considers expanding the current program to manage larger volumes of debris. However, the lake level constrains the temporal limit of this approach, since the Ross Dam boat ramp becomes stranded as the lake level declines, effectively limiting the transfer of debris to a relatively short window of perhaps a couple of months in the early summer (see Figure 3.4 above). Production by this method could be enhanced if the debris were processed and densified at the existing upper lake storage pen and loaded into bins or booms of clean logs and larger root wads only. Bins would be a very productive means of moving debris quickly by barge and then loading directly onto trucks for transfer to the existing barge at Diablo Lake. Refer to the discussion in Method 9 above for barging bins of debris and for towing booms of logs and root wads to Ross Dam. Increased production by this method may impact private use of the boat launch area, as the increased truck traffic and machinery could not be accommodated while the public was in the vicinity. Photograph 4.17 shows typical truck loading of loose debris, while Photograph 4.18 shows typical transfer dump loading of transfer bins that could be used to move processed debris directly from a barge to truck and then to the Diablo Lake barge again, then to waiting trucks at the Diablo boat ramp. Photograph 4.19 shows the existing Diablo Lake ramp below Ross Dam tailrace.

Photograph 4.17 Loading Loose Debris into Trucks

Photograph 4.18 Transfer Bin and Roll-off Truck

Photo 4.19. Diablo Reservoir Access Ramp below Ross Dam

The limited space available in the near vicinity of the Ross Dam boat ramp would constrain operations, and the hourly production is not likely to exceed about 4 to 6 trucks per hour (about 40 to 60 yd^3 per hour). Within an 8-hour shift and with existing facilities, it is not likely SCL crews could move more than about 500 yd^3 of debris per day with this method. For our time estimate, we assume that the transfer trucks would only move the bins from the Ross Dam boat ramp down to the waiting barge on Diablo Reservoir below Ross Dam, then return. Waiting transfer trucks or unloading facilities would be positioned

at the Diablo Dam boat access ramp to empty the bins and return them to the barge for re-use on the short hop between Ross Lake and Diablo Reservoir. Based on this production rate, the monthly debris transfer rate would not be likely to exceed about 10,000 yd^3, hence the total volume of stored debris would require more than 4.5 months, which is greater than the available time in which the reservoir would be high enough to accomplish the work. Capital costs would be minimal unless SCL needed to purchase roll-off trucks to transfer debris bins, since transfer trucks are readily available for rent or via contract operators. Capital costs for this method do not include the cost of a tugboat or barge. See Method 8 above for more information on barging and tug operations. Summary production rates and labor costs for Method 10 are provided in Table 4.10 below.

Table 4.10 Method 10 Load Transfer from Ross Dam to Diablo Reservoir to Diablo Access Road

	Time	Rental Transfer Truck Costs	Labor Hours	Labor Costs	Total
Rate or Units	(weeks)	(at $500/day)	(man-hours)	(at $152/hr)	
Transferring Existing Stored Debris at Ross Dam (45,000 yd^3)	20	$150,000 (assume 3 trucks are needed to maintain production)	2400	$364,800	$414,800
Transferring Annual Debris at Ross Dam (6,000 yd^3)	3	$22,500 (assume 3 trucks are needed to maintain production)	360	$18,240	$77,220

5 Analysis and Evaluation of Alternatives

Application of each of these 10 Primary Handling Methods at Ross Lake may include combinations of several methods to sort and process the debris, to move the debris to accessible locations, and then finally to market or end-use. Development of various Alternatives for managing and disposing of the stored and additional annual debris at Ross Lake considered each handling and processing method, and where it seemed appropriate, combined methods to create a single Alternative that could reasonably accommodate the volume of debris expected to be encountered and managed. These various alternatives thus developed were covered extensively in an internal evaluation workshop in which the alternatives were priced and scored using unbiased techniques. Summary tables with the results of the Alternatives Evaluation Workshop are included in Appendix A.

Prior to the evaluation workshop, SCL led a site visit to Ross Dam, Ruby Arm, Dry Creek, and the Hozemeen storage pen area. The field visit included rough estimation of the type, size, and quality of the stored debris, developed in consensus with SCL's right-of-way crew that is annually responsible for collecting and storing debris. In addition, the field visit included a walk-through of the Hozmeen complex area, and the potential loading and handling area just to the south of the building complex. The Dry Creek disposal area was reviewed to show how the debris was being used to help control invasive near-shore weeds and grasses. The site visit also provided an opportunity to interview SCL personnel for alternative suggestions and approaches to debris disposal, and to obtain other opinions of various ideas for disposal.

The debris disposal alternatives considered in this study were developed to a conceptual level only. The purpose of the evaluation was to refine the previously identified alternatives, and to consider additional alternatives that had not previously been considered. These alternatives also include previous debris disposal methods as well. A preferred alternative, alternatives, or combination of alternatives were determined by evaluating each alternative within a matrix of key factors, each of which received an appropriate weighting, and then scored by multiplying the factor weighting by the ranking assigned to each factor as applied to each alternative.

The alternative weighting matrix factors were developed in collaboration with SCL staff including the Skagit operations team, dam safety group, and environmental/regulatory staff. A matrix was prepared for the alternatives to address the particular issues surrounding the disposal of the present significant accumulation of debris, and another matrix was prepared for the same or similar alternatives addressing the long term disposal of the average annual additional debris generated by the watershed. Evaluation factors included consideration of overall timing for implementation, constraints on implementations resulting from reservoir operations, initial capital costs and future operations and maintenance costs, worker safety, dam safety, permitting requirements, and environmental and recreation impacts resulting from the particular methods associated with each debris disposal alternative.

The evaluation workshop included members of the SCL Skagit Project staff that are tasked with debris management at Ross Lake, SCL staff from the Seattle headquarters office within the Dam Safety organization, the Environmental Regulatory organization,

and the Consultant's technical team. The workshop was facilitated by the SCL project manager and the Consultant task lead. A fair and open process was implemented to fairly consider differing opinions equally, and to prevent any one perspective from dominating the discussion. The workshop first considered and refined the evaluation factors by combining, refining, or eliminating the preliminary factors through consensus agreement. Next the workshop participants determined the appropriate weighting of each factor, and finally scored each alternative according to its expected performance with respect to each factor.

Following the workshop, a revised evaluation matrix with the refined evaluation factors, weighting values, and alternative scoring was distributed to SCL workshop participants for review and editing. This final report was developed to reflect the conclusions of the evaluation workshop and summarize the recommended next steps SCL might take to implement a solution to the debris problem.

Refinement of the evaluation factors during the workshop and through several subsequent editing sessions through comments from SCL staff determined the following key considerations:

- Dam Safety, including gate operation, spillway operation, and project access
- General Safety, including worker safety, public safety
- Cost, including initial capital cost of necessary equipment, additional labor costs incurred above that of the current SCL staffing dedicated to debris management, and contract labor and equipment costs for specialized equipment or methods (such as high lead logging equipment)
- Environmental sustainability, including reconnecting debris transport from the upper Skagit River watershed to the lower Skagit River watershed below the dams, aquatic habitat restoration value, carbon sequestration, and other considerations
- Environmental and recreational impacts, such as visual appearance or landscape scarring, trail closure, and emissions such as smoke and ash,
- Horizon timing and scheduling, including the time required to obtain either on-time permits or annual permits for continued operations, and the actual time to accomplish the short term and long term (future years) debris disposal activities.
- Limitations or constraints resulting from reservoir operations, such as ability to process debris independent of reservoir level or not, accessibility to east and west sides of the lake, and minimizing impacts to recreational activities on the lake such as boating and fishing.

Weighting of each of the key factors considered assumed a value of 1 for the most important factor to 3 for the least important factor. Ranking of each alternative in each of the key factors assumed a value of 1 for the best performance to 4 for the poorest performance. Total score for each alternative was calculated by multiplying the rank within each factor by the weight of that factor, then summing all the individual scores to a total for each alternative. The best performing alternative was identified as that which had the lowest cumulative score, while the poorest performing alternative had the highest cumulative score.

The final definition of the various alternatives was settled following the evaluation workshop, refinement of the matrix table, inclusion of retrospective comments from SCL staff, and elimination of those alternatives deemed infeasible by the workshop participants. This refinement included some reorganization of the numbering and ordering of each of the alternatives relative to their increasing complexity and cost. The final alternative definitions are summarized in Tables 6.1 and 6.2 below, along with their relative total scores.

6 Results of Evaluation

The evaluation workshop and the supporting calculations and equipment/staff limitations highlighted the importance of some of the key factors considered, and revealed the extent to which some of the alternatives would require considerable consultation with other agencies for approval.

For example, examination of the high lead system necessary to lift debris from Ruby Arm up to Highway 20 revealed that a permanent cleared corridor along the path of the skyline cable system would be necessary to adequately carry woody debris and bins, given the lift and clearance afforded by the yarding system. This would require permitting and consultation with the National Park Service to enable necessary clearing of obstructing trees along the lift path of the skyline system. Very large yarder systems would be required if it was necessary to completely or partially suspend the loads lifted from Ruby Arm, given the very long span and the limited clearance above the ground. Smaller yarder systems could also provide the lift up to Highway 20, but these would not lift the loads clear of the ground, and would accomplish the work by dragging the loads up the slope over the skidding trail. Smaller, non-lifting yarder systems and crews are more readily available and their operating costs are lower.

Also, examination of market values for all wood products that could be produced from the type and volume of debris revealed that the overall poor quality and low market value of products that could be produced from the debris made it unlikely for these products to be sold without incurring considerable additional cost to SCL. The highest value products, such as sawlogs, were determined to be of greater value to SCL if they were retained for replacement debris boom logs, given the relatively low number of these quality logs in the accumulated debris or expected annually with new debris. Market values are very low for products such as mulch, landscaping chips, pulpwood, and root wads, and it was determined that it would incur a net cost to SCL to produce, transport, and market them to consumers.

Additionally, SCL project staff experience with collection and transporting of woody debris in the past made it clear that towing booms of all but clean logs would be very difficult to conduct without likely losing most of the smaller material along the long tow route to Ruby Arm. This likely rules out all but towing barge loads of debris downstream that is contained or confined to prevent loss, and implementation necessarily requires the acquisition of large floating plant equipment.

Another key consideration for debris processing that was determined to be of importance is the ability to position equipment on the west side of the head of the lake at the present location of the debris booms. This area is flooded at full reservoir level, which would

prevent heavy debris handling equipment such as an excavator or log shovel from occupying this area until late summer or fall when the water level receded. Once the machine was positioned on the west side to process debris, it could not be moved back across the lake to be retrieved except by barge once the lake level was raised again in spring, or by traversing the lake bed and river channel. The conclusions suggested strongly that processing debris would be more feasible on the Hozemeen Landing area on the east side of the lake, as it is accessible via road from the Canadian side of the border.

Investigation of the feasibility of biomass energy generation to supply the Park Service buildings at Hozemeen landing revealed that the volume of debris that could be consumed by a biomass electricity generation system was a small fraction of the available debris, leaving the major portion of the debris to be managed by other means. In addition, the available biogas generator and engine/electric generator systems were much larger than the anticipated demand for the facilities at Hozemeen. Hence, if the biogas alternative were selected, it would be necessary to either increase the average electricity demand to consume the power produced by the smallest of the available systems by a large amount, or add a load bank system for expending the excess energy produced. If future biogas generator systems are developed in a smaller size range, this method should be examined further.

The recent availability and success of clean-burning air-curtain contained burn bins in use in other areas of the U.S. to dispose of wood waste revealed that the average annual volume of debris expected could be disposed of within a relatively short time by small crews consisting of existing SCL staff without need to contract any of the work. Additionally, the Hozemeen landing area provides sufficient space and accessibility to make such a burning operation feasible. The cost of these units is relatively low and their record of success elsewhere suggest that contained burning is feasible at Ross Lake. In addition, the emissions from these systems are quite low, and the overall CO_2 footprint of burning is quite small compared to other means requiring high horsepower chipping and grinding equipment burning diesel fuel.

The final scores for each alternative for short term disposal of the large volume of accumulated debris are illustrated in Table 6.1 below. The final scores for each alternative for long-term disposal of additional annual accumulations of debris are illustrated in Table 6.2 below.

Table 6.1 – Short Term Debris Disposal Alternatives

Alternative Number and Description	Final Weighted Score
1 - First Nations (Canada) assume responsibility for disposal of all debris	N/A (1)
2 - Collect and open burn debris at upper end of lake on west side bag site, haul ash down lake to boat access ramp at dam.	***52***
3 - Collect and open burn debris at upper end of lake on east side Hozemeen landing area, haul ash down lake to boat access ramp at dam.	***47***
4A - Collect and sort debris at upper end of lake. Marketable logs to be moved across to east side Hozemeen landing area and sold and hauled away to Canadian customers. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	***49.5***
4B - Collect and sort debris at upper end of lake. Marketable logs to be retained by Project staff for replacement boom logs. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	***52***
5A - Collect and sort debris at upper end of lake and move all of it across lake to Hozemeen landing area. Marketable logs to be sold and hauled away to Canadian customers. All remaining debris to be burned in burn bins, haul ash down the lake to boat access ramp at dam.	***51***
5B - Collect and sort debris at upper end of lake and move all of it across lake to Hozemeen landing area. Marketable logs to be retained by Project staff for replacement boom logs. All remaining debris to be burned in burn bins, haul ash down the lake to boat access ramp at dam.	***51***
6A - Collect and sort debris at upper end of lake. Marketable logs towed in booms down the lake to boat access ramp at dam, loaded into trucks and hauled to Diablo then down to highway via Diablo boat ramp. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	***56***
6B - Collect and sort debris at upper end of lake. Marketable logs towed in booms down the lake to skyline and lifted to Hwy 20. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	***58***

7A - Collect and sort debris at upper end of lake. Marketable logs boomed, root wads loaded onto barge, and all towed down lake to boat access ramp at dam, loaded into trucks and hauled to Diablo then down to highway via Diablo boat ramp. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	***56***
7B - Collect and sort debris at upper end of lake. Marketable logs boomed, root wads loaded onto barge, and all towed down lake to skyline and lifted to Hwy 20. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	***59***
7C - Collect and sort debris at upper end of lake. Marketable logs to be used by Project for replacement boom logs, root wads loaded onto barge and towed down lake to skyline and lifted to Hwy 20. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	***59***
8A - Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs boomed, root wads loaded on barge, and all towed down lake to skyline and lifted to Hwy 20. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.	***63***
8B - Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs used by Project for replacement boom logs, root wads loaded on barge and towed down lake to skyline and lifted to Hwy 20. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.	***63***
9 - Collect and drag all debris to skyline site in boom with workboat. Sort into marketable logs and haul only these to highway via skyline, burn rest in burn boxes on barge or on shore in Ruby Arm.	***65***
10A - Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs boomed, root wads loaded on barge, and all towed down lake to skyline and lifted to Hwy 20. Chip and convert usable debris into biomass electrical generation fuel for on site use at NPS facilities. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.	***65***
10B - Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs used by Project for replacement boom logs, root wads loaded on barge and towed down lake to skyline and lifted to Hwy 20. Chip and convert usable debris into biomass electrical generation fuel for on site use at NPS facilities. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.	***51***
11A - Collect and move all stored debris all at once or in phases to Hozemeen landing. Chip usable debris into landscaping chips and loaded in bins. Marketable logs boomed, root wads and chip bins loaded on barge, and all towed down lake to skyline and	***51***

lifted to Hwy 20. All remaining unusable debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.	
11B - Collect and move all stored debris all at once or in phases to Hozemeen landing. Chip usable debris into landscaping chips and loaded in bins. Marketable logs used by Project for replacement boom logs, root wads and chip bins loaded on barge and towed down lake to skyline and lifted to Hwy 20. All remaining unusable debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.	***54***
12A - Collect and move all stored debris all at once or in phases to Hozemeen landing. Grind and chip all debris into landscaping mulch and hog fuel and load in bins. Marketable logs (sawlogs AND pulp) boomed, root wads and mulch/chip bins loaded on barge, and all towed down lake to skyline and lifted to Hwy 20.	***54***
12B - Collect and move all stored debris all at once or in phases to Hozemeen landing. Grind and chip all debris into landscaping mulch and hog fuel and load in bins. Marketable logs used by Project for replacement boom logs. Pulp logs would be boomed, root wads and mulch/chip bins loaded on barge, and all towed down lake to skyline and lifted to Hwy 20.	***57***
13A - Collect and sort all stored debris into logs, root wads, and other debris. Marketable logs (sawlogs AND pulp) boomed, root wads and all debris loaded into bins on barge, and all towed down lake to skyline and lifted to Hwy 20. Transport all material to Agg Ponds via truck. Root wads placed in river at Agg Pond. All remaining debris to be processed at Agg ponds into landscaping chips, mulch, and hog fuel, and used for landscaping, erosion control, and weed suppression projects.	***57***
13B - Collect and sort all stored debris into logs, root wads, and other debris. Marketable logs used by Project for replacement boom logs. Pulp logs boomed, root wads and all debris loaded into bins on barge, and all towed down lake to skyline and lifted to Hwy 20. Transport all material to Agg Ponds via truck. Root wads placed in river at Agg Pond. All remaining debris to be processed at Agg ponds into landscaping chips, mulch, and hog fuel, and used for landscaping, erosion control, and weed suppression projects.	***52***

*(1) – Alternative was eliminated as infeasible

Table 6.2 – Long Term Debris Disposal Alternatives

Alternative Number and Description	Final Weighted Score
1 - First Nations (Canada) assume responsibility for disposal of all debris	N/A (1)
2 - Collect and open burn debris at upper end of lake on west side bag site, haul ash down lake to boat access ramp at dam.	***51***
3 - Collect and open burn debris at upper end of lake on east side Hozemeen landing area, haul ash down lake to boat access ramp at dam.	***46***
4A - Collect and sort debris at upper end of lake. Marketable logs to be moved across to east side Hozemeen landing area and sold and hauled away to Canadian customers. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	***48.5***
4B - Collect and sort debris at upper end of lake. Marketable logs to be retained by Project staff for replacement boom logs. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	***51***
5A - Collect and sort debris at upper end of lake and move all of it across lake to Hozemeen landing area. Marketable logs to be sold and hauled away to Canadian customers. All remaining debris to be burned in burn bins, haul ash down the lake to boat access ramp at dam.	***47***
5B - Collect and sort debris at upper end of lake and move all of it across lake to Hozemeen landing area. Marketable logs to be retained by Project staff for replacement boom logs. All remaining debris to be burned in burn bins, haul ash down the lake to boat access ramp at dam.	***47***
6A - Collect and sort debris at upper end of lake. Marketable logs towed in booms down the lake to boat access ramp at dam, loaded into trucks and hauled to Diablo then down to highway via Diablo boat ramp. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	***55***
6B - Collect and sort debris at upper end of lake. Marketable logs towed in booms down the lake to skyline and lifted to Hwy 20. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	***58***

7A - Collect and sort debris at upper end of lake. Marketable logs boomed, root wads loaded onto barge, and all towed down lake to boat access ramp at dam, loaded into trucks and hauled to Diablo then down to highway via Diablo boat ramp. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	***55***
7B - Collect and sort debris at upper end of lake. Marketable logs boomed, root wads loaded onto barge, and all towed down lake to skyline and lifted to Hwy 20. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	***58***
7C - Collect and sort debris at upper end of lake. Marketable logs to be used by Project for replacement boom logs, root wads loaded onto barge and towed down lake to skyline and lifted to Hwy 20. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	***59***
8A - Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs boomed, root wads loaded on barge, and all towed down lake to skyline and lifted to Hwy 20. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.	***62***
8B - Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs used by Project for replacement boom logs, root wads loaded on barge and towed down lake to skyline and lifted to Hwy 20. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.	***62***
9 - Collect and drag all debris to skyline site in boom with workboat. Sort into marketable logs and haul only these to highway via skyline, burn rest in burn boxes on barge or on shore in Ruby Arm.	***65***
10A - Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs boomed, root wads loaded on barge, and all towed down lake to skyline and lifted to Hwy 20. Chip and convert usable debris into biomass electrical generation fuel for on site use at NPS facilities. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.	***65***
10B - Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs used by Project for replacement boom logs, root wads loaded on barge and towed down lake to skyline and lifted to Hwy 20. Chip and convert usable debris into biomass electrical generation fuel for on site use at NPS facilities. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.	***53***
11A - Collect and move all stored debris all at once or in phases to Hozemeen landing. Chip usable debris into landscaping chips and loaded in bins. Marketable logs boomed, root wads and chip bins loaded on barge, and all towed down lake to skyline and	***53***

lifted to Hwy 20. All remaining unusable debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.	
11B - Collect and move all stored debris all at once or in phases to Hozemeen landing. Chip usable debris into landscaping chips and loaded in bins. Marketable logs used by Project for replacement boom logs, root wads and chip bins loaded on barge and towed down lake to skyline and lifted to Hwy 20. All remaining unusable debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.	***53***
12A - Collect and move all stored debris all at once or in phases to Hozemeen landing. Grind and chip all debris into landscaping mulch and hog fuel and load in bins. Marketable logs (sawlogs AND pulp) boomed, root wads and mulch/chip bins loaded on barge, and all towed down lake to skyline and lifted to Hwy 20.	***53***
12B - Collect and move all stored debris all at once or in phases to Hozemeen landing. Grind and chip all debris into landscaping mulch and hog fuel and load in bins. Marketable logs used by Project for replacement boom logs. Pulp logs would be boomed, root wads and mulch/chip bins loaded on barge, and all towed down lake to skyline and lifted to Hwy 20.	***57***
13A - Collect and sort all stored debris into logs, root wads, and other debris. Marketable logs (sawlogs AND pulp) boomed, root wads and all debris loaded into bins on barge, and all towed down lake to skyline and lifted to Hwy 20. Transport all material to Agg Ponds via truck. Root wads placed in river at Agg Pond. All remaining debris to be processed at Agg ponds into landscaping chips, mulch, and hog fuel, and used for landscaping, erosion control, and weed suppression projects.	***57***
13B - Collect and sort all stored debris into logs, root wads, and other debris. Marketable logs used by Project for replacement boom logs. Pulp logs boomed, root wads and all debris loaded into bins on barge, and all towed down lake to skyline and lifted to Hwy 20. Transport all material to Agg Ponds via truck. Root wads placed in river at Agg Pond. All remaining debris to be processed at Agg ponds into landscaping chips, mulch, and hog fuel, and used for landscaping, erosion control, and weed suppression projects.	***51***

7 Recommendations

Consideration of permitting issues associated with any permanent alterations of the landscape surrounding the lake shoreline such as the high lead lifting of debris to Highway 20 appeared to make all high lead alternatives less feasible than other alternatives. Additionally, the low market value of wood products that could be produced from the accumulated debris make it less feasible to achieve break-even economic value to any alternative that includes marketing added value products. SCL crews indicted during the workshop that existing operations typically can accommodate the collection and transport of a limited annual volume of high environmental value root wads via barge or towed boom to the dam, where the debris could be loaded into dump trucks and transferred to the Diablo reservoir landing area below Ross Dam for eventual use in seeding the river below Newhalem with woody debris. However, the volume of material that can be feasibly transported and moved by this method using SCL crews and equipment is limited.

Based on the results of the evaluation workshop and matrix rankings, the preferred alternative ***for short –term disposal*** of the large volume of accumulated debris would include alternatives, as follows:

- For the initial disposal effort to remove the significant volume of accumulated debris, open burning with ***Alternative 3*** at the west side bag site appears to be the most favorable alternative.
- Very nearly as favorable for removing the large accumulated volume is ***Alternative 4A***, in which marketable logs are sold to Canadian customers, and all remaining debris is open burned at the west side bag site
- Following at a close 3rd in score is ***Alternative 5***, where all debris is moved to the east side Hozemeen landing area and processed for log sales (or retained by SCL for boom logs) and remaining debris is burned in air-curtain burn bins.
- For all debris processing at the head of the lake, it is likely to be more cost effective to rent excavators, burn bins, chippers, grinders, and other equipment not already owned by SCL in Canada and mobilized via the existing road system to the Hozemeen landing area and either moved across the lake to the west side bag site or used entirely at Hozemeen. Note that the existing bridge condition on the road to Hozemeen may limit the size of machines that could be mobilized.

Similarly, the preferred alternative ***for long–term disposal*** of the lesser volume of annual debris accumulation would include alternatives, as follows:

- For the annual disposal effort to dispose of the lesser volume of annual accumulated debris, open burning with ***Alternative 3*** at the west side bag site appears to be the most favorable alternative.
- Very nearly as favorable for removing the lesser annual accumulated volume is ***Alternative 4A***, in which marketable logs are sold to Canadian customers, and all remaining debris is open burned at the west side bag site

- And again, following at a close 3rd in score is ***Alternative 5***, where all debris is moved to the east side Hozemeen landing area and processed for log sales (or retained by SCL for boom logs) and remaining debris is burned in air-curtain burn bins.

Appendix A. Evaluation Workshop Matrices

Table A-1. Short Term Debris Disposal Alternatives Evaluation

	Alternatives for Short Term Immediate Solutions for Stored Debris												
		Dam Safety	General Safety & Worker Safety	Cost (including additional Skagit Project Equipment that would need to be purchased + Additional Skagit Project Staffing Req'd to Accomplish) - Revenue (if applicable)			Environmental Sustainability	Environmental and Recreational Impacts	Horizon Timing/Schedule (i.e. how many weeks, months, or years will it take to accomplish? Include planning timing, engineering, permitting, application, etc.)			Reservoir Elevation Limitations?	
									Environmental Permits?	Time To Accomplish Permitting	Time To Accomplish Tasks on Site		
-	Weighting of Factors (1=highest importance, 5=lowest)	1	2	2			3	3	4	5	3	2	
	Scoring	(1=no risk, 2=moderate risk, 3=high risk)	(1=not >existing, 2=moderately increased risk, 3=high risk)	(1=$ none to low, 2=$$ moderate, 3=$$$ high, 4=$$$$ very high)	Addtl Labor (man hours/yr)	Actual Cost above existing (first-time)	(1=high, 2=moderate, 3=low)	(1=minor, 2=moderate impacts, 3=severe impacts or public objection)	(1=none, 2=<3months approval, 3=>3months approval)	(1=4 months, 2=9 months, 3=1 year or more)	(1=2 weeks, 2=4 weeks, 3=8 weeks, 4=several months)	(1=none, 2=few restrictions, 3=considerable restricted)	
	Notes			Relative Capital Cost	(3 FTE's is SCL current baseline)	(Assume $152/hr labor rate)	(carbon sequestration, aquatic habitat function, etc.)	(such as sightlines or aesthetics)		(labor costs, FTE's)	(labor costs, FTE's)	(i.e. does reservoir level limit availability of debris to floating plant equipment)	***SCORE (lowest=preferred)***
	Description of Alternative												-
2	Collect and open burn debris at upper end of lake on west side bag site, haul ash down lake to boat access ramp at dam.	1	2	1.5	496	$76,000	3	2	3	2	1	2	***52***
3	Collect and open burn debris at upper end of lake on east side Hozemeen landing area, haul ash down lake to boat access ramp at dam.	1	2	1.5	496	$76,000	3	1	3	2	1	1	***47***
4A	Collect and sort debris at upper end of lake. Marketable logs to be moved across to east side Hozemeen landing area and sold and hauled away to Canadian customers. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	1	2	1.5	544	$72,200	2.5	2	3	2	1	1.5	***49.5***
4B	Collect and sort debris at upper end of lake. Marketable logs to be retained by Project staff for replacement boom logs. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	1	2	1.5	496	$76,000	3	2	3	2	1	2	***52***

5A	**Collect and sort debris at upper end of lake and move all of it across lake to Hozemeen landing area. Marketable logs to be sold and hauled away to Canadian customers. All remaining debris to be burned in burn bins, haul ash down the lake to boat access ramp at dam.**	**1**	**2**	**4**	**1960**	**$317,200**	**3**	**1**	**2**	**2**	**2**	**1**	***51***
5B	**Collect and sort debris at upper end of lake and move all of it across lake to Hozemeen landing area. Marketable logs to be retained by Project staff for replacement boom logs. All remaining debris to be burned in burn bins, haul ash down the lake to boat access ramp at dam.**	**1**	**2**	**4**	**1936**	**$325,000**	**3**	**1**	**2**	**2**	**2**	**1**	***51***
6A	**Collect and sort debris at upper end of lake. Marketable logs towed in booms down the lake to boat access ramp at dam, loaded into trucks and hauled to Diablo then down to highway via Diablo boat ramp. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.**	**2**	**2**	**1.5**	**544**	**$72,200**	**2**	**2**	**3**	**2**	**3**	**2**	***56***
6B	**Collect and sort debris at upper end of lake. Marketable logs towed in booms down the lake to skyline and lifted to Hwy 20. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**2**	**544**	**$122,200**	**2**	**2**	**3**	**2**	**3**	**2**	***58***
7A	**Collect and sort debris at upper end of lake. Marketable logs boomed, root wads loaded onto barge, and all towed down lake to boat access ramp at dam, loaded into trucks and hauled to Diablo then down to highway via Diablo boat ramp. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.**	**2**	**2**	**1.5**	**496**	**$65,200**	**2**	**2**	**3**	**2**	**3**	**2**	***56***
7B	**Collect and sort debris at upper end of lake. Marketable logs boomed, root wads loaded onto barge, and all towed down lake to skyline and lifted to Hwy 20. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**2.5**	**616**	**$158,200**	**2**	**2**	**3**	**2**	**3**	**2**	***59***
7C	**Collect and sort debris at upper end of lake. Marketable logs to be used by Project for replacement boom logs, root wads loaded onto barge and towed down lake to skyline and lifted to Hwy 20. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**2.5**	**616**	**$169,000**	**2**	**2**	**3**	**2**	**3**	**2**	***59***
8A	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs boomed, root wads loaded on barge, and all towed down lake to skyline and lifted to Hwy 20. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**4.5**	**2056**	**$407,200**	**2**	**2**	**3**	**2**	**3**	**2**	***63***

8B	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs used by Project for replacement boom logs, root wads loaded on barge and towed down lake to skyline and lifted to Hwy 20. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**4.5**	**2056**	**$418,000**	**2**	**2**	**3**	**2**	**3**	**2**	***63***
10A	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs boomed, root wads loaded on barge, and all towed down lake to skyline and lifted to Hwy 20. Chip and convert usable debris into biomass electrical generation fuel for on site use at NPS facilities. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**4**	**1696**	**$367,200**	**2**	**3**	**3**	**2**	**3**	**2**	***65***
10B	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs used by Project for replacement boom logs, root wads loaded on barge and towed down lake to skyline and lifted to Hwy 20. Chip and convert usable debris into biomass electrical generation fuel for on site use at NPS facilities. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**4**	**1696**	**$378,000**	**2**	**3**	**3**	**2**	**3**	**2**	***65***
11A	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Chip usable debris into landscaping chips and loaded in bins. Marketable logs boomed, root wads and chip bins loaded on barge, and all towed down lake to skyline and lifted to Hwy 20. All remaining unusable debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**2**	**736**	**$144,400**	**1**	**2**	**2**	**2**	**3**	**2**	***51***
11B	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Chip usable debris into landscaping chips and loaded in bins. Marketable logs used by Project for replacement boom logs, root wads and chip bins loaded on barge and towed down lake to skyline and lifted to Hwy 20. All remaining unusable debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**2**	**736**	**$155,200**	**1**	**2**	**2**	**2**	**3**	**2**	***51***
12A	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Grind and chip all debris into landscaping mulch and hog fuel and load in bins. Marketable logs (sawlogs AND pulp) boomed, root wads and mulch/chip bins loaded on barge, and all towed down lake to skyline and lifted to Hwy 20.**	**1**	**3**	**3.5**	**1200**	**$230,400**	**1**	**2**	**2**	**2**	**3**	**2**	***54***

12B	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Grind and chip all debris into landscaping mulch and hog fuel and load in bins. Marketable logs used by Project for replacement boom logs. Pulp logs would be boomed, root wads and mulch/chip bins loaded on barge, and all towed down lake to skyline and lifted to Hwy 20.**	**1**	**3**	**3.5**	**1200**	**$241,200**	**1**	**2**	**2**	**2**	**3**	**2**	***54***
13A	**Collect and sort all stored debris into logs, root wads, and other debris. Marketable logs (sawlogs AND pulp) boomed, root wads and all debris loaded into bins on barge, and all towed down lake to skyline and lifted to Hwy 20. Transport all material to Agg Ponds via truck. Root wads placed in river at Agg Pond. All remaining debris to be processed at Agg ponds into landscaping chips, mulch, and hog fuel, and used for landscaping, erosion control, and weed suppression projects.**	**2**	**3**	**3**	**1080**	**$176,700**	**1**	**3**	**2**	**2**	**3**	**2**	***57***
13B	**Collect and sort all stored debris into logs, root wads, and other debris. Marketable logs used by Project for replacement boom logs. Pulp logs boomed, root wads and all debris loaded into bins on barge, and all towed down lake to skyline and lifted to Hwy 20. Transport all material to Agg Ponds via truck. Root wads placed in river at Agg Pond. All remaining debris to be processed at Agg ponds into landscaping chips, mulch, and hog fuel, and used for landscaping, erosion control, and weed suppression projects.**	**2**	**3**	**3**	**1080**	**$187,500**	**1**	**3**	**2**	**2**	**3**	**2**	***57***
	Scoring overall is calculated by multiplying the individual category score by the weight of that category												

Notes associated with each alternative provided in Table A-2 below.

Table A-2. Notes for Short Term Debris Disposal Alternatives

Alternative Number	Notes
2	Assume about 4 weeks to burn stored debris in big piles with brush fans by 3 project staff, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. The machine would possibly have to remain on the west side of the lake for months at a time. Project staff have suggested that they would likely have to rent a machine in Canada and park it on the west side for 6 months out of the year.
3	Assume about 4 weeks to burn stored debris in fewer smaller piles with brush fans by 3 project staff, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be rented and trucked in from Canada. The debris collection and moving it across the lake to Hozemeen can only practically occur during high lake level, but processing and burning can be done at any time by pulling it out of the water and stacking it to dry on the Hozemeen landing. Project staff suggest that the best way to execute this alternative is to tackle the stored volume of debris over several successive seasons, sinc there is more debris than can be readily stored in the dry at Hozemeen.
4A	Assume about 4 weeks to burn stored debris in big piles with brush fans by 3 project staff, and 2 days to move logs to Hozemeen and load on trucks, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. The machine would possibly have to remain on the west side of the lake for months at a time. Project staff have suggested that they would likely have to rent a machine in Canada and park it on the west side for 6 months out of the year. Similarly, a rental machine out of Canada would be required to lift logs out of the lake at Hozemeen and stack them for sale to Canadian customers.
4B	Assume about 4 weeks to burn stored debris in big piles with brush fans by 3 project staff, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. The machine would possibly have to remain on the west side of the lake for months at a time. Project staff have suggested that they would likely have to rent a machine in Canada and park it on the west side for 6 months out of the year.
5A	Assume about 16 weeks to burn debris in 3 burn bins (at 15 cy per hour per bin) by 3 project staff, and 1 day to help load logs on trucks; burn bin rental $2500/month each x 3, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Processing would be more efficient if logs could be bunked in cribs or in steel bunks at Hozemeen, as space there is somewhat limited. This alternative would also require a small barge to move ash bins down to the dam for removal at boat launch.

5B	Assume about 16 weeks to burn debris in 3 burn bins (at 15 cy per hour per bin) by 3 project staff; burn bin rental $2500/month each x 3, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Processing would be more efficient if logs could be bunked in cribs or in steel bunks at Hozemeen, as space there is somewhat limited. This alternative would also require a small barge to move ash bins down to the dam for removal at boat launch.
6A	Assume about 4 weeks to burn stored debris in big piles with brush fans by 3 project staff, and 2 days to boom and tow logs to Ross Dam and load on trucks, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. The machine would possibly have to remain on the west side of the lake for months at a time. Project staff have suggested that they would likely have to rent a machine in Canada and park it on the west side for 6 months out of the year. A log loader or the project's excavator would be needed at the boat launch at Ross Dam to lift logs out and load into dump trucks to be hauled down to the Diablo launch to be offloaded onto the Diable barge and then again to offload from the barge onto trucks for final haul at the Diablo dam boat launch. Lots of handling for not very many loads of logs.
6B	Assume about 4 weeks to burn stored debris in big piles with brush fans by 3 project staff, and 2 days to boom and tow logs to Ruby Arm and lift to Hwy 20 with skyline, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Assume skyline crew for one week @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. The machine would possibly have to remain on the west side of the lake for months at a time. Project staff have suggested that they would likely have to rent a machine in Canada and park it on the west side for 6 months out of the year. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
7A	Assume about 3 weeks to burn remaining stored debris in big piles with brush fans by 3 project staff, and 5 days to boom and tow logs and root wads to Ross Dam and load on trucks, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. The machine would possibly have to remain on the west side of the lake for months at a time. Project staff have suggested that they would likely have to rent a machine in Canada and park it on the west side for 6 months out of the year. A barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. A log loader or the project's excavator would be needed at the boat launch at Ross Dam to lift logs and root wads out and load into dump trucks to be hauled down to the Diablo launch to be offloaded onto the Diable barge and then again to offload from the barge onto trucks for final haul at the Diablo dam boat launch. Lots of handling for not very many loads of logs and root wads.
7B	Assume about 3 weeks to burn stored debris in big piles with brush fans by 3 project staff, and 10 days to boom and tow logs and root wads on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. The machine would possibly have to remain on the west side of the lake for months at a time. Project staff have suggested that they would likely have to rent a machine in Canada and park it on the west side for 6 months out of the year. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
7C	Assume about 3 weeks to burn stored debris in big piles with brush fans by 3 project staff, and 10 days to boom and tow root wads on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. The machine would possibly have to remain on the west side of the lake for months at a time. Project staff have suggested that they would likely have to rent a machine in Canada and park it on the west side for 6 months out of the year. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Lifting root wads off the barge at Ruby Arm and up the skyline would be slow and somewhat dangerous work, as the Project crew would be working on the barge, but not as risky as choking up loose logs directly from the water. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
8A	Assume about 15 weeks to burn stored debris in burn bins (at 15 cy per hour per bin) by 3 project staff, and 10 days to boom and tow root wads on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Lifting root wads off barge at Ruby Arm would be less risky. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
8B	Assume about 15 weeks to burn stored debris in burn bins (at 15 cy per hour per bin) by 3 project staff, and 10 days to boom and tow root wads on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Lifting root wads off barge at Ruby Arm would be less risky than picking logs out of the water as in Alt 8A. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
10A	Assume about 12 weeks to process, chip, and burn stored debris in burn bins by 3 project staff, and 10 days to boom and tow logs and root wads on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Chipper rental $7500/month, burn bins $2500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Portable chipper unit would have to be rented in Canada and stationed at Hozemeen to process useable debris into fuel chips for biomass generation. Probably would require construction of fuel bumker near NPS buildings. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Lifting root wads off barge at Ruby Arm would be less risky. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
10B	Assume about 12 weeks to process. chip, and burn stored debris in burn bins by 3 project staff, and 10 days to boom and tow root wads on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Chipper rental $7500/month, burn bins $2500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Portable chipper unit would have to be rented in Canada and stationed at Hozemeen to process useable debris into fuel chips for biomass generation. Probably would require

	construction of fuel bumker near NPS buildings. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Lifting root wads off barge at Ruby Arm would be less risky than picking logs out of the water as in Alt 10A. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
11A	Assume about 4 weeks to process, chip, and burn in 3 burn bins (at 15 cy per hour per bin) by 3 project staff, and 10 days to boom and tow logs, root wads and bins on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Chipper rental $7500/month, burn bins $2500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Portable chipper unit would have to be rented in Canada and stationed at Hozemeen to process useable debris into landscaping chips. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Lifting root wads and chip bins off barge at Ruby Arm would be less risky. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
11B	Assume about 4 weeks to process, chip, and burn in 3 burn bins (at 15 cy per hour per bin) by 3 project staff, and 10 days to boom and tow logs, root wads and bins on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Chipper rental $7500/month, burn bins $2500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Portable chipper unit would have to be rented in Canada and stationed at Hozemeen to process useable debris into landscaping chips. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Lifting root wads and chip bins off barge at Ruby Arm would be less risky than picking logs out of the water as in Alt 11A. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
12A	Assume about 8 weeks to process, grind, chip, and load into bins by 3 project staff, and 10 days to boom and tow logs, root wads and bins on barge to Ruby Arm and lift with skyline up to Hwy 20. Chipper and grinder rental $7500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing can continue until stockpile at Hozemeen is gone. Portable chipper and grinding units would have to be rented in Canada and stationed at Hozemeen to process useable debris into landscaping chips and mulch, as they are NOT the same machines. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Lifting root wads and chip/mulch bins off barge at Ruby Arm would be less risky. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
12B	Assume about 8 weeks to process, grind, chip, and load into bins by 3 project staff, and 10 days to boom and tow logs, root wads and bins on barge to Ruby Arm and lift with skyline up to Hwy 20. Chipper and grinder rental $7500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing can continue until stockpile at Hozemeen is gone. Portable chipper and grinding units would have to be rented in Canada and stationed at Hozemeen to process useable debris into landscaping chips and mulch, as they are NOT the same machines. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the pulp logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Lifting root wads and chip/mulch bins off barge at Ruby Arm would be less risky. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
13A	Assume about 6 weeks to process and load into bins by 3 project staff, and 15 days to boom and tow logs, root wads and bins on barge to Ruby Arm and lift with skyline up to Hwy 20. Chipper and grinder rental $7500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing can continue until stockpile at Hozemeen is gone. Separate portable chipper and grinding units would be stationed at Agg ponds to process useable debris into landscaping chips and mulch, as they are NOT the same machines. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads and bins of debris onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Lifting root wads and debris bins off barge at Ruby Arm would be less risky. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
13B	Assume about 6 weeks to process and load into bins by 3 project staff, and 15 days to boom and tow logs, root wads and bins on barge to Ruby Arm and lift with skyline up to Hwy 20. Chipper and grinder rental $7500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing can continue until stockpile at Hozemeen is gone. Separate portable chipper and grinding units would be stationed at Agg ponds to process useable debris into landscaping chips and mulch, as they are NOT the same machines. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads and bins of debris onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Lifting root wads and debris bins off barge at Ruby Arm would be less risky. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.

Table A-3. Long Term Debris Disposal Alternatives Evaluation

	Alternatives for Long Term Solutions for Stored Debris												
		Dam Safety	General Safety & Worker Safety	Cost (including additional Skagit Project Equipment that would need to be purchased + Additional Skagit Project Staffing Req'd to Accomplish) - Revenue (if applicable)			Environmental Sustainability	Environmental and Recreational Impacts	Horizon Timing/Schedule (i.e. how many weeks, months, or years will it take to accomplish? Include planning timing, engineering, permitting, application, etc.)			Reservoir Elevation Limitations?	
									Environmental Permits?	Time To Accomplish Permitting	Time To Accomplish Tasks on Site		
-	Weighting of Factors (1=highest importance, 5=lowest)	1	2	2			3	3	4	5	3	2	
	Scoring	(1=no risk, 2=moderate risk, 3=high risk)	(1=not >existing, 2=moderately increased risk, 3=high risk)	(1=$ none to low, 2=$$ moderate, 3=$$$ high, 4=$$$$ very high)	Addtl Labor (man hours/yr)	Actual Cost above existing (first-time)	(1=high, 2=moderate, 3=low)	(1=minor, 2=moderate impacts, 3=severe impacts or public objection)	(1=none, 2=<3months approval, 3=>3months approval)	(1=4 months, 2=9 months, 3=1 year or more)	(1=2 weeks, 2=4 weeks, 3=8 weeks, 4=several months)	(1=none, 2=few restrictions, 3=considerable restricted)	
	Notes			Relative Capital Cost	(3 FTE's is SCL current baseline)	(Assume $152/hr labor rate)	(carbon sequestration, aquatic habitat function, etc.)	(such as sightlines or aesthetics)		(labor costs, FTE's)	(labor costs, FTE's)	(i.e. does reservoir level limit availability of debris to floating plant equipment)	***SCORE (lowest=preferred)***
	Description of Alternative												-
2	Collect and open burn debris at upper end of lake on west side bag site, haul ash down lake to boat access ramp at dam.	1	2	1	88	$14,000	3	2	3	2	1	2	***51***
3	Collect and open burn debris at upper end of lake on east side Hozemeen landing area, haul ash down lake to boat access ramp at dam.	1	2	1	136	$21,000	3	1	3	2	1	1	***46***
4A	Collect and sort debris at upper end of lake. Marketable logs to be moved across to east side Hozemeen landing area and sold and hauled away to Canadian customers. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	1	2	1	136	$10,200	2.5	2	3	2	1	1.5	***48.5***
4B	Collect and sort debris at upper end of lake. Marketable logs to be retained by Project staff for replacement boom logs. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.	1	2	1	112	$18,000	3	2	3	2	1	2	***51***

5A	**Collect and sort debris at upper end of lake and move all of it across lake to Hozemeen landing area. Marketable logs to be sold and hauled away to Canadian customers. All remaining debris to be burned in burn bins, haul ash down the lake to boat access ramp at dam.**	**1**	**2**	**2**	**400**	**$55,825**	**3**	**1**	**2**	**2**	**2**	**1**	***47***
5B	**Collect and sort debris at upper end of lake and move all of it across lake to Hozemeen landing area. Marketable logs to be retained by Project staff for replacement boom logs. All remaining debris to be burned in burn bins, haul ash down the lake to boat access ramp at dam.**	**1**	**2**	**2**	**376**	**$63,625**	**3**	**1**	**2**	**2**	**2**	**1**	***47***
6A	**Collect and sort debris at upper end of lake. Marketable logs towed in booms down the lake to boat access ramp at dam, loaded into trucks and hauled to Diablo then down to highway via Diablo boat ramp. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.**	**2**	**2**	**1**	**160**	**$14,200**	**2**	**2**	**3**	**2**	**3**	**2**	***55***
6B	**Collect and sort debris at upper end of lake. Marketable logs towed in booms down the lake to skyline and lifted to Hwy 20. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**2**	**160**	**$49,200**	**2**	**2**	**3**	**2**	**3**	**2**	***58***
7A	**Collect and sort debris at upper end of lake. Marketable logs boomed, root wads loaded onto barge, and all towed down lake to boat access ramp at dam, loaded into trucks and hauled to Diablo then down to highway via Diablo boat ramp. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.**	**2**	**2**	**1**	**160**	**$14,200**	**2**	**2**	**3**	**2**	**3**	**2**	***55***
7B	**Collect and sort debris at upper end of lake. Marketable logs boomed, root wads loaded onto barge, and all towed down lake to skyline and lifted to Hwy 20. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**2**	**160**	**$59,200**	**2**	**2**	**3**	**2**	**3**	**2**	***58***
7C	**Collect and sort debris at upper end of lake. Marketable logs to be used by Project for replacement boom logs, root wads loaded onto barge and towed down lake to skyline and lifted to Hwy 20. All remaining debris to be open burned at west side bag site, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**2.5**	**160**	**$70,000**	**2**	**2**	**3**	**2**	**3**	**2**	***59***
8A	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs boomed, root wads loaded on barge, and all towed down lake to skyline and lifted to Hwy 20. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**4**	**388**	**$140,388**	**2**	**2**	**3**	**2**	**3**	**2**	***62***

8B	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs used by Project for replacement boom logs, root wads loaded on barge and towed down lake to skyline and lifted to Hwy 20. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**4**	**448**	**$161,188**	**2**	**2**	**3**	**2**	**3**	**2**	***62***
10A	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs boomed, root wads loaded on barge, and all towed down lake to skyline and lifted to Hwy 20. Chip and convert usable debris into biomass electrical generation fuel for on site use at NPS facilities. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**4**	**328**	**$121,700**	**2**	**3**	**3**	**2**	**3**	**2**	***65***
10B	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Marketable logs used by Project for replacement boom logs, root wads loaded on barge and towed down lake to skyline and lifted to Hwy 20. Chip and convert usable debris into biomass electrical generation fuel for on site use at NPS facilities. All remaining debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**4**	**328**	**$132,500**	**2**	**3**	**3**	**2**	**3**	**2**	***65***
11A	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Chip usable debris into landscaping chips and loaded in bins. Marketable logs boomed, root wads and chip bins loaded on barge, and all towed down lake to skyline and lifted to Hwy 20. All remaining unusable debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**3**	**352**	**$78,900**	**1**	**2**	**2**	**2**	**3**	**2**	***53***
11B	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Chip usable debris into landscaping chips and loaded in bins. Marketable logs used by Project for replacement boom logs, root wads and chip bins loaded on barge and towed down lake to skyline and lifted to Hwy 20. All remaining unusable debris to be burned in burn bins at Hozemeen, haul ash down the lake to boat access ramp at dam.**	**1**	**3**	**3**	**352**	**$89,700**	**1**	**2**	**2**	**2**	**3**	**2**	***53***
12A	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Grind and chip all debris into landscaping mulch and hog fuel and load in bins. Marketable logs (sawlogs AND pulp) boomed, root wads and mulch/chip bins loaded on barge, and all towed down lake to skyline and lifted to Hwy 20.**	**1**	**3**	**3**	**384**	**$83,900**	**1**	**2**	**2**	**2**	**3**	**2**	***53***

12B	**Collect and move all stored debris all at once or in phases to Hozemeen landing. Grind and chip all debris into landscaping mulch and hog fuel and load in bins. Marketable logs used by Project for replacement boom logs. Pulp logs would be boomed, root wads and mulch/chip bins loaded on barge, and all towed down lake to skyline and lifted to Hwy 20.**	**1**	**3**	**3**	**384**	**$94,700**	**1**	**2**	**2**	**2**	**3**	**2**	***53***
13A	**Collect and sort all stored debris into logs, root wads, and other debris. Marketable logs (sawlogs AND pulp) boomed, root wads and all debris loaded into bins on barge, and all towed down lake to skyline and lifted to Hwy 20. Transport all material to Agg Ponds via truck. Root wads placed in river at Agg Pond. All remaining debris to be processed at Agg ponds into landscaping chips, mulch, and hog fuel, and used for landscaping, erosion control, and weed suppression projects.**	**2**	**3**	**3**	**552**	**$84,450**	**1**	**3**	**2**	**2**	**3**	**2**	***57***
13B	**Collect and sort all stored debris into logs, root wads, and other debris. Marketable logs used by Project for replacement boom logs. Pulp logs boomed, root wads and all debris loaded into bins on barge, and all towed down lake to skyline and lifted to Hwy 20. Transport all material to Agg Ponds via truck. Root wads placed in river at Agg Pond. All remaining debris to be processed at Agg ponds into landscaping chips, mulch, and hog fuel, and used for landscaping, erosion control, and weed suppression projects.**	**2**	**3**	**3**	**552**	**$95,250**	**1**	**3**	**2**	**2**	**3**	**2**	***57***
	Scoring overall is calculated by multiplying the individual category score by the weight of that category												

Notes associated with each alternative provided in Table A-4 below.

Table A-4. Notes for Long Term Debris Disposal Alternatives

Alternative Number	Notes
2	Assume about 3 days to burn annual debris in big piles with brush fans by 3 project staff, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. Project staff have suggested that they would likely have to rent a machine in Canada for a week or so if they can't haul the project excavator up to the bag site.
3	Assume about 1 week to burn annual debris in fewer smaller piles with brush fans by 3 project staff, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be rented and trucked in from Canada. The debris collection and moving it across the lake to Hozemeen can only practically occur during high lake level, but processing and burning can be done at any time by pulling it out of the water and stacking it to dry on the Hozemeen landing. Project staff suggest that the best way to execute this alternative is to move the permanen bag site to the Hozemeen side of the lake, once the large volume of existing stored debris is eliminated.
4A	Assume about 4 days to burn stored debris in big piles with brush fans by 3 project staff, and 1 day to move logs to Hozemeen and load on trucks, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. The machine would possibly have to remain on the west side of the lake for months at a time. Project staff have suggested that they would likely have to rent a machine in Canada and park it on the west side for 6 months out of the year. Similarly, a rental machine out of Canada would be required to lift logs out of the lake at Hozemeen and stack them for sale to Canadian customers.
4B	Assume about 4 days to burn stored debris in big piles with brush fans by 3 project staff, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. The machine would possibly have to remain on the west side of the lake for months at a time. Project staff have suggested that they would likely have to rent a machine in Canada and park it on the west side for 6 months out of the year.
5A	Assume about 3 weeks to burn debris in 3 burn bins (at 15 cy per hour per bin) by 3 project staff, and 1 day to help load logs on trucks; burn bin rental $2500/month each x 3, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but

	processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Processing would be more efficient if logs could be bunked in cribs or in steel bunks at Hozemeen, as space there is somewhat limited. This alternative would also require a small barge to move ash bins down to the dam for removal at boat launch.
5B	Assume about 3 weeks to burn debris in 3 burn bins (at 15 cy per hour per bin) by 3 project staff; burn bin rental $2500/month each x 3, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Processing would be more efficient if logs could be bunked in cribs or in steel bunks at Hozemeen, as space there is somewhat limited. This alternative would also require a small barge to move ash bins down to the dam for removal at boat launch.
6A	Assume about 4 days to burn stored debris in big piles with brush fans by 3 project staff, and 2 days to boom and tow logs to Ross Dam and load on trucks, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. The machine would possibly have to remain on the west side of the lake for months at a time. Project staff have suggested that they would likely have to rent a machine in Canada and park it on the west side for 6 months out of the year. A log loader or the project's excavator would be needed at the boat launch at Ross Dam to lift logs out and load into dump trucks to be hauled down to the Diablo launch to be offloaded onto the Diable barge and then again to offload from the barge onto trucks for final haul at the Diablo dam boat launch. Lots of handling for not very many loads of logs.
6B	Assume about 4 days to burn stored debris in big piles with brush fans by 3 project staff, and 2 days to boom and tow logs to Ruby Arm and lift to Hwy 20 with skyline, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Assume skyline crew for one week @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. The machine would possibly have to remain on the west side of the lake for months at a time. Project staff have suggested that they would likely have to rent a machine in Canada and park it on the west side for 6 months out of the year. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
7A	Assume about 4 days to burn stored debris in big piles with brush fans by 3 project staff, and 2 days to boom and tow logs and root wads to Ross Dam and load on trucks, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. The machine would possibly have to remain on the west side of the lake for months at a time. Project staff have suggested that they would likely have to rent a machine in Canada and park it on the west side for 6 months out of the year. A barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. A log loader or the project's excavator would be needed at the boat launch at Ross Dam to lift logs and root wads out and load into dump trucks to be hauled down to the Diablo launch to be offloaded onto the Diable barge and then again to offload from the barge onto trucks for final haul at the Diablo dam boat launch. Lots of handling for not very many loads of logs and root wads.
7B	Assume about 4 days to burn stored debris in big piles with brush fans by 3 project staff, and 2 days to boom and tow logs and root wads on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. The machine would possibly have to remain on the west side of the lake for months at a time. Project staff have suggested that they would likely have to rent a machine in Canada and park it on the west side for 6 months out of the year. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
7C	Assume about 4 days to burn stored debris in big piles with brush fans by 3 project staff, and 2 days to boom and tow root wads on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be barged across the lake or walked across at low lake level. The debris collection can only practically occur during high lake level, but processing and burning can practially only occur after lake level has dropped and debris has dried out. The machine would possibly have to remain on the west side of the lake for months at a time. Project staff have suggested that they would likely have to rent a machine in Canada and park it on the west side for 6 months out of the year. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Lifting root wads off the barge at Ruby Arm and up the skyline would be slow and somewhat dangerous work, as the Project crew would be working on the barge, but not as risky as choking up loose logs directly from the water. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
8A	Assume about 2.5 weeks to burn remaining stored debris in 3 burn bins (at 15 cy per hour per bin) by 3 project staff, and 3 days to boom and tow root wads on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Lifting root wads off barge at Ruby Arm would be less risky. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
8B	Assume about 2.5 weeks to burn remaining stored debris in burn bins (at 15 cy per hour per bin) by 3 project staff, and 3 days to boom and tow root wads on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Lifting root wads off barge at Ruby Arm would be less risky than picking logs out of the water as in Alt 8A. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
10A	Assume about 2 weeks to process, chip, and burn stored debris in burn bins (at 15 cy per hour per bin) by 3 project staff, and 3 days to boom and tow logs and root wads on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Chipper rental $7500/month, burn bins $2500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Portable chipper unit would have to be rented in Canada and stationed at Hozemeen to process useable debris into fuel chips for biomass generation. Probably would require construction of fuel bumker near NPS buildings. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Lifting root wads off barge at Ruby Arm would be less risky. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
10B	Assume about 2 weeks to process. chip, and burn stored debris in burn bins (at 15 cy per hour per bin) by 3 project staff, and 3 days to boom and tow root wads on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Chipper rental $7500/month, burn bins $2500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and

	stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Portable chipper unit would have to be rented in Canada and stationed at Hozemeen to process useable debris into fuel chips for biomass generation. Probably would require construction of fuel bumker near NPS buildings. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Lifting root wads off barge at Ruby Arm would be less risky than picking logs out of the water as in Alt 10A. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
11A	Assume about 2 weeks to process, chip, and burn in 3 burn bins (at 15 cy per hr each bin) by 3 project staff, and 4 days to boom and tow logs, root wads and bins on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Chipper rental $7500/month, burn bins $2500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Portable chipper unit would have to be rented in Canada and stationed at Hozemeen to process useable debris into landscaping chips. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Lifting root wads and chip bins off barge at Ruby Arm would be less risky. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
11B	Assume about 2 weeks to process, chip, and burn in 3 burn bins (at 15 cy per hr each bin) by 3 project staff, and 4 days to boom and tow logs, root wads and bins on barge to Ruby Arm and lift with skyline up to Hwy 20, plus one day by 2 staff to haul ash in bins on small barge to Ross Dam. Chipper rental $7500/month, burn bins $2500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing and burning can continue until stockpile at Hozemeen is gone. With burn bins, it may be possible to burn wet debris as well without waiting for it to dry. Portable chipper unit would have to be rented in Canada and stationed at Hozemeen to process useable debris into landscaping chips. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Lifting root wads and chip bins off barge at Ruby Arm would be less risky than picking logs out of the water as in Alt 11A. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
12A	Assume about 2 weeks to process, grind, chip, load into bins by 3 project staff, and 6 days to boom and tow logs, root wads and bins on barge to Ruby Arm and lift with skyline up to Hwy 20. Chipper and grinder rental $7500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing can continue until stockpile at Hozemeen is gone. Portable chipper and grinding units would have to be rented in Canada and stationed at Hozemeen to process useable debris into landscaping chips and mulch, as they are NOT the same machines. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Lifting root wads and chip/mulch bins off barge at Ruby Arm would be less risky. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
12B	Assume about 2 weeks to process, grind, chip, load into bins by 3 project staff, and 6 days to boom and tow logs, root wads and bins on barge to Ruby Arm and lift with skyline up to Hwy 20. Chipper and grinder rental $7500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing can continue until stockpile at Hozemeen is gone. Portable chipper and grinding units would have to be rented in Canada and stationed at Hozemeen to process useable debris into landscaping chips and mulch, as they are NOT the same machines. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the pulp logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Lifting root wads and chip/mulch bins off barge at Ruby Arm would be less risky. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
13A	Assume about 3 weeks to process, sort, and load bins by 3 project staff, and 8 days to boom and tow logs, root wads and bins on barge to Ruby Arm and lift with skyline up to Hwy 20. Chipper and grinder rental $7500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing can continue until stockpile at Hozemeen is gone. Separate portable chipper and grinding units would be stationed at Agg ponds to process useable debris into landscaping chips and mulch, as they are NOT the same machines. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads and bins of debris onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Lifting root wads and debris bins off barge at Ruby Arm would be less risky. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.
13B	Assume about 3 weeks to process, sort, and load bins by 3 project staff, and 8 days to boom and tow logs, root wads and bins on barge to Ruby Arm and lift with skyline up to Hwy 20. Chipper and grinder rental $7500/month each. Assume skyline crew for two weeks @$5,000/day plus $25,000 mob and demob. This alternative would require an excavator to be rented in Canada and stationed at Hozemeen during high lake level to pick debris out of the water as its moved across from the bag site. The debris collection can only practically occur during high lake level, but processing can continue until stockpile at Hozemeen is gone. Separate portable chipper and grinding units would be stationed at Agg ponds to process useable debris into landscaping chips and mulch, as they are NOT the same machines. Processing would be more efficient if root wads could be bunked in cribs or in steel bunks at Hozemeen to stockpile for loading on barge, as space there is somewhat limited. A large barge would also have to be provided at Ross with sufficient deck space to place a small excavator or crane to lift root wads and bins of debris onto deck. Barge would probably require a bigger tow/push boat than the current aluminum work boat. The skyline system would require either a permanent tailhold on the knob on the north side of Ruby Arm, and permanent guyline tailholds on the hillside above the Highway 20 pullout. Picking the logs out of the water at Ruby Arm would be slow and somewhat dangerous work, as the Project crew would be working over water the entire time to attach chokers to each log in turn. Lifting root wads and debris bins off barge at Ruby Arm would be less risky. Skyline system would also need to have a path cleared up the slope to the Highway 20 pullout to avoid damaging existing trees.

Appendix C – Powerpoint Slides from Workshop

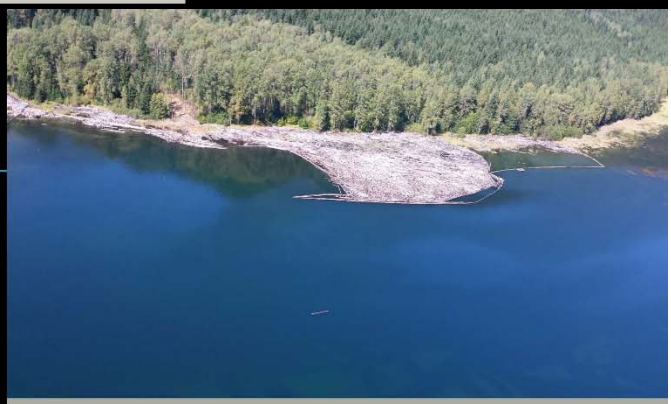
Debris Volume Estimates		Volume of Annual Debris (total 45,000 yd3)	% of debris	yd3	#trucks/bins
Marketable Logs	yd^3 (equiv.) per log truck	20 yd^3	0.25%	112.5	5.6
Habitat Rootwads	yd^3 (equiv.) per trash truck	25 yd^3	1.00%	450	18.0
Marketable Chips	yd^3 (equiv.) per chip box truck	45 yd^3	2.50%	1125	25.0
Hog Fuel	yd^3 (equiv.) per chip box truck	45 yd^3	96.25%	43312.5	962.5
OR Burnable Debris	yd^3 (equiv.) per burn bin	10 yd^3	96.25%	43312.5	4331.3

		Volume of Stored Debris (total 6,000 yd3)	% of debris	yd3	#trucks/bins
Marketable Logs	yd^3 (equiv.) per log truck	20 yd^3	0.50%	30	1.5
Habitat Rootwads	yd^3 (equiv.) per trash truck	25 yd^3	2.50%	150	6.0
Marketable Chips	yd^3 (equiv.) per chip box truck	45 yd^3	10.00%	600	13.3
Hog Fuel	yd^3 (equiv.) per chip box truck	45 yd^3	87.00%	5220	116.0
OR Burnable Debris	yd^3 (equiv.) per burn bin	10 yd^3	87.00%	5220	522.0

		Volume of ash remaining (assuming 1% by volume ash content)
Existing Burnable Debris	yd^3 (equiv.) per trash bin	433 yd^3
Annual Burnable Debris	yd^3 (equiv.) per trash bin	52 yd^3

Alternative 1

Grant debris at upper end of lake to First Nations Bands.



Assumptions:

- All debris to be acquired by First Nations Bands now and in future from SCL holding area

Pros:

- No net cost to SCL except for moving existing debris storage to east shore holding area
- No new access or alterations to existing SCL debris collection or handling methods or equipment needed

Cons:

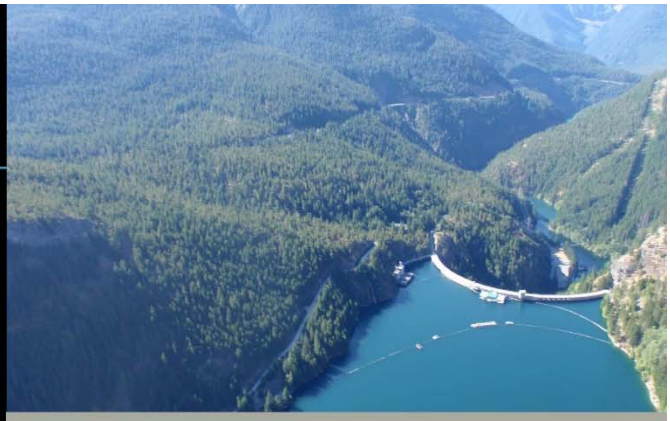
- First Nations Bands would have to guarantee they would take ALL of the debris

Equipment Needed:

- None new

Alternative 2

Collect and burn debris at upper end of lake on site, haul ash down lake to Ross dam boat access ramp.



Assumptions:

- All debris open burned
- SCL Staff responsible for collecting debris
- Contractor responsible for burning debris

Pros:

- Relatively inexpensive
- No new methods, except for hauling excavator to site to manage debris

Cons:

- Open burning, which may require special permitting
- Burning of large and heavy debris would take a long time (i.e. logs and rootwads)
- Ash remaining will amount to as much as 1% of total debris volume (as much as 450 cubic yards ash from existing debris, and as much as 60 cubic yards annually)
- SCL staff would have to haul ash back down the lake to the dam boat access ramp to be loaded into trucks and re-handled to dispose of it.

Equipment Needed:

- None new, unless barge not available to haul excavator (need to check with SCL on barge size)

Alternative 3

Collect and burn debris at upper end of lake across lake on Hozomeen landing area.

Assumptions:

- All debris open burned
- SCL Staff responsible for collecting debris
- Contractor responsible for burning debris

Pros:

- Relatively inexpensive
- No new methods

Cons:

- Open burning, which may require special permitting
- Burning of large and heavy debris would take a long time (i.e. logs and rootwads)
- Ash remaining will amount to as much as 1% of total debris volume (as much as 450 cubic yards ash from existing debris, and as much as 60 cubic yards annually)
- If this option is selected, SCL staff would have to haul ash back down the lake to the dam boat access ramp to be loaded into trucks and re-handled to dispose of it. Alternately, ash could be hauled to Canada for disposal.

Equipment Needed:

- None new

Alternative 4

Collect and sort debris at upper end of lake into marketable logs and debris to be burned on site, logs to be moved across lake to Hozomeen to be sold and hauled away to Canadian customers.

Assumptions:

- All debris open burned
- SCL Staff responsible for collecting debris
- Contractor responsible for burning debris
- Log customers would haul logs using self-loader log trucks or provide their own means to load their trucks.

Pros:

- Relatively inexpensive
- Saw log handling by SCL staff or contractor

Cons:

- Open burning, which may require special permitting
- Burning of large and heavy debris would take a long time (i.e. rootwads)
- Marketing of logs to Canadian customers would require some effort.
- Ash remaining will amount to as much as 1% of total debris volume (as much as 450 cubic yards ash from existing debris, and as much as 60 cubic yards annually)
- If this option is selected, SCL staff would have to haul ash back down the lake to the dam boat access ramp to be loaded into trucks and re-handled to dispose of it. Alternately, ash could be hauled to Canada for disposal.

Equipment Needed:

- Log shovel or excavator to lift logs out of water to storage area at Hozomeen Landing on east side

Alternative 5

Collect and sort debris at upper end of lake into marketable logs and debris, move all debris and logs across lake to be processed on Hozomeen landing area. Marketable logs to be sold in Canada and hauled out on the Canadian end of lake from landing area, while all remaining debris to be burned at Hozomeen Landing.

Assumptions:

- All debris open burned
- SCL Staff responsible for collecting debris and moving it to Hozomeen Landing on east side of lake
- Contractor responsible for burning debris
- Log customers would haul logs using self-loader log trucks or provide their own means to load their trucks

Pros:

- Relatively inexpensive
- Saw log handling by SCL staff or contractor

Cons:

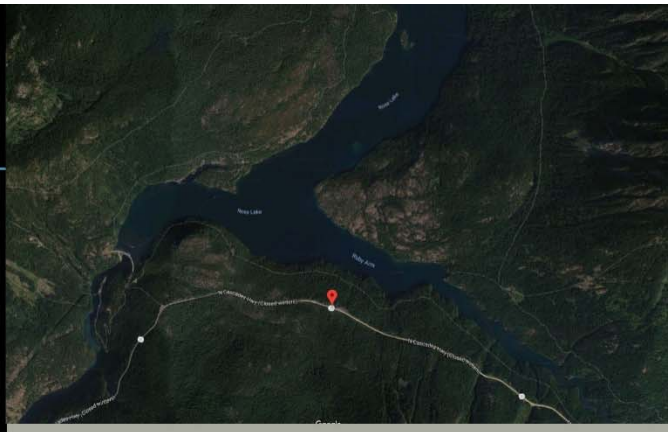
- Open burning, which may require special permitting
- Burning of large and heavy debris would take a long time (i.e. rootwads)
- Ash remaining will amount to as much as 1% of total debris volume (as much as 450 cubic yards ash from existing debris, and as much as 60 cubic yards annually)
- Marketing of logs to Canadian customers would require some effort.
- If this option is selected, SCL staff would have to haul ash back down the lake to the dam boat access ramp to be loaded into trucks and re-handled to dispose of it. Alternately, ash could be hauled to Canada for disposal.

Equipment Needed:

- Log shovel or excavator to lift logs and debris out of water to storage area at Hozomeen Landing on east side

Alternative 6

Collect and sort debris at storage site on west side of upper end of lake into marketable logs. Drag booms of sorted logs down the lake to skyline to be lifted up to Hwy 20. Debris to be burned on site west side.



Assumptions:

- All debris open burned
- SCL Staff responsible for collecting debris
- Contractor responsible for burning debris
- Log customers would haul logs using self-loader log trucks or provide their own means to load their trucks

Pros:

- Potential revenue could be earned from saw log sales
- Saw log handling by SCL staff or contractor

Cons:

- Relatively expensive, given the cost of hiring a large yarder and crew to lift logs up to Highway 20 with skyline system, which would require restringing skyline each year.
- Highlead would require stringing cable down the slope to the lake
- Open burning, which may require special permitting
- Burning of large and heavy debris would take a long time (i.e. rootwads)
- Marketing of logs to US customers would require some effort.
- Ash remaining will amount to as much as 1% of total debris volume (as much as 450 cubic yards ash from existing non-sawlog debris, and as much as 60 cubic yards annually)
- If this option is selected, SCL staff would have to haul ash back down the lake to the dam boat access ramp or to the skyline to be loaded into trucks and re-handled to dispose of it. Alternately, ash could be hauled to Canada for disposal.

Equipment Needed:

- Larger barge to serve as tail-block for highlead system (for highlead system only, not permanent-tail-block skyline)
- Possibly need a barge mounted log shovel to lift logs out of water and onto shore landing area to be choked up and lifted up the slope (for highlead system only)

Alternative 7

Collect and sort debris at storage site at upper end of lake into marketable logs and root wads, drag booms of logs to skyline, load rootwads onto barge then haul to skyline, debris to be burned at storage site west side of lake.

Assumptions:

- All debris open burned
- SCL Staff responsible for collecting debris
- Contractor responsible for burning debris
- Log customers would haul logs using self-loader log trucks or provide their own means to load their trucks

Pros:

- Potential revenue could be earned from saw log sales
- Saw log handling by SCL staff or contractor

Cons:

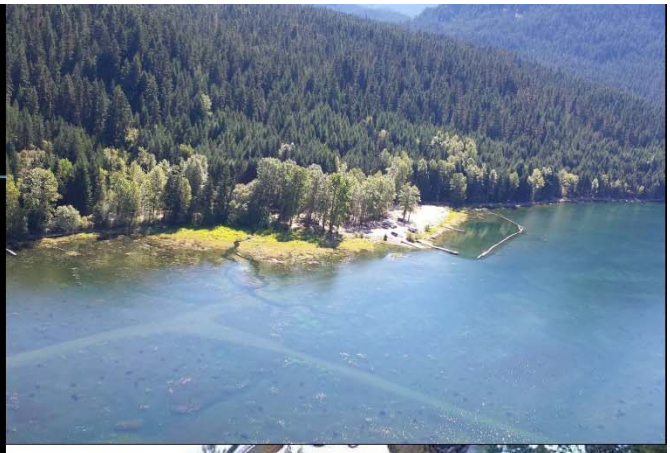
- Relatively expensive, given the cost of hiring a large yarder and crew to lift logs up to Highway 20 with skyline system, which would require restringing skyline each year.
- Would require rerunning skyline each year, which would potentially cause damage to the haul path up the slope, and would require a good deal of effort on the part of the logging contractor to carry haywire up to the permanent tailblock and down the slope from Highway 20 to the lake. SCL would have to coordinate with contractor to string haywire across the lake on SCL barge or boat
- Open burning, which may require special permitting
- Burning of large and heavy debris would take a long time (i.e. rootwads)
- Marketing of logs to US customers would require some effort.
- Ash remaining will amount to as much as 1% of total debris volume (as much as 450 cubic yards ash from existing non-sawlog debris, and as much as 60 cubic yards annually)
- If this option is selected, SCL staff would have to haul ash back down the lake to the dam boat access ramp or to the skyline to be loaded into trucks and re-handled to dispose of it. Alternately, ash could be hauled to Canada for disposal.

Equipment Needed:

- Larger barge to haul rootwads and ash residue

Alternative 8

Collect and sort debris at storage site at upper end of lake into marketable logs and root wads, drag booms of logs to skyline, load rootwads onto barge then haul to skyline, debris to be burned in burn bins at existing storage site or at Hozomeen Landing. No burning at Ruby Arm (per Shelley Adams).



Assumptions:
- All debris bin burned
- SCL Staff responsible for collecting debris
- Contractor responsible for burning debris
- Log customers would haul logs using self-loader log trucks or provide their own means to load their trucks

Pros:
- Potential revenue could be earned from saw log sales
- Saw log handling by SCL staff or contractor

Cons:
- Relatively expensive, given the cost of hiring a large yarder and crew to lift logs up to Highway 20 with skyline system, which would require restringing skyline each year.
- Would require rerunning skyline each year, which would potentially cause damage to the haul path up the slope, and would require a good deal of effort on the part of the logging contractor to carry haywire up to the permanent tailblock and down the slope from Highway 20 to the lake. SCL would have to coordinate with contractor to string haywire across the lake on SCL barge or boat
- Open burning, which may require special permitting
- Burning of large and heavy debris would take a long time (i.e. rootwads)
- Marketing of logs to US customers would require some effort.
- Ash remaining will amount to as much as 1% of total debris volume (as much as 450 cubic yards ash from existing non-sawlog debris, and as much as 60 cubic yards annually)
- If this option is selected, SCL staff would have to haul ash back down the lake to the dam boat access ramp or to the skyline to be loaded into trucks and re-handled to dispose of it. Alternately, ash could be hauled to Canada for disposal.

Equipment Needed:
- Larger barge to haul rootwads and ash residue

Alternative 9

Collect and sort debris at existing storage site at upper end of lake, chip and convert useable debris into biomass electrical generation fuel for on-site use at NPS facilities at Hozomeen landing area. Separate and drag saw logs in boom, and rootwads in boom or on barge to skyline to be lifted up to Hwy 20 pullout. Rest of debris to be burned in burn boxes at Hozomeen landing site.

Assumptions:
- All debris bin burned
- SCL Staff responsible for collecting debris
- Contractor responsible for burning debris
- Log customers would haul logs using self-loader log trucks or provide their own means to load their trucks

Pros:
- Potential revenue could be earned from saw log sales
- Saw log handling by SCL staff or contractor

Cons:
- Relatively expensive, given the cost of hiring a large yarder and crew to lift logs upt the Highway 20 with skyline system
- Bin burning, which may require special permitting
- Burning of large and heavy debris would take a long time (i.e. poor quality rootwads not suitable for sale or use)
- Marketing of logs and rootwads to US customers would require some effort.
- Ash remaining will amount to as much as 1% of total debris volume (as much as 450 cubic yards ash from existing non-sawlog debris, and as much as 60 cubic yards annually)
- If this option is selected, SCL staff would have to haul ash back down the lake to the dam boat access ramp or to the skyline to be loaded into trucks and re-handled to dispose of it. Alternately, ash could be hauled to Canada for disposal.

Equipment Needed:
- Possibly larger or different barge to assist logging contractor with restringing skyline each year
- Medium excavator to lift debris out of the water at Hozomeen Landing for processing
- Chipper for processing suitable debris into syngas fuel feed material
- Syngas converter and biogas generation equipment for NPS facility
- Burn Bins
- Bulk bins to haul biochar down lake on barge and then up slope on skyline system

Alternative 10

Collect and sort debris on site at west side storage site. Chip good debris into landscaping mulch, to be hauled on barge in bins, with good rootwads towed in booms or hauled on barge, and marketable logs towed in booms to skyline and up slope to Hwy 20 pullout.

Assumptions:

- Similar to Alternatives 7 and 8 with some exceptions

Pros:

- No burning

Cons:

- Lots of material to handle and process at the remote upper lake site

Equipment Needed:

- Tub or drum grinder to be used at upper lake debris holding area
- Larger barge to transport grinder and excavator to upper lake site and to haul mulch bins down to Ruby Arm

Alternative 11

Haul all debris to Ruby Arm by booming and dragging from upper lake storage sites. Send all debris to Highway 20 via the skyline, transport all material to Agg Ponds. Sort into marketable lumber and rootwads. Rootwads placed in river at Agg Pond. Remaining debris would be chipped at Ruby Arm, hauled up slope using skyline system, and used for landscaping, erosion control, and weed suppression projects.

Assumptions:

- SCL staff would manage all debris collecting and towing operations
- Contractor would manage all heavy lift operations up to Highway 20
- Either SCL or a contractor could manage debris processing operations
- Log customers would load logs at Highway 20 with their own shovel or self-loader

Pros:

- Revenue from saw logs, rootwads, pulp logs, mulch

Cons:

- Relatively expensive, given cost of large yarder, new large barge, processing equipment, etc.
- Marketing of logs, pulp, and mulch would require moderate effort

Equipment Needed:

- Larger barge to house grinding/chipping equipment, shovel, bins, misc equipment.
- Log shovel or excavator – barge mounted
- Chipper and/or grinder – barge mounted
- Bulk bins

Alternative 12

Collect and sort debris on site into marketable logs, remaining debris to be ground into landscaping mulch, and logs not suitable for sawlogs but good for pulp production. Grind to mulch on site, haul mulch in bins on barge, logs of all types in booms down lake to skyline and up hill in bins and clean log bundles.

Assumptions:

Pros:

Cons:

Equipment Needed:

Skyline Yarder Considerations	Logs and rootwads only (weight - lbs)	Debris bins + logs and rootwads (weight - lbs)	Koller K507 Tower Truck Mounted	Koller K702 Tower Track Mounted	Madill 172	Madill 071	Thunderbird TSY255	Skagit 737	Berger Mark 6
Capacity Requirements/ Line Pull	2500	7500	9,480 lbs ave drum	17,640 lbs ave drum	10,000 lbs ave drum	10,000 lbs ave drum	20,000 lbs ave drum	120,000 lbs ave drum	250,000 lbs ave drum
Type of Yarder System (motorized slack-pulling carriage, north bend, etc.)									
Motorized Slack-Pulling Carriage?	yes	yes	yes	yes	yes	yes	yes	yes	yes
North Bend? (to move mainline laterally)	possibly	no	yes	yes	yes	yes	yes	yes	yes
Swing Yarder	yes	yes	no	no	no	no	yes	no	no
Highlead? (does not fully suspend load)			yes	yes	yes	yes	yes	yes	yes
Live Skyline? (Fully suspends load w/ addtl drum)			no	no	yes	yes	yes	yes	yes
Standing Skyline? (Fully suspends load w/ addtl drum)			no	no	yes	yes	yes	yes	yes
Barge or no barge required?	no	yes	yes	yes	yes	yes	yes	no	no
Permanent Facilities (tailhold, etc.)	yes	yes	no	no	No* (but requires tailhold for live or standing skyline)	No* (but requires tailhold for live or standing skyline)	yes	yes	yes
Tower Height	at least 50 feet at Hwy20	at least 50 feet at Hwy 20	49	49	70	70	50	90	110
Intermediate Support/s needed?	maybe	yes	yes	yes	yes	yes	yes	no	no
Clearing of Skid Trail Required?	maybe	yes	yes	yes	yes	yes	yes	no	no
Drum Line Capacity (Skyline)			3400 ft of 3/4"	2550 ft of 7/8"				7,500 ft of 1-1/4"	10,000 ft of 1-3/4"
Maximum Yarding Distance (approx)			800 ft	2,500 ft	1,500 ft	1,500 ft	1,800 ft	4,000 ft	5,000 ft

Koller K507 Tower
Truck Mounted

Koller K702 Tower
Track Mounted

Madill 172
Track Mounted

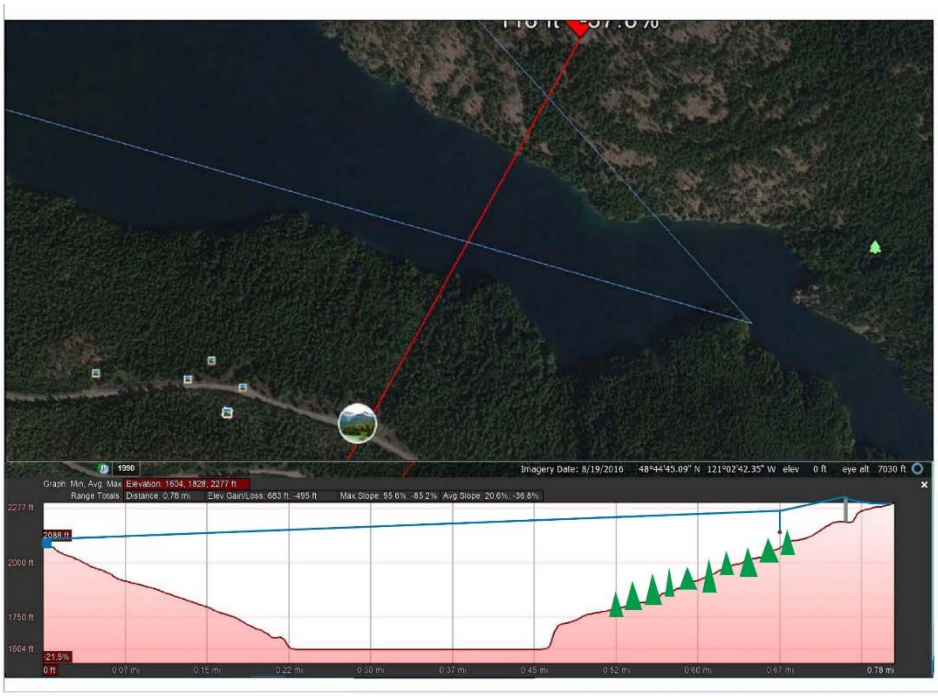
Madill 071
Track Mounted

Thunderbird TSY255
Track Mounted

Skagit 737
Trailer Mounted

Berger Mark 6
Track Mounted

Trash and Debris Handling Equipment		Existing Project Equipment?	New?	Used?	Rental?
Floating Plant					
	Barge - modular 8' x 20' modules	No	Yes	Yes	Yes
	Tugboat - Skagit Project tug	Yes	N/A	N/A	N/A
	Workboat - Aluminum 20 foot	Yes	N/A	N/A	N/A
Handling Equipment					
	Excavator - 10 ton, barge transportable	No	Yes	Yes	Yes
	Excavator - 25 ton, land transportable	No	Yes	Yes	Yes
	Truck - 10 yd3 dump	Yes	N/A	N/A	N/A
Misc Equipment					
	Burn Boxes (25 yd^3 capacity)	No	Yes	Yes	No
	Debris Bins (5 yd^3 capacity)	No	Yes	No	No
Power Generation Equipment					
	Syngas converter	No	Yes	No	No
	Syngas engine-generator (GE Jenbacher)	No	Yes	No	No


1990
Imagery Date: 8/19/2016 48°44'45.09" N 121°02'42.35" W elev 0 ft eye alt 7030 ft
Graph: Min, Avg, Max Elevation: 1604, 1828, 2277 ft
Range Totals: Distance: 0.78 mi Elev Gain/Loss: 683 ft, -495 ft Max Slope: 55.6%, -65.2% Avg Slope: 20.6%, -36.6%
2277 ft
2088 ft
2000 ft
1750 ft
1604 ft
21.5%
0 ft
0.07 mi
0.15 mi
0.22 mi
0.30 mi
0.37 mi
0.45 mi
0.52 mi
0.60 mi
0.67 mi
0.78 mi

Harvester Forwarder & More