Biomass Feedstock Recovery and Transport Assessment
Teslin and Haines Junction, Yukon

PRESENTED TO
Government of Yukon

APRIL 12, 2017
ISSUED FOR USE
FILE: 704-ENW.WENW03015-02

Tetra Tech Canada Inc.
61 Wasson Place
Whitehorse, YT Y1A 0H7 CANADA
Tel 867.668.3068 Fax 867.668.4349

This page intentionally left blank.

EXECUTIVE SUMMARY

This report contains a volume-based evaluation of the cost to collect and process Yukon's residual wood from forest development and other clearing activities for use as boiler fuel by the communities of Teslin and Haines Junction, Yukon.

While heating with cordwood is a historic and long established practice in the region, the use of wood chip fuel for heating is not currently widespread and the potential demand or scale of the chip market is not well understood. This report is a volume-based evaluation of the cost to collect and process residual wood from harvest and development activities for use by local communities.

The quantity and quality of wood chips required is based on the equipment selected for the district heating projects underway in Teslin and Haines Junction. The Teslin project is installing ten 100kW Hargassner wood chip boilers. Four of the same boilers are proposed for installation at the Da Ku Cultural Centre in Haines Junction. These boilers perform best with a wood chip that is no more than 5 centimetres in any dimension and 35% or less wet basis moisture content.

The Government of Yukon (YG) is able to obtain woody biomass residuals (residuals) from various land tenures. These tenures include commercial timber harvesting, mining, gravel pit development, and fuel abatement. Residues from commercial timber harvest can include tops, branches, and cull logs. This residue is equal to approximately 15% of merchantable harvest. At mines, timber may be used for purposes of working the mine, but may not be sold or removed from the site without a licence. Similarly, gravel pit development can result in large quantities of residuals, which remain under the control of YG unless sold as part of the development contract. Fuel abatement projects near communities thin timber stands to reduce the hazards of wildfire. Currently, the wood removed in these projects is usually left for the personal use of local residents. Available quantities of residuals were evaluated for both communities, in the ranges of 50 km, 100 km, and 150 km from the community. The annual volume of residuals available near Teslin is approximately 48,000 m^3, while the annual volume near Haines Junction is approximately 26,000 m^3.

The majority of material that results from gravel pit or mine clearing will be whole logs, while material generated from commercial logging operations and fuel abatement projects will be shorter and smaller in diameter, consisting mainly of tops, limbs, and understory. Pick-up of residuals from commercial timber harvesting and fuel abatement projects is likely to require a solid-bed dump truck along with a log truck with log loader, to ensure that the smaller material can be safely hauled. Pick-up of whole logs from gravel pits and mining will require only a log truck with log loader.

The system recommended for the Haines Junction and Teslin areas is to collect the wood residuals using log trucks with attached log loaders. The residuals will be delivered to processing centres (Transfer Stations), where the wood will be stockpiled in log form, staged for drying and inventory, chipped, and stored for delivery to end users. End users will be responsible for transporting the wood chips from the Transfer Stations to the end use sites, as needed. The Transfer Stations will be located within 5 km of Teslin and Haines Junction. Each Transfer Station will include a log yard, office trailer, chip storage building, and paved loading area.

At a Transfer Station, logs are unloaded and placed on racks to dry for a season. When dry, the logs are shuttled by a front end loader to a mobile chipper for processing. A log loader feeds the logs through the chipper, which discharges chips into a storage building. One chipper is shared between both sites, and is moved between sites before the chip supply in the storage building at the other site is exhausted. Initially 4 round trips per year are anticipated for the chipper with it being based in Teslin where the larger demand exists. Each site has its own wheeled front end loader and knuckleboom log loader. The end users are responsible for hauling chips from the storage building to their boiler plants. Table 1 summarizes the costs aggregating and processing roundwood to wood chips. These costs include: pick-up and delivery to Transfer stations, depreciation, repair, maintenance and operating costs on equipment and facilities, but do not include the capital costs for the site improvements, insurance, and financing. The capital cost for site improvements and the chip storage building at each site is $507,720. The capital cost for a used front end loader and used log loader at each site is $189,000. The chipper, which is shared between the sites, has a capital cost of $689,000. Total estimated capital cost for both Transfer Stations and equipment is $2.1 million.

Table 1: Summary of Costs to Aggregate Roundwood and Produce Chips

Site	Cost to Deliver Residuals to Processing Site ($/m³)	Transfer Station - Staging Delivered Logs ($/m³)	Transfer Station - Loader Forwarding to Chipper ($/m³)	Transfer Station - Log Loader and Wood Chipper Costs ($/m³)	Misc. Transfer Station Costs ($/m³)	*Cost to Aggregate and Process Roundwood to Chips ($/m³)
Teslin	$21.22	$1.34	$2.68	$5.60	$5.76	$36.60
HJ	$10.53	$1.34	$2.68	$5.60	$19.62	$39.76

Note *Roundwood 25% m.c. assumed density 474 kg/m³

The cost for end users to transport wood from the Transfer Station to their boiler plants is approximately $16.18/m³. The costs for both logwood and chipped wood in Table 1 are expressed on a basis of a solid cubic metre of wood. At 25% moisture content, solid wood has a density of approximately 474 kg/m³. Actual chip density is approximately 50% less than roundwood at the same moisture content; this report uses the same density basis for both roundwood and chipped wood for consistency.

The cost of fossil fuels typically used for heating in Teslin and Haines Junction were compared to wood pellets and wood chips.

Table 2 and Table 3 summarize the fuel costs for Teslin and Haines Junction, respectively. The costs of the local wood chips which could be produced as described in this report are shown in bold.

Table 2: Energy Fuel Cost Comparison for Teslin

Technology, Unit	Cost/Unit	Input Energy (MJ / Unit)	Assumed Efficiency	Output Energy (MJ / Unit)	Energy Cost ($/GJ)
Furnace Oil, litre	$1.12	39.0	78%	30.4	$36.90
Artic Stove Oil, litre	$1.15	34.7	78%	27.1	$42.35
Propane, litre	$0.88	25.5	75%	19.1	$46.09
Wood Pellet (Bags), tonne	$358	19,500	75%	14,625	$24.50
Wood Pellet (Bulk), tonne	$330	19,500	75%	14,625	$22.56
***Woodchip (local-25% MC), tonne**	**$111**	**15,000**	**70%**	**10,500**	**$10.60**
Woodchip (BC-30% MC), tonne	$336	14,000	70%	9,800	$34.29

Note *Estimated cost assigns $0 value to the wood residuals gathered at forest landings

Table 3: Energy Fuel Cost Comparison for Haines Junction

Technology, Unit	Cost/Unit	Input Energy (MJ / Unit)	Assumed Efficiency	Output Energy (MJ / Unit)	Energy Cost ($/GJ)
Furnace Oil, litre	$1.10	39.0	78%	30.4	$36.08
Artic Stove Oil, litre	$1.11	34.7	78%	27.1	$40.96
Propane, litre	$0.88	25.5	75%	19.1	$46.09
Wood Pellet (Bags), tonne	$358	19,500	75%	14,625	$24.50
Wood Pellet (Bulk), tonne	$330	19,500	75%	14,625	$22.56
***Woodchip (local-25% MC), tonne**	**$118**	**15,000**	**70%**	**10,500**	**$11.24**
Woodchip (BC-30% MC), tonne	$395	14,000	70%	9,800	$40.31

Note *Estimated cost assigns $0 value to the wood residuals gathered at forest landings

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 WOOD WASTE VOLUME ASSUMPTIONS AND CALCULATIONS 1
- **2.1** Commercial Timber Harvesting 2
- **2.2** Gravel Extraction 2
- **2.3** Mining 3
- **2.4** Fuel Abatement Projects 3
- **2.5** Summary of Wood Sources 4

3.0 WOOD WASTE AVAILABILITY NEAR TESLIN 4
- **3.1** Timber Harvest Areas 4
- **3.2** Gravel Extraction 7
- **3.3** Mining 7
- **3.4** Fuel Abatement 8
- **3.5** Teslin Summary 8

4.0 WOOD WASTE AVAILABILITY NEAR HAINES JUNCTION 8
- **4.1** Timber Harvest Areas 8
- **4.2** Gravel Extraction 10
- **4.3** Mining 10
- **4.4** Fuel Abatement 11
- **4.5** Haines Junction Summary 11

5.0 RECOVERY AND DELIVERY TO TRANSFER STATION 11
- **5.1** Recovery at Forest Landings 12
- **5.2** Delivery to Transfer Station 12

6.0 PROCESSING AND STORAGE 15
- **6.1** Transfer Station Layout 15
- **6.2** Wood Chip Fuel Quality 16
- **6.3** Equipment 16
- **6.4** Woodchipping Options 18

7.0 DELIVERY TO END USERS 19

8.0 SUMMARY OF COSTS 19

9.0 COMPARATIVE COST OF ENERGY 20

10.0 CONCLUSIONS 21

11.0 CLOSURE 22

LIST OF TABLES IN TEXT

Table 1: Summary of Costs to Aggregate Roundwood and Produce Chips ii
Table 2: Energy Fuel Cost Comparison for Teslin ii
Table 3: Energy Fuel Cost Comparison for Haines Junction iii
Table 4: Baseline Forest Characteristics by Region 4
Table 5: Summary of Residual Volumes by Land Use Activity 4
Table 6: Teslin Commercial Timber Harvest Residuals 6
Table 7: Teslin Gravel Pit Timber Volumes using Method 1 7
Table 8: Teslin Gravel Pit Timber Volumes using Method 2 7
Table 9: Teslin Mining Timber Volumes 7
Table 10: Teslin Fuel Abatement Timber Volumes 8
Table 11: Anticipated Annual Wood Waste near Teslin within 150 km 8
Table 12: FY 2016 Commercial Timber Volume Harvested near Haines Junction 9
Table 13: Haines Junction Commercial Timber Harvest Residuals 9
Table 14: Haines Junction Gravel Pit Timber Volumes using Method 1 10
Table 15: Haines Junction Gravel Pit Timber Volumes using Method 2 10
Table 16: Haines Junction Mining Timber Volumes 10
Table 17: Haines Junction Fuel Abatement Timber Volumes 11
Table 18: Anticipated Annual Wood Waste near Haines Junction within 150 km 11
Table 19: Distances and Volumes from Teslin Transfer Station to Forest Landings 13
Table 20: Distances and Volumes from Haines Junction Transfer Station to Forest Landings 13
Table 21: Costs to Pick up at Forest Landings and Deliver to Transfer Stations 14
Table 22: Comparing Gravel/Mining to Forestry/Fuel Abatement Costs 14
Table 23: Delivery Cost Comparison by Distance from Transfer Station 15
Table 24: Transfer Station Operating Costs 17
Table 25: Chipper Assumptions for Calculating Transfer Station Operating Costs 17
Table 26: Front End Loader Assumptions for Calculating Transfer Station Operating Costs 18
Table 27: Log Loader Assumptions for Calculating Transfer Station Operating Costs 18
Table 28: Delivery Cost from Transfer Station to Boiler Plant 19
Table 29: Summary of Costs to Aggregate Roundwood and Produce Chips 20
Table 30: Energy Fuel Cost Comparison for Teslin 21
Table 31: Energy Fuel Cost Comparison for Haines Junction 21

APPENDIX SECTIONS

FIGURES

Figure 1 Areas of Potential Clearing within the Teslin Study Area
Figure 2 Areas of Potential Clearing within the Haines Junction Study Area
Figure 3 Transfer Station Process Flow Diagram
Figure 4 Transfer Station Site Plan
Figure 5 Log Truck with Self-Loading Boom
Figure 6 Wheeled Front End Loader with Log Grapple
Figure 7 Knuckleboom Log Loader for Feeding Chipper
Figure 8 Wood Chipper with Drum Chipping Head

APPENDICES

Appendix A Tetra Tech's General Conditions
Appendix B Transfer Station Capital Cost Estimate

LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Government of Yukon and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Government of Yukon, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech's Services Agreement. Tetra Tech's General Conditions are provided in Appendix A of this report.

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) has been contracted by the Government of Yukon (YG) to complete a Biomass Feedstock Recovery and Transport Assessment for the communities of Teslin and Haines Junction, Yukon.

The goal of the study is to complete a volume-based evaluation of the cost to collect and process Yukon's residual wood from harvest and development activities for use by local communities. This report relies on information contained in Tetra Tech report 704-ENW.WENW03015-01 completed in February 2017, contracted by the Government of Yukon (YG) Forest Management Branch (FMB) for potential to source wood generated as waste from industrial processes in the areas of Haines Junction and Watson Lake, YT (Tetra Tech 2017). This study focuses on providing woodchip fuel for two commercial scale district heating systems in the communities of Teslin and Haines Junction. It is the established position of Yukon government that: "a transition to a biomass economy has the potential to reduce heating costs for Yukoners, create new jobs in the local forest and heating industries, reduce greenhouse gas (GHG) emissions, and move the territory towards sustainable renewable energy and greater energy self-sufficiency" (YG 2016).

The scope of work for this project is an evaluation of available residual wood waste (residuals; waste) available in the Teslin and Haines Junction areas, and an assessment of the costs to recover and transport woody biomass to a processing and distribution centre, process the biomass into chips, and deliver woodchips to the end users in Teslin and Haines Junction from available residual wastes. While heating with cordwood is a historic and long established practice in the region, the market for woodchip fuel for heating is not currently widespread, and the potential demand or scale of the chip market has not been defined. Therefore this effort is to be used as a component of general planning purposes to explore whether woodchips can be economically and sustainably produced locally in the Yukon.

This study assumes that the YG will cover the costs to collect the biomass material from sites where it is generated, transport it to a common processing centre in each community, stage the material for drying, process and store the wood chips. The end users will be responsible for the costs to load and deliver the chips from the central processing centre. The residual wood collected at the forest landings is assigned $0 value.

The quantity and quality of wood chips required is based on the equipment selected for the district heating projects underway in Teslin and Haines Junction. The Teslin project is installing ten 100kW Hargassner woodchip boilers. Four of the same boilers are proposed for installation at the Da Ku Cultural Centre in Haines Junction. These boilers perform best with a woodchip that is no more than 5 centimetres in any dimensions and 35% or less wet basis moisture content. YG provided estimates of the annual heat demand of the buildings which will be heated by wood chips. This annual demand is 3.0×10^6 kWh in Teslin and 0.5×10^6 kWh in Haines Junction.

2.0 WOOD WASTE VOLUME ASSUMPTIONS AND CALCULATIONS

Average merchantable volumes were determined by averaging the volume per hectare in the Southern Yukon Timber Supply Analysis (TSA) predicted for 250 years for the Nisutlin and Teslin Forest Management Units (FMUs) to represent the Teslin region, and for the Kluane FMU to represent Haines Junction (Henry, 2000). Merchantable forest area was compared to average area losses to fire per year to determine the % losses of fire/ha/TSA/yr. This is less than 1% and was discounted from further analysis.

Weighted species mixes in each FMU from the TSA forest strata area summary, total land base (not including strata with deciduous as leading species, and averaged for Nisutlin and Teslin) were used to generate a weighted average wood density (kg/m^3) for Teslin and Haines Junction. Dry densities were obtained for White Spruce and Lodgepole Pine which are the predominant confer species in the areas of interest (Miles and Smith 2009). Wood density in this report is presented in terms of wet solid volume and oven dry mass (kg or tonne, where 1,000 kg = 1 tonne). Wet volume is the basis by which timber is removed from the forest. Oven dry mass provides an estimate of the calorific value of the wood fuel, which can then be discounted based on the actual moisture content to arrive at the true heating value. Similarly, the reported oven dry mass will be less than the actual mass hauled by truck, and this actual mass will vary depending on the moisture content.

2.1 Commercial Timber Harvesting

Where commercial timber harvesting occurs, there is the opportunity to harvest residual biomass from harvest waste such as tops, limbs, and branches. Residual biomass harvest for commercial logging operations increases total logged volume by approximately 15%, including tops and smaller sized stems (Louise Blanchard, pers. comm. February 20, 2017). Other harvesters estimate 25% of biomass left as residual wood from harvest operations, not all of which will be feasible to process for biomass (Myles Thorp, pers. comm. February 23, 2017). Unfeasible biomass residual volume is estimated to be 10% using these greater estimates. Unfeasible residuals include needles, small branches, and deciduous trees which are felled or damaged in the logging operation. Deciduous trees are not harvested for fuelwood or sawlogs, and thus will not be skidded to the road. For the purposes of this report, the amount of waste generated from commercial timber harvesting operations, which is feasible to collect and remove for biomass purposes, is estimated to be 15% of merchantable stand volume. The discussion of the economics of collecting these residuals is discussed elsewhere in this report.

2.2 Gravel Extraction

Gravel quarrying activities are administered through leases, designated public pits, highway pits, and private pits under Quarry Permits. As of 2015, there were 650 gravel pits throughout Yukon for construction and maintenance of highways and airports. Most of the gravel reserves in Yukon were developed with the development of Yukon's highway and airport systems; however, new pits are being developed and existing pits are being expanded to support ongoing maintenance and road improvements. YG does not track gravel reserve development on an annual basis, and it is unknown how much new gravel reserve development is anticipated in Yukon in the next few years (Justine Scheck, pers. comm. February 23, 2017).

Merchantable density of forest in gravel reserves and undeveloped portions of gravel pits was assumed to be equal to the regional averages in the TSA, because most gravel pits and reservations are in low-lying areas along roads, rather than in alpine areas. If the timber sourced from expansion activities at these gravel pits was devoted exclusively to biomass fuel production, then effective density will be 115% of merchantable density since the 15% of feasible residuals will also be included in the total. Due to the uncertainty in estimating gravel pit land utilization, two methods were used to estimate timber volumes from gravel pits.

The first method considers active highway gravel pits along the Alaska Highway, Canol Road, Haines Road, etc. Assumptions are that the spacing of the active gravel pits is consistent with localized gravel demand, and that the number of active gravel pits will be constant going into the future. As most of the Alaska Highway in Yukon was paved in the 1980's, the age of the existing gravel pits is assumed to be approximately 40 years. Inspection of current aerial photographs indicates that the average size of a highway gravel pit is approximately 3 hectares. Therefore, each 40 year old gravel pit expanded at an average rate of 0.075 ha/year, although in reality the pits will have been expanded in larger increments.

In addition to active highway gravel pits, there are privately owned pits in Yukon, as well as reservations on crown land for future gravel pits. The second calculation method for gravel pit timber volumes uses the land dispositions for gravel pit reservations and quarry leases obtained from GeoYukon. Aerial imagery was used to determine the extent to which these dispositions and reservations were already cleared, and this cleared area was excluded. The assumption in this case is that the remaining forested area of these reservations and pits will be cleared to 80% of the extent of the disposition, in a period of 10 years. The 80% factor accounts for areas that will never be cleared due to the boundaries of the gravel resource within each site.

Method 1 is more conservative, as it only considers active gravel pits, and not reservations. Therefore, although timber volumes are shown for both gravel pit methods, only the results for Method 1 are used in this report when calculating costs for sourcing, transporting, and processing wood residuals with respect to gravel pits.

2.3 Mining

A claim holder may only use timber cut on a mining claim for the purpose of working the claim, and not for any other commercial or personal use (YG 2014). If timber is cut on a mining claim, in most cases YG will issue a Forest Resources Permit for commercial use of this timber, with stumpage fees, or will allow the timber to be taken by the public for personal use.

Mining development has been estimated using quartz and placer mining tenures in the Yukon Lands Viewer. Many mining claims, especially quartz, are on remote mountain peaks, and therefore the biomass may not be easily accessible. Mining claims within the study area were evaluated on a case by case basis to determine if they were within 2 km of a public highway, or within 2 km of an established logging or mining haul road. Mining claims which did not have obvious road access to at least a portion of the claim were assumed to be exploratory and were excluded from analysis.

Placer mining generally occurs in gravelly riparian areas, and quartz mining often occurs at higher elevations. Therefore, merchantable timber volume on mining claims as a function of area was assumed to be 2/3 of the regional averages for merchantable timber in the TSA. However, if this timber was used for biomass fuel production, then an additional 15% will be available from the tops and residuals which are feasible to collect, as previously discussed.

Most miners have multiple claims, and it was assumed that the majority of their work was concentrated in 5% of the total area claimed, per year, and of those areas worked, 20% of the area was cleared annually. This results in 1% of total active claims cleared per year.

2.4 Fuel Abatement Projects

Fuel abatement projects in Yukon are targeted to reduce forest fire risk near communities. However, there is no formal reporting for areas thinned or amount of biomass removed from the forests. Currently, the wood and residuals are piled for local firewood use, chipped, or burned. In the FireSmart program, from 2012 to 2016 390 ha have been thinned in 133 areas, averaging approximately 3 ha per FireSmart thinning area (Caleb Tomlinson pers. comm. February 2, 2017). The estimated volume removed through FireSmart projects in Yukon is 30% of stand volume, although this varies considerably (Caleb Tomlinson, pers. comm. February 13, 2017).

The assumption of 30% of merchantable stand volume will be used for fuel abatement projects near Teslin, as there is no significant bark beetle impact there. In Haines Junction, 60% of merchantable stand volume will be assumed to be removed from treatment areas, to account for removal of all standing dead trees (excluding bird habitat trees, etc.). If all merchantable harvested volume is devoted to biomass fuel, then an additional 15% of feasible tops and branches will be included in the total volume calculation. However, it is likely that large-scale fuel abatement treatments will be most economical if the merchantable timber was used commercially, leaving the residuals for chipping. This latter assumption, that the merchantable timber is used commercially, will be used in this report.

Harvesting of biomass for woodchip fuel could be a good fit for fuel abatement projects as it could potentially provide an economical outlet for the wood residuals, if there is a low density of merchantable timber or if the primary removals are understory, thus enabling communities to complete fuel mitigation activities on an accelerated time table.

2.5 Summary of Wood Sources

Table 4 presents the forest characteristics for the Teslin and Haines Junction regions of interest, based on data from the Southern Yukon TSA. Percentage components of Spruce and Pine are only calculated for those stands which have Spruce or Pine as the leading species, as stands with deciduous as the leading species are assumed to be unmerchantable and will not be targeted for harvest. Deciduous species are not specifically targeted or avoided for use as biomass fuel, but deciduous–leading stands make up only 11% of the Haines Junction area, and 6% of the Teslin area, and thus do not significantly affect these assumptions which are based on merchantable timber stand density and conifer wood characteristics. As previously discussed, the dry density of wood is presented on a wet volume basis.

Table 4: Baseline Forest Characteristics by Region

Region	Merchantable Timber Density (m^3/ha)	Oven Dry Density (kg/m^3)	% Spruce	% Pine
Teslin	113	376	52%	48%
Haines Junction	100	373	96%	4%

Table 5 presents a summary of the available residual volumes which are estimated based on each land use activity considered in this report. With mining and gravel pits, it is assumed that all standing wood on a site is available to YG for biomass use (logwood and feasible residuals), and thus mining and gravel pits provide considerably more biomass per unit area than commercial harvesting. The residual availability for each land use activity is based on the merchantable timber density shown for each region in Table 5, with adjustments as already described to account for variations in timber density or harvest methods.

Table 5: Summary of Residual Volumes by Land Use Activity

Region	Residual Availability (m^3/ha)			
	Timber Harvest	Mining	Gravel Pits	Fuel Abatement
Teslin	17	86	129	5
Haines Junction	15	77	115	9

3.0 WOOD WASTE AVAILABILITY NEAR TESLIN

3.1 Timber Harvest Areas

There are several Timber Harvest Plan (THP) areas within 150 km of Teslin (Figure 1). These are:

- Sawmill Road - Demonstration Forest
- Lubbock Valley 2011 (LV-1 and LV-2)
- Lubbock Valley 2012 (LV-4 through LV-9)
- Marsh Lake

The Sawmill Road – Demonstration Forest THP (SRDF) is the closest to Teslin (YG 2011). The 6 Operating Units (OU) of SRDF are all within 8 km of Teslin. Lubbock Valley THP (LV) is approximately 130 km from Teslin, and Marsh Lake THP (ML) is approximately 132 km from Teslin. The regions around Teslin have not been hard-hit by beetles, and therefore approximately 10% of the trees are standing dead.

The SRDF is the only commercial harvesting location in the Teslin Tlingit Traditional Territory, which is covered by the Teslin Strategic Forest Management Plan (Teslin SFMP) (YG 2006). To date, there has been very little harvesting in the Teslin area. There is only one active commercial licence in the Teslin SFMP, specifically in the SRDF, and there has been no harvesting to date under that licence. As of March 2017, there is a single applicant for a harvest licence for OU D-2 for 60 m^3 of sawlogs and 35 m^3 of fuelwood (David Swinson, pers. comm. March 15, 2017). One-way road distances to these THPs from Teslin range from 2 to 8 km.

Lubbock Valley (LV) and Marsh Lake (ML) are both located in the Whitehorse forestry region. LV is located on the west shore of Little Atlin Lake and logging here has been occurring since the early 1980’s (YG 2011a; YG 2012). From 1985 to 1998, removals were approximately 89 m^3 per year. Between 1998 and 2010, approximately 1,311 m^3 were harvested (average of 110 m^3 annually). Of the volume harvested, approximately 80% was used for sawlogs, and 20% was used for fuelwood. For 2010, 221 m^3 was harvested, consisting of 135 m^3 of sawlogs and 86 m^3 of fuel wood. One-way road distance to this site from Teslin is approximately 130 km.

The Marsh Lake THP is located near the Marsh Lake Dump at the north end of Marsh Lake (YG 2011b). This is a timber harvest area which has been used by locals for several decades. Annual demand for forest products from this THP has been in the range of 50-200 m^3. From 1985-1999, approximately 5,382 m^3 was removed (average of 359 m^3/year), and from 2000-2009 the removals were approximately 100 m^3 per year. One-way road distance to this site from Teslin is approximately 132 km.

Table 6 details the available harvest volume and projected wood waste which will be generated from commercial harvest activities on the THPs identified. It is important to note that the target volume listed for these OUs is approximately 16% of the net merchantable volume for these OUs, and thus, the THPs can support considerably more logging than is currently targeted. However, there is currently weak demand for timber from these THPs. Additionally, if these THPs were exhausted, there is much more timberland which could sustainably support commercial harvest. In fiscal year (FY) 2015-2016 (ending March 31st), there was no commercial softwood harvest in the Teslin SFMP, and in the Whitehorse region, the harvest was 1,367 m^3 for fuelwood and 258 m^3 for sawlogs (Gavin Dykshoorn, pers. comm. February 13, 2017). The Annual Allowable Cut in the Teslin region is 25,000 m^3/year, and in the Whitehorse region it is 10,000 m^3/year coniferous trees and 2,000 m^3/year deciduous trees (YG 2017).

Table 6: Teslin Commercial Timber Harvest Residuals

THP	Distance Category	OU Area (ha)	Allowed OU Harvest Limits			Actual Historical Harvest		
			Total Target Volume (m^3)	Total Waste from Target Volume (m^3)	Total Waste from Target Volume (kg)	Estimated Mean Annual Merch. Volume (m^3/yr)	Assumed Mean Annual Waste Volume (m^3/yr)	Total Waste from Target Volume (kg)
Sawmill Rd - Demo Forest[1]	0-50 km	361	4,300	645	242,609	10	2	564
Lubbock Valley	51-100 km	1,973	14,065	2,110	793,557	110	17	6,206
Marsh Lake	101-150 km	16	2,000	300	112,841	100	15	5,642
Total		**2,350**	**20,365**	**3,055**	**1,149,007**	**220**	**33**	**12,413**

Note 1 The SRDF THP has not seen any recent commercial harvest, however, for the purposes of this report, 10 m^3/year is assumed

3.2 Gravel Extraction

Using Method 1, which considers only active highway gravel pits, there are 64 identified active gravel pits along the Alaska Highway, Canol Road, Atlin Road, and South Klondike Highway (Figure 1). Table 7 presents the results from this method, which as discussed previously, assumes an existing cleared size of 3 ha per pit and an average age of 40 years per existing active pit, and then calculates future annual clearing based on this rate of land usage.

Table 7: Teslin Gravel Pit Timber Volumes using Method 1

Distance Category	Number of Active Gravel Pits	Anticipated Area to be Cleared (ha/yr)	Anticipated Volume of Wood Waste (m^3/yr)	Anticipated Dry Mass of Wood Waste (kg/yr)
0-50 km	10	1	97	36,497
51-100 km	24	2	233	87,593
101-150 km	30	2	291	109,491
Total	**64**	**5**	**621**	**233,582**

The results using Method 2 are shown in Table 8. Note that the active highway gravel pits which were analyzed in Method 1 are a subset of the gravel pit dispositions which are used to generate this table.

Table 8: Teslin Gravel Pit Timber Volumes using Method 2

Distance Category	Number of Gravel Pit Dispositions	Gross Area of Dispositions (ha)	Estimated Forested Area of Dispositions (ha)	Anticipated Area to be Cleared per Year (ha/yr)	Anticipated Volume of Wood Waste (m^3/yr)	Anticipated Dry Mass of Wood Waste (kg/yr)
0-50 km	46	1,455	1,078	86	11,158	4,196,894
51-100 km	32	1,093	810	65	8,382	3,152,842
101-150 km	52	1,719	1,273	102	13,179	4,957,040
Total	**130**	**4,268**	**3,161**	**253**	**32,719**	**12,306,775**

3.3 Mining

Spatial data on Placer and Quartz mining claims near Teslin were obtained from GeoYukon (Figure 1). Table 9 presents the data for the Teslin region. There were a significant number of claims in closely spaced groups, so rather than provide the total number of mining claims, adjacent claims were grouped into "mining areas." This more closely approximates the number of different sites which have the potential to produce residual biomass.

Table 9: Teslin Mining Timber Volumes

Distance Category	Number of Placer Mining Areas	Number of Quartz Mining Areas	Anticipated Area to be Cleared (ha/yr)	Anticipated Volume of Wood Waste (m^3/yr)	Anticipated Dry Mass of Wood Waste (kg/yr)
0-50 km	0	0	0	0	0
51-100 km	14	7	8,030	6,926	2,605,009
101-150 km	6	17	46,383	40,005	15,047,375
Total	**20**	**24**	**54,412**	**46,931**	**17,652,384**

3.4 Fuel Abatement

A fuel abatement treatment plan for Teslin was not available; however, the interface zone near Teslin is estimated to be approximately 500 hectares. It is unknown how much treatment to this zone has already taken place. Based on the fact that bark beetle activity is minimal in Teslin, a treatment horizon of 50 years is assumed. This time horizon ensures that understory removal and thinning will take place at approximately the rate of forest regrowth, while maintaining a thinner and younger stand. Table 10 provides a summary of the results.

Table 10: Teslin Fuel Abatement Timber Volumes

Area of Interface Zone (ha)	Total Merchantable Volume (m^3)	Total Waste from Merch. Volume (m^3)	Area Treated Per Year (ha/yr)	Estimated Mean Annual Merch. Volume (m^3/yr)	Estimated Mean Annual Waste Volume (kg/yr)
500	16,875	2,531	10	51	19,042

It is important to note that much of the treatment and corresponding wood removal is likely already being accomplished by local residents with personal firewood cutting permits. In the past 3 years, YG has issued approximately 50 personal use firewood cutting permits per year in the Teslin District. YG assumes an average fuelwood harvest of 7 m^3 per permit, although each permit allows harvest of up to 25 m^3 (David Swinson, pers. comm. March 15, 2017). While it is likely that some of the permit holders in the Teslin District live outside of Teslin, if all 50 permit holders harvested their wood in the interface zone near Teslin, then this will easily exceed the volume of wood projected in Table 10. While YG does have control over personal fuelwood harvesting locations, execution of fuel abatement projects in the Teslin interface area which divert residuals for biomass use may interfere with the firewood supply of local residents.

3.5 Teslin Summary

Table 11 presents a summary of wood waste sources near Teslin sorted by rank.

Table 11: Anticipated Annual Wood Waste near Teslin within 150 km

Source	Wet Volume (m^3)	Oven Dry Mass (kg)	Rank
Mining	46,931	17,652,384	1
Gravel (Method 1)	621	233,582	2
Fuel Abatement	51	19,042	3
Forestry	33	12,413	4
Total	**47,635**	**17,917,420**	

4.0 WOOD WASTE AVAILABILITY NEAR HAINES JUNCTION

For Haines Junction, as with Teslin, the distance categories from the urban centre to timber residuals are calculated based on radial distance, with the exception that all sites situated along the North Klondike Highway or along the Alaska Highway past the junction of those highways are excluded, at the request of the client (Figure 2).

4.1 Timber Harvest Areas

Timber volumes and available areas around Haines Junction were determined using Operating Unit net and/or target areas and target volumes identified in the Timber Harvest Plans for their areas (Figure 2). Where gross areas and volumes were only available, 50% of gross area and volume was considered available to account for reserves, roads, unmerchantable areas, etc. Fuelwood harvest areas were not included, as fuelwood harvest is anticipated to be on a small scale, and is not anticipated to leave residual waste sufficient for biomass harvest.

Haines Junction Operating Units under THPs are those associated with:

- Mackintosh East
- Building Logs
- Marshal Creek
- Bear Creek
- Pine Canyon
- Quill Creek
- Kluane Lake East

Near Haines Junction 84,043 hectares are tenured with timber harvest plans within the study radius for forestry operations. Operating Units within those Timber Harvest Plans within those areas total 4,469 hectares available for harvest, considering reserve areas and other withdrawals from harvest. The available volume in these currently specified Operating Units is 549,334 m^3. Assuming that commercial operations will remove commercially merchantable stems, and that 15% of commercial volume is available for biomass as residuals, 82,400 m^3 of volume is available as wood waste in the OU area, totaling 30,729,686 oven dry kg.

Table 12 presents the commercial timber volumes for FY 2016 for the Champagne-Aishihik Forest Resources Management Plan region, which is the sum of all of the THPs discussed for Haines Junction.

Table 12: FY 2016 Commercial Timber Volume Harvested near Haines Junction

Tenure Type	FY 2016 Volume (m^3)
Fuelwood	11,805
Timber Resources (sawlog)	91
Total	**11,896**

Assuming that the harvest levels in Haines Junction for FY 2016 represent typical harvest volumes for the area, the existing OU area will take 50 years to completely harvest assuming the same harvest levels going forward. Table 13 presents the results for Haines Junction showing the gross timber and residuals available from the existing THPs, as well as the annual timber and residuals generated if these OUs were harvested over a 50 year period, which is approximately equal to current harvest levels. The current OU area is only a fraction of the total timber resource in this region, and is well below the maximum sustainable harvest level.

Table 13: Haines Junction Commercial Timber Harvest Residuals

Distance Category	Available OU Area (assuming OUs not already partially logged)	Allowed OU Harvest Limits			Assuming 50-year Harvest Cycle of OUs		
		Merchantable Volume (m^3)	Waste Volume (m^3)	Dry Mass of Waste (kg)	Merchantable Volume (m^3/yr)	Waste Volume (m^3/yr)	Dry Mass of Waste (kg/yr)
0-50 km	4,385	544,294	81,644	30,447,749	10,886	1,633	608,955
51-100 km	0	0	0	0	0	0	0
101-150 km	84	5,040	756	281,937	101	15	5,639
Total	**4,469**	**549,334**	**82,400**	**30,729,686**	**10,987**	**1,648**	**614,594**

4.2 Gravel Extraction

Using Method 1, which considers only active highway gravel pits, there are 47 identified active gravel pits along the Alaska Highway, Haines Road, and Aishihik Road. Table 14 presents the results from this method, which as discussed previously, assumes an existing cleared size of 3 ha per pit and an average age of 40 years per existing active pit, and then calculates future annual clearing based on this rate of land usage.

Table 14: Haines Junction Gravel Pit Timber Volumes using Method 1

Distance Category	Number of Active Gravel Pits	Anticipated Area to be Cleared (ha/yr)	Anticipated Volume of Wood Waste (m^3/yr)	Anticipated Dry Mass of Wood Waste (kg/yr)
0-50 km	17	1	147	54,681
51-100 km	23	2	198	73,981
101-150 km	7	1	60	22,516
Total	**47**	**4**	**405**	**151,178**

The results using Method 2 are shown in Table 15. Note that the gravel pit dispositions which are used to generate this table in most cases encompass the active highway gravel pits which were analyzed in Method 1.

Table 15: Haines Junction Gravel Pit Timber Volumes using Method 2

Distance Category	Number of Gravel Pit Dispositions	Gross Area of Dispositions (ha)	Estimated Forested Area of Dispositions (ha)	Anticipated Area to be Cleared per Year (ha/yr)	Anticipated Volume of Wood Waste (m^3/yr)	Anticipated Dry Mass of Wood Waste (kg/yr)
0-50 km	38	1,211	1,002	80	9,217	3,437,256
51-100 km	30	1,530	1,192	95	10,968	4,090,230
101-150 km	20	896	500	40	4,602	1,716,337
Total	**88**	**3,637**	**2,694**	**216**	**24,787**	**9,243,823**

4.3 Mining

Spatial data on Placer and Quartz mining claims near Haines Junction were obtained from GeoYukon. Table 16 presents the data for the Haines Junction region. There were a significant number of claims in closely spaced groups, so rather than provide the total number of mining claims, adjacent claims were grouped into “mining areas.” This more closely approximates the number of different sites which have the potential to produce residual biomass.

Table 16: Haines Junction Mining Timber Volumes

Distance Category	Number of Placer Mining Areas	Number of Quartz Mining Areas	Anticipated Area to be Cleared (ha/yr)	Anticipated Volume of Wood Waste (m^3/yr)	Anticipated Dry Mass of Wood Waste (kg/yr)
0-50 km	8	2	1,648	1,263	471,114
51-100 km	9	7	16,742	12,836	4,786,789
101-150 km	10	2	11,911	9,132	3,405,534
Total	**27**	**11**	**30,301**	**23,231**	**8,663,436**

4.4 Fuel Abatement

There are two fuel abatement treatment plans in the region around Haines Junction. The first is for Haines Junction itself, and the second is for Silver City. Based on beetle activity levels, a treatment horizon of 20 years is assumed for this area. Table 17 provides a summary of the results.

Table 17: Haines Junction Fuel Abatement Timber Volumes

Location	Distance to HJ (km)	Treatment Area (ha)	Total Merch. Volume (m^3)	Total Waste from Merch. Volume (m^3)	Estimated Mean Annual Merch. Volume (m^3/yr)	Estimated Mean Annual Waste Volume (m^3/yr)	Estimated Mean Annual Waste Volume (kg/yr)
Silver City	63	521	31,260	4,689	1563	234	87,434
HJ	0	1,239	74,340	11,151	3717	558	207,929
Total		**1,760**	**105,600**	**15,840**	**5,280**	**792**	**295,363**

4.5 Haines Junction Summary

Table 18 presents a summary of wood waste sources near Haines Junction sorted by rank.

Table 18: Anticipated Annual Wood Waste near Haines Junction within 150 km

Source	Wet Volume (m^3)	Oven Dry Mass (kg)	Rank
Mining	23,231	8,663,436	1
Forestry	1,648	614,594	2
Fuel Abatement	792	295,363	3
Gravel (Method 1)	405	151,178	4
Total	**26,076**	**9,724,570**	

5.0 RECOVERY AND DELIVERY TO TRANSFER STATION

It is assumed in this study that forest residuals will be delimbed and skidded to landing areas as part of the conditions of the permit granted. It is also assumed there is minimal additional cost to stacking forest residuals for access by a truck with mounted log loader than other approved methods of cleaning sites of residuals to reclaim forested land, or disposal of residuals from mining or gravel operations.

In areas of North America where there are established woodchip markets for fuel, two models have evolved for collecting and processing the material. The first model does the chipping into a van trailer at a landing where logs have been skidded from the forest. The second model has a log truck pick up the logs from a landing where they have been skidded and delivered to a central chip processing site. Chipping at the forest landing is more commonly done where the chipped wood can be directly delivered to the market and significant quantities of material are available for chipping at each location to justify moving and setting up the chipper, forwarder and chip trucks. This model also requires access for large van trailers, which can typically haul 90 cubic metres of woodchips.

Using a log truck with a log loader attached to pick up the residual material and deliver to a common processing site is more efficient when there are multiple sites and limited quantities at each site. A single truck and driver can be dispatched instead of multiple pieces of equipment and generally the bulk density of logs loaded on a logging truck will be approximately 2 times greater than chipped wood depending on the uniformity and shape of the logs.

The model recommended for the Haines Junction and Teslin areas to collect and process the wood is using log trucks with attached log loaders and delivery to a central Transfer Station. The majority of material that results from gravel pit or mine clearing will be whole logs while material generated from commercial logging residuals will be shorter and smaller in diameter as the main trunk will have been harvested. Picking up residuals from commercial timber harvesting is likely to require a solid dump truck body along with a log truck with log loader to ensure that the smaller material can be safely hauled.

5.1 Recovery at Forest Landings

Logging trucks equipped with hydraulic log loading booms are available for hire in the Yukon Territory. They can be either configured as an individual truck or a B-Train with towed trailer (Myles Thorp, pers. comm. March 23, 2017). While there may be some sites where B-Train configurations could be accommodated it is assumed for this study that individual logging trucks with an average load size of 40 cubic metres will be used to pick up wood residuals in the form of logs from mining sites and gravel pits. At forest landings where residuals are the result of commercial logging operations it is assumed that a 40 foot dump trailer and tractor will accompany the self-loading log truck to haul shorter material from topping logs that could not be safely transported on a log truck. An average of 20 cubic metres of logs stacked on the log truck and 20 cubic metres hauled in the dump trailer are used per round trip when the residuals are the result of a commercial timber harvest.

The time to set up and load the log truck at the landing for mines and gravel pit clearings is estimated at 1 hour and the time to set up and load the log truck and dump trailer is estimated at 1.5 hours at commercial timber harvest sites.

5.2 Delivery to Transfer Station

Based on the sites identified earlier in this report, an average distance and volume from the Transfer Stations to the forest landings is estimated for each zone and activity expected to generate residual material. The results are shown in Table 19 and Table 20.

Table 19: Distances and Volumes from Teslin Transfer Station to Forest Landings

Distance Category	Forestry		Gravel			Mining		Fuel Abatement	
	Average Distance to Site (km)	Total Volume (m^3/yr)	Average Distance to Site (km)	Active Pits Total Volume (m^3/yr)	Land Dispositions Total Volume (m^3 /yr)	Average Distance to Site (km)	Total Volume (m^3/yr)	Average Distance to Site (km)	Total Volume (m^3/yr)
0-50 km	5	2	36	97	11,158	n/a	0	2	51
51-100 km	130	17	103	233	8,382	114	6,926	n/a	0
101-150 km	132	15	163	291	13,179	189	40,005	n/a	0
Total		**33**		**621**	**32,719**		**46,931**		**51**

Table 20: Distances and Volumes from Haines Junction Transfer Station to Forest Landings

Distance Category	Forestry		Gravel			Mining		Fuel Abatement	
	Average Distance to Site (km)	Total Volume (m^3/yr)	Average Distance to Site (km)	Active Pits Total Volume (m^3/yr)	Land Dispositions Total Volume (m^3/yr)	Average Distance to Site (km)	Total Volume (m^3/yr)	Average Distance to Site (km)	Total Volume (m^3/yr)
0-50 km	37	1,633	28	147	9,217	34	1,263	4	558
51-100 km	n/a	0	83	198	10,968	96	12,836	63	234
101-150 km	110	15	141	60	4,602	151	9,132	n/a	0
Total		**1,648**		**405**	**24,787**		**23,231**		**792**

The travel times are calculated based on the average of round trip road distances to the landing locations within radii of 0-50 km, 50-100 km, and 100-150 km from the Transfer Stations for each source of residual material. An average speed of 60 km/hour is used to calculate the travel time from pick up location to the Transfer Stations.

The initial annual quantity of wood required at the Haines Junction and Teslin processing stations is estimated to be 766 m^3 and 4,578 m^3, respectively. This is based on district heating projects that are planned for the two communities with annual heating loads of 500,000 kWh for Haines Junction and 3,000,000 kWh for Teslin, (thermal loads for district heating projects at the two locations were supplied by YG). The cost to contract a log truck and driver in the local area is assumed to be $165 per hour (Ivan Thompson, pers. comm. March 27, 2017). The cost to deliver the wood from the forest landing sites to the transfer station is calculated by starting in the closest zones and working out to the outer zones. 1.5 hours is added to the travel times to accommodate loading and unloading of the truck.

Table 21 shows costs for picking up and delivering material to the Transfer Station at each location based on working out from the closest zones until the demand is met.

Table 21: Costs to Pick up at Forest Landings and Deliver to Transfer Stations

Community	Initial Volume (m^3/yr)	Number of Truck Trips (*n*/yr)	Distance Driven (km/yr)	Transport Cost ($/$m^3$)
Teslin	2,170	54	11,862	$21.22
Haines Junction	361	9	570	$10.53

While commercial timber harvesting and fuel abatement removals do occur close to the village of Haines Junction, it is more economical to collect whole logs from gravel and mining tenures. This is due to the added cost of bringing a second dump truck to haul the shorter tops and smaller diameter residuals at commercial logging sites that cannot be safely hauled on a log truck. It is also assumed that the overall length and density of this material will be lower than whole tree logs, so the net volume on the dump truck and log truck will be approximately equal to the volume of whole trees that can be hauled on a single log truck from gravel and mining tenures. Table 22 summarizes the added costs for collecting from these locations vs. mining and gravel tenures.

Table 22: Comparing Gravel/Mining to Forestry/Fuel Abatement Costs

Collection Sites	Initial Volume (m^3/yr)	Number of Truck Trips (*n*/yr)	Distance Driven (km/yr)	Transport Cost ($/$m^3$)
HJ (Gravel and Mining)	361	9	570	$10.53
HJ (Forestry and Fuel Abatement)	361	18	144	$17.60

Table 23 demonstrates the added cost of moving into a zone farther from the Transfer Station. The average distances shown in this table are based on averages of all 4 tenure types considered (forestry, gravel, mining, and fuel abatement), and assume that residuals are picked up using a single vehicle. In reality the material will be procured in the most cost effective locations first so moving into the next zone away from the Transfer Station will minimally affect the cost to pick up and deliver.

Table 23: Delivery Cost Comparison by Distance from Transfer Station

Distance Category	Average Distance (km)	Loading Time (hr)	Round Trip Drive Time (hr)	Unloading Time (hr)	Total Time (hr)	Transport Cost ($/m^3)
0-50 km	21	1.0	0.7	0.5	2.2	$9.06
51-100 km	98	1.0	3.3	0.5	4.8	$19.69
101-150 km	148	1.0	4.9	0.5	6.4	$26.49

Due to the efficiency of sending only one vehicle and hauling 40 m^3 loads, gathering material in the 100 km to 150 km zone does not appear to be prohibitive in cost; however, in practice each site will have unique costs based on quality of secondary roads and ease of access.

6.0 PROCESSING AND STORAGE

The processing and transfer stations are to be located within 5 km of the villages of Teslin and Haines Junction to reduce overall trucking costs as the log trucks can haul more than three times greater mass of wood fuel than the available end dump trucks that will deliver woodchips to the end user. Other advantages of locating the Transfer Stations close to the villages are available utilities and convenience for staffing.

The Processing and Transfer Stations will accommodate the following tasks:

- Accept delivery from log trucks with grapple unloading booms
- Store and stage approximately 5,000 m^3 of logs
- Chip logs into woodchip fuel
- Covered storage on paved surfaces for 495 m^3 of woodchips
- Provide equipment and access for loading woodchips from storage on to end dump trucks
- Figure 3 shows a summary of the process flow at the Transfer Station.

6.1 Transfer Station Layout

The Transfer Station serves the functions of: accepting and staging residuals in round wood from forest landings, maintaining inventory to allow drying of the logs, processing round wood into woodchips and covered storage of chipped wood for pick up by the community. A site plan layout was developed for the initial woodchip demand anticipated at Teslin and is included in Figure 4.

At the Transfer Station log decks are constructed using logs for runners and bunk ends constructed from I-Beams. Spacing of the aisles provides room for the log truck with self-loading boom (Figure 5), to unload directly onto the log decks. An access road on both sides of the log stacks allows delivery trucks to enter an aisle from one side of the yard, unload onto a stack, and exit from the opposite side. In addition a landing area is provided for unloading and separating shorter length and smaller diameter material. Log storage decks are planned to be 2.5 metres high, full log, or 6 metres wide, and approximately 24 metres long. The log storage area needed for a one year supply of logs requires 0.25 hectares. The storage area and access roads will be cleared, leveled and covered with compacted gravel.

At the end of the log deck area a covered storage building with a paved floor is provided to minimize contamination of the chipped wood. Paved aprons are provided for chipping the logs and blowing chips directly into the building and for loading woodchips from the storage onto 20 m³ end dump trucks for delivery to the district heating systems. A circular drive is planned to allow end dump trucks to pull in to be loaded from the side, and then continue off the site. The circular drive will be paved with asphalt.

The Chip Storage building contains sufficient space to hold 2-weeks of fuel at peak heating demand or approximately 495 m³. The peak heating demand was assumed for 10 boilers, each rated for 100 kW. A small personnel trailer was planned for the site with toilet facilities. The layout of each Transfer Station is identical even though Haines Junction's initial expected demand is only 1/6 of Teslin's planned demand. It is anticipated that in the future, Haines Junction's demand for woodchips will equal or exceed Teslin's due to the larger population.

The estimated capital cost to construct the Transfer Stations is $508,000 each, with no capital cost included for the acquisition of land. The sites chosen should have room to expand the log storage yards as demand for woodchips increases. The building location and design should also allow for future additional storage. A more detailed capital cost breakdown of the Transfer Stations is included in Appendix B.

6.2 Wood Chip Fuel Quality

Biomass combustion units designed to burn wood chips are flexible in the moisture content, chip size and ash percentage that they can burn. Generally larger industrial biomass burners, 1,000 kW and up, can effectively burn fuel with moisture content up to 50% and handle larger chip sizes and higher ash contents. Smaller wood chip boilers such as the models selected for the Teslin and Haines Junction projects require dryer and smaller, more uniform chip sizes. Ash content is directly related to the volume of bark and dirt embedded in the log from skidding and handling. Leaving tree tops and limbs in the woods can improve chip quality as they contain a higher percentage of bark to wood and when gathered, and have the potential to introduce excess dirt and foreign material into the fuel supply. Critical to success in establishing woodchip burning appliances in the YT is a quality woodchip that minimizes material handling problems in the smaller appliances likely to be installed. Quality is defined as: consistent moisture content between 25% and 35%, sizing less than 5 cm in all dimensions, minimal or no oversized pieces to jam fuel handling, ash content <1%, and free from debris such as rocks and dirt.

The most cost effective method for producing dryer woodchips is to stage the wood in log form and allow the logs to air dry. The predominate trees species available in the areas are white spruce and lodgepole pine which, if harvested green, should sit in log form for approximately 1 year to have the resulting woodchips be in the range of 35% to 25% moisture. Also available in the area are fire killed and beetle killed trees that will be dry enough to chip when harvested. The round wood can be staged at either the landing in the forest or at the central processing site to allow drying to the level required for the chips.

It is critical that foreign debris not be picked up and fed through the chipper due to potential damage to the chipper and to the furnace fuel handling system, should the foreign material end up in the fuel supply. To reduce dirt accumulating on the logs, winter logging practices are recommended and the Transfer Station is recommended to have log decks for storing logs clear of the ground. The staging area next to the chipper and floor of the chip storage are to be paved to reduce chances of introducing foreign debris into the fuel.

6.3 Equipment

Equipment provided at the Transfer Stations includes:

- At each Transfer Station a used front end loader on wheels in good condition with 3 m³ bucket and log grapple, 3,000 kg net load capacity
- At each location a used knuckle boom loader for feeding logs into the chipper

- A new mobile chipper that can be shuttled between the two Transfer Stations

The used front end loader with the log grapple attached will be used to stage wood on the log decks and transport logs from the log decks to the chipper. A front end loader similar to a Volvo L50 in good condition with a 3 to 4 m^3 commodity bucket and log grapple attachments are suggested (see Figure 6). A budget of $100,000 with 8,000 hours of useful life remaining was used to amortize and assign operating costs for this piece of equipment.

The used log loader with knuckleboom attachment will be stationed next to the mobile chipper that will blow chips directly into the storage building. A log loader similar to a Barko 495ML log loader with knuckleboom in good condition is suggested (see Figure 7). A budget of $80,000 with 6,000 hours of useful remaining life was used to amortize and assign costs for the log loader.

The mobile chipper selected is able to handle logs up 50 cm in diameter making a uniform chip using a drum chipper design. The model selected was a new Bandit model 2290 whole tree chipper with 440 Hp engine (see Figure 8). A budget of $689,000 and a useful life of 9,000 hours is used to amortize and assign operating costs for the chipper. The cost for operating the chipper assumes a throughput of 50% of the rated capacity with a loaded labor rate of $45 per hour for a skilled heavy equipment operator. Table 24 summarizes the operating costs for the Transfer Stations. Table 25, Table 26, and Table 27 list the assumptions used. In these tables, “Ownership cost per hour” equals (capital cost - salvage value) / hours of useful life, but it does not include: insurance, interest, or opportunity cost of investment. “Machine cost per hour” includes fuel, depreciation, lubricants, repair and maintenance, and labor.

Table 24: Transfer Station Operating Costs

Site	Transfer Station - Staging Delivered Logs ($/m^3)	Transfer Station - Loader Forwarding to Chipper ($/m^3)	Transfer Station - Log Loader and WoodChipper Costs ($/m^3)	Misc. Transfer Station Costs ($/m^3)	Total Operating Costs at Transfer Station ($/m^3)
Teslin	$1.34	$2.68	$5.60	$5.76	**$15.38**
HJ	$1.34	$2.68	$5.60	$19.62	**$29.24**

Table 25: Chipper Assumptions for Calculating Transfer Station Operating Costs

Item	Value	Units
loaded labor Rate	$45.00	$/hr
Chipping Capacity	135	m^3/hr
Chipper productivity (% of time logs flow thru chipper)	50%	percent
Volume chipped per cycle	400	m^3
Chip density at 25% moisture	240	kg/m^3
Chipper R&M costs	$91.87	per hour
Chipper Capital Cost	$689,000	
Chipper Hp	440	Hp
useful life	9,000	hours
salvage value	$137,800	
Ownership cost per hour	$61.24	per hour
Fuel use chipper	73.21	litre per hour
Fuel cost	$80.53	per hour
Lubricants and fluids	$12.08	per hour

Table 25: Chipper Assumptions for Calculating Transfer Station Operating Costs

Item	Value	Units
Machine cost per hour without operator	$245.72	per hour

Table 26: Front End Loader Assumptions for Calculating Transfer Station Operating Costs

Item	Value	Units
capital cost	$100,000	
useful life	8,000	hours
salvage value	$20,000	
Ownership cost per hour	$10.00	per hour
fuel use	20.80	litre per hour
fuel cost	$22.88	per hour
Loader Hp	125	Hp
Loader R & M Costs	$15.00	per hour
lubricants	$3.43	per hour
Machine cost per hour without operator	$51.31	per hour

Table 27: Log Loader Assumptions for Calculating Transfer Station Operating Costs

Item	Value	Units
capital cost	$80,000	
useful life	6,000	hours
salvage value	$16,000	
Ownership cost per hour	$10.67	per hour
fuel use	12.48	litre per hour
fuel cost	$13.73	per hour
Loader Hp	75	Hp
Loader R & M Costs	$16.00	per hour
lubricants	$2.06	per hour
Machine cost per hour without operator	$42.45	per hour

6.4 Woodchipping Options

Both grinders and wood chippers can process logs or chunk wood into wood fuel. A grinder is able to handle logs with more dirt or debris than chippers. Grinders usually make a smaller, finer end product and when used with a small enough screen virtually eliminate longer sticks or oversized pieces. Grinders have higher maintenance costs but generally a longer useful life. Generally chippers are preferred for smaller boiler appliances similar to the Hargassner units being installed in Haines Junction and Teslin as chips tend to combust better than ground material.

Bear Creek Logging located in Haines Junction has purchased a Bandit model 3680 drum grinder (Ivan Thompson, pers. comm., March 27, 2017). The projected cost to go on site and perform grinding of a client's logs is $375/hr for the grinder and $125/hr for a log loader with Knuckleboom attachment to feed the grinder. A setup charge for each move of the grinder will be charged at the rate of $165/hr. Estimated throughput for the grinder is 50 tonnes per hour (Ivan Thompson, pers. comm., March 27, 2017).

Using the costs provided by Mr. Thompson for grinding services, and assuming that there will be 8 set up fees per year for moving the machine from Haines Junction to Teslin, the cost for contracting the grinding of the wood residuals is $9.45/m³, compared to $5.69/m³ to purchase a new chipper and used log loader and employ a skilled operator.

7.0 DELIVERY TO END USERS

It is assumed that the district heating plants can accommodate deliveries up to 20 cubic metres of woodchips from an end dump truck which is a typical tri-axle dump truck used for hauling bulk commodities and readily available for hire in the area. It is not proposed to have full time staffing at the Transfer Station for loading the woodchips from the covered storage on to the delivery trucks. Community users will be required to contract with a company that could provide a truck and driver capable of operating a wheeled loader and safely loading the delivery truck at the Transfer Station. Distance from the Transfer Station to the boiler plant should be 5 km or less for both sites. Table 28 summarizes delivery costs.

Table 28: Delivery Cost from Transfer Station to Boiler Plant

Site	*Delivery Volume (m³)	Round Trip Cycle Time (hr)	Trucking Rate ($/hr)	Loading Cost ($/load)	Delivery Cost ($/m³)
Teslin	10.2	1	$165	$0	$16.18
HJ	10.2	1	$165	$0	$16.18

Note *Delivery volume is based on round wood equivalent = 474 kg/m³ at 25% moisture wet basis

All calculations for processing costs and transportation costs are based on m³ of round wood (solid wood). The density of solid wood at 25% moisture is assumed to be 474 kg/m³ while the density of 25% moisture chipped wood is assumed to be 241 kg/m³. The 20 m³ end dump truck used to deliver the woodchips to the district energy site will hold 10.2 m³ of equivalent solid wood.

It is not anticipated that the woodchips will be sold or have value at the Transfer Station so no scale is planned. For planning purposes a reasonably accurate history of woodchips delivered can be kept in a log book where the contracted truck driver records loader buckets dumped on to the delivery truck, or a record of the number of loads from a known volume delivery truck. No value is assigned to the community users for operating the wheeled loader. That cost is assumed by the Yukon Government and included in miscellaneous costs inTable 24.

8.0 SUMMARY OF COSTS

Table 29 summarizes the costs for aggregating roundwood and producing woodchips. The costs to deliver residuals to the Transfer Station vary depending on the distances to the sources of the residuals. Because Teslin is expected to require a greater volume of woodchips, and because there is less activity which generates residuals in close proximity to Teslin, the delivery cost of the residuals to Teslin is higher than for Haines Junction.

Table 29: Summary of Costs to Aggregate Roundwood and Produce Chips

Site	Cost to Deliver Residuals to Transfer Station ($/m^3)	Transfer Station - Staging Delivered Logs ($/m^3)	Transfer Station - Loader Forwarding to Chipper ($/m^3)	Transfer Station - Log Loader and Wood Chipper Costs ($/m^3)	Misc. Transfer Station Costs ($/m^3)	Total From Forest to Processed Chips ($/m^3)
Teslin	$21.22	$1.34	$2.68	$5.60	$5.76	$36.60
HJ	$10.53	$1.34	$2.68	$5.60	$19.62	$39.76

Staging of delivered logs at the Transfer Station is accomplished by the front end loader with a log grapple. It is assumed that the loader can carry 3 m^3 of residuals in each grapple load, and that the cycle time to grab a load of logs from the delivery point and stage them on the racks is 5 minutes. However, it is also assumed that the front end loader will only have to handle 1/2 of the material when it is delivered, and that the other 1/2 of the material will be stacked by the self-loading logging truck. The cost of the truck unloading and stacking is included in the cost to deliver the residuals to the Transfer Station.

The cost for the loader to forward the logs from the racks to the chipper is based on the same assumptions except this time the loader must handle all the logs, rather than 50%, resulting in twice the cost per cubic metre for this step compared to the previous.

The knuckleboom log loader will be stationed next to the chipper and will operate in conjunction with the chipper. The front end loader will place the logs in a stack within reach of the log loader. Chipper throughput is estimated at 67.5 m^3/hr, 50% of the rated capacity of the chipper; this assumption includes an allowance for times when material is not being processed by the chipper since it is expected that the throughput of the chipper will be greater than the cycle time of the log loader.

Miscellaneous costs include utilities at each site, and the round trip cost to move the chipper between Haines Junction and Teslin four times per year. An annual cost of $6,000 for utilities at each site is assumed; because of the lower throughput at Haines Junction, this results in a greater cost per cubic metre. The cost for movement of the chipper is shared by the two sites proportional to each site's chip production.

For tasks at the Transfer Station, a loaded labor rate of $45.00/hr is assumed for YG staff operating the front end loader, log loader, and chipper.

9.0 COMPARATIVE COST OF ENERGY

The cost of fossil fuels typically used for heating in Teslin and Haines Junction were compared to two biomass fuels, wood pellets and woodchips. Table 30 and Table 31 summarize the fuel costs for Teslin and Haines Junction, respectively.

Historical costs for the fossil fuels were provided by YG. In this analysis, fossil fuel prices shown are averages of the three year period of 2014-2016.

The cost for bulk wood pellet delivery and for bagged pellets was obtained for Whitehorse, and is assumed to be approximately the same for both Teslin and Haines Junction. Bagged pellets are sold in 40 lb. (18 kg) bags, while bulk pellets are assumed to come in loads of approximately 30 tonnes.

Woodchip prices from BC are assumed to be from sawmills in the Terrace or Dawson Creek regions, delivered to the end user in Yukon. Note that sourcing wood pellets from BC is less costly than sourcing woodchips from BC due to the greater bulk density of wood pellets.

The costs of local woodchips were based on the transport and processing costs developed in this report.

Table 30: Energy Fuel Cost Comparison for Teslin

Technology, Unit	Cost/Unit	Input Energy (MJ / Unit)	Assumed Efficiency	Output Energy (MJ / Unit)	Energy Cost ($/GJ)
Furnace Oil, litre	$1.12	39.0	78%	30.4	$36.90
Artic Stove Oil, litre	$1.15	34.7	78%	27.1	$42.35
Propane, litre	$0.88	25.5	75%	19.1	$46.09
Wood Pellet (Bags), tonne	$358	19,500	75%	14,625	$24.50
Wood Pellet (Bulk), tonne	$330	19,500	75%	14,625	$22.56
***Wood Chip (local-25% MC), tonne**	**$111**	**15,000**	**70%**	**10,500**	**$10.60**
Woodchip (BC-30% MC), tonne	$336	14,000	70%	9,800	$34.29

Note *Estimated cost assigns $0 value to the wood residuals gathered at forest landings

Table 31: Energy Fuel Cost Comparison for Haines Junction

Technology, Unit	Cost/Unit	Input Energy (MJ / Unit)	Assumed Efficiency	Output Energy (MJ / Unit)	Energy Cost ($/GJ)
Furnace Oil, litre	$1.10	39.0	78%	30.4	$36.08
Artic Stove Oil, litre	$1.11	34.7	78%	27.1	$40.96
Propane, litre	$0.88	25.5	75%	19.1	$46.09
Wood Pellet (Bags), tonne	$358	19,500	75%	14,625	$24.50
Wood Pellet (Bulk), tonne	$330	19,500	75%	14,625	$22.56
***Woodchip (local-25% MC), tonne**	**$118**	**15,000**	**70%**	**10,500**	**$11.24**
Woodchip (BC-30% MC), tonne	$395	14,000	70%	9,800	$40.31

Note *Estimated cost assigns $0 value to the wood residuals gathered at forest landings

10.0 CONCLUSIONS

Locally produced woodchips from forest residuals at $10.60 per GJ in Teslin and $11.24 per GJ in Haines Junction, are less than half the net cost per GJ of the next lowest cost fuel choice of bulk wood pellets and 1/3 the cost of furnace oil for both Teslin and Haines Junction. Calculated in the cost of net delivered GJ for the woodchips are the costs to pick up and transport the wood from forest landings to community processing centres, stage and store the wood in log form to allow it to dry, process the logs into woodchips, and pick up and deliver the wood chips to the end users. Not included in the cost of the woodchips are capital costs for the processing centres, insurance on the facilities or equipment, interest costs on the invested capital or costs for stumpage fees or getting the wood to the forest landings. Included in the woodchip cost are all operating costs, including depreciation costs on the equipment at the processing centres.

Initial capital investment in the two sites is estimated at $508,000 each for site work and buildings, $189,000 each for a wheel loader and log loader for each site, and $689,000 for a chipper shared between the two sites, for a total of $2.1 million. Although this capital cost assumes that the two sites share a mobile chipper, a local logging company has invested in a grinder capable of processing the log wood into a ground material, and could potentially provide the grinding at one or both of the sites as a service. Woodchip quality is critical to successfully growing the users of woodchip fuel and the equipment or service provider to process the wood is an important consideration.

The suggested model for producing woodchips for community use from these residuals is: collection in log form from forest landings, delivery to a central processing plant near each community, storing in log form to allow for drying, and chipping into a covered storage for pick up by the community users.

Adequate wood volumes in the form of residuals generated from commercial activities conducted on public lands exist to support supplying woodchips for community thermal energy systems in both the Teslin and Haines Junction communities. In Haines Junction within 50 km of the community more than 10 times the initial projected demand of 361 m^3 of residuals is available from commercial timber harvests annually. In Teslin within 100 km of the community it is estimated that more than 3 times the initial projected annual demand of 2,170 m^3 is available annually, primarily from mine clearing activities.

11.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

Prepared by:
Tom Wilson
Wilson Engineering Services, PC
Direct Line: 814.337.8223
TWilson@wilsonengineeringservices.com

Reviewed by:
Kristina Gardner, RPF, PMP
Senior Project Manager - Whitehorse
Environment and Water Practice
Direct Line: 867.668.9229
Kristina.Gardner@tetratech.com

REFERENCES

Government of Yukon (YG). 2016. Yukon Biomass Energy Strategy. http://www.energy.gov.yk.ca/pdf/Yukon-Biomass-Energy-Strategy-Feb2016.pdf. [accessed March 29, 2017]

Government of Yukon (YG). 2014. Fact Sheet 7: Timber on Mining Claims. http://www.emr.gov.yk.ca/forestry/timber_mining_claims.html. [accessed March 24, 2017]

Government of Yukon (YG). 2011. Sawmill Road - Demonstration Forest Timber Harvest Plan. http://www.emr.gov.yk.ca/forestry/pdf/approved_sawmill_road_demonstration_forest_thp.pdf. [accessed March 14, 2017]

Government of Yukon (YG). 2006. Forest Management Plan for the Teslin Tlingit Traditional Territory. http://www.emr.gov.yk.ca/forestry/pdf/fmp_for_tttt.pdf. [accessed March 14, 2017]

Government of Yukon (YG). 2011a. 2011 Lubbock Valley Timber Harvest Plan. http://www.emr.gov.yk.ca/forestry/pdf/approved_thp_lubbockvalley_whitehorse_20110106.pdf. [accessed March 15, 2017]

Government of Yukon (YG). 2012. 2012 Lubbock Valley THP. http://www.emr.gov.yk.ca/forestry/pdf/approved_thp_2012lubbockvalley_20121105.pdf. [accessed March 15, 2017]

Government of Yukon (YG). 2011b. 2011 Marsh Lake THP. http://www.emr.gov.yk.ca/forestry/pdf/approved_thp_marshlakedump_20110210.pdf. [accessed March 15, 2017]

Government of Yukon (YG). 2017. Annual Allowable Cut / Annual Limit. http://www.emr.gov.yk.ca/forestry/annual_allowable_cut.html. [accessed March 24, 2017]

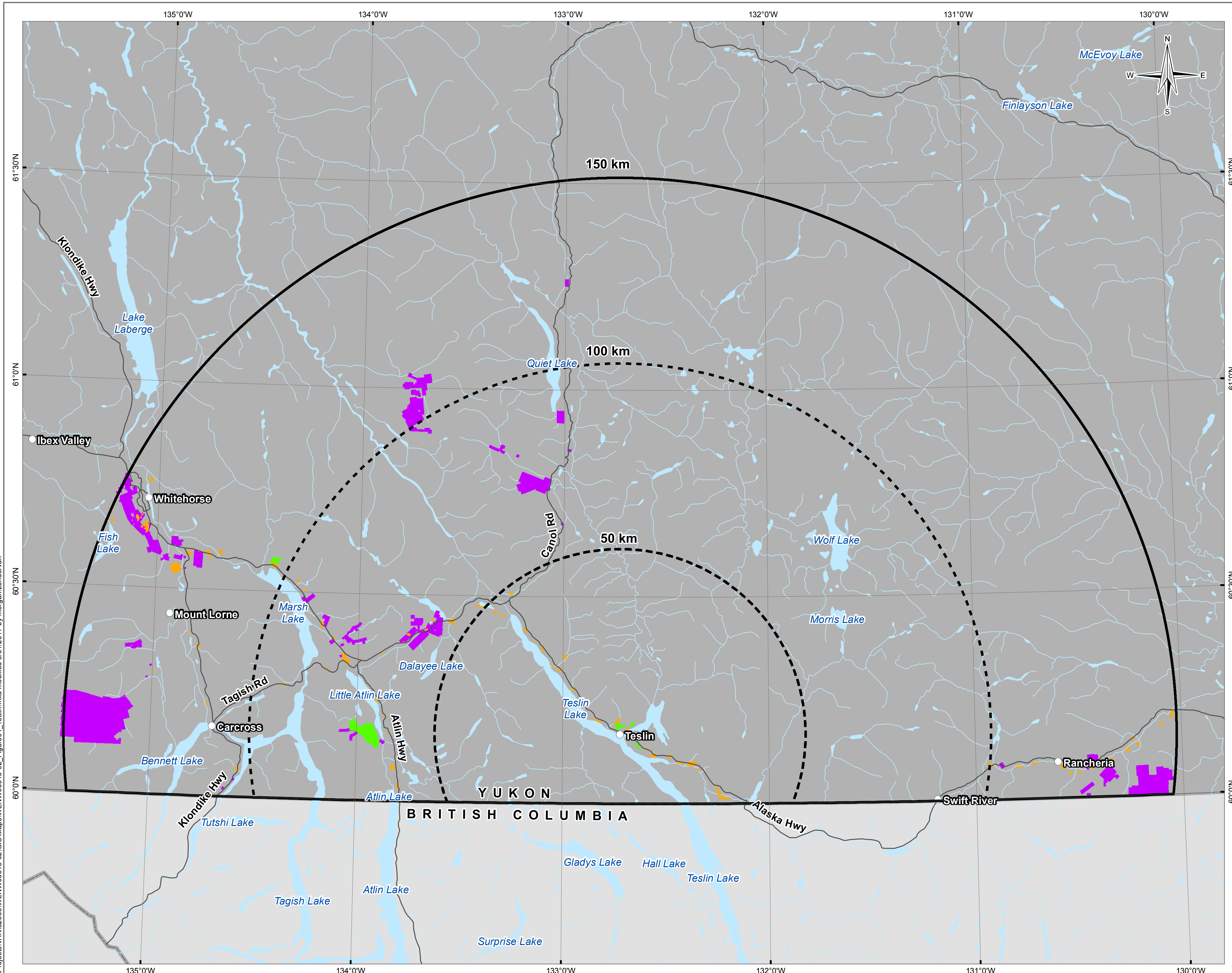
Henry P. 2000. Timber Supply Analysis Southern Yukon March 2000.

Miles, Patrick D. and Smith, Brad W. 2009. Specific Gravity and Other Properties of Wood and Bark for 156 Tree Species Found in North America. United States Department of Agriculture, Forest Service, Northern Research Station. https://www.nrs.fs.fed.us/pubs/rn/rn_nrs38.pdf. [accessed March 20, 2017]

Tetra Tech Inc. 2017. Wood Waste Feedstock Assessment – Haines Junction and Watson Lake, YT 704-ENW.WENW03015-01.

FIGURES

Figure 1 Areas of Potential Clearing within the Teslin Study Area
Figure 2 Areas of Potential Clearing within the Haines Junction Study Area
Figure 3 Transfer Station Process Flow Diagram
Figure 4 Transfer Station Site Plan
Figure 5 Log Truck with Self-Loading Boom
Figure 6 Wheeled Front End Loader with Log Grapple
Figure 7 Knuckleboom Log Loader for Feeding Chipper
Figure 8 Wood Chipper with Drum Chipping Head



NOTES
Base data source:
CanVec 1:1M
Areas of potential clearing assembled from various Geomatics Yukon datasets (accessed February 2017)

STATUS
ISSUED FOR REVIEW

BIOMASS FEEDSTOCK RECOVERY & TRANSPORT ASSESSMENT, HAINES JUNCTION AND TESLIN

Areas of Potential Clearing within the Teslin Study Area

PROJECTION	DATUM	CLIENT
Yukon Albers	NAD83	Yukon Government

Scale: 1:1,000,000

20 10 0 20

Kilometres

FILE NO.
WENW03015-02_Figure01_Teslin.mxd

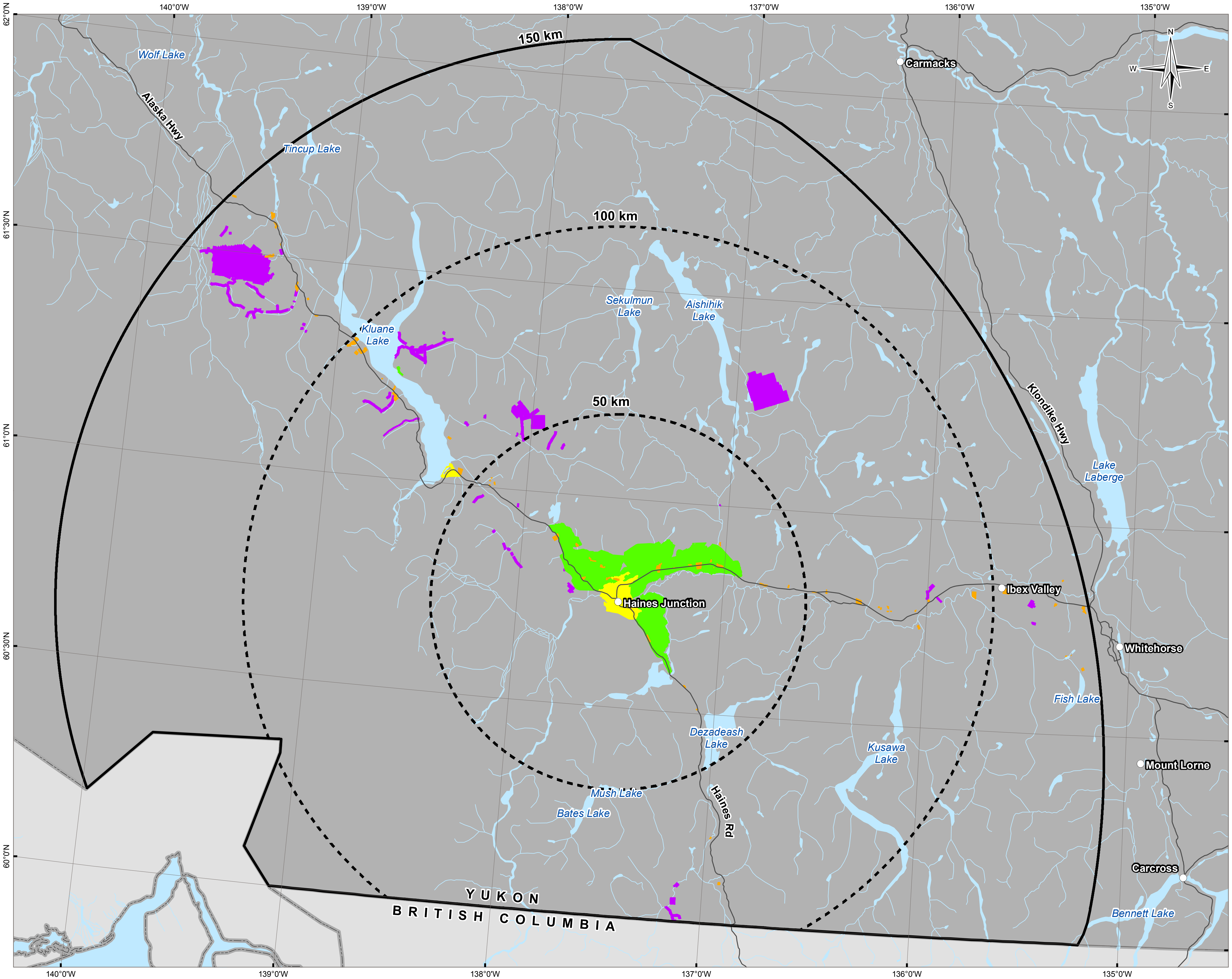
TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	MEZ	SL	PO	0

DATE	PROJECT NO.
March 27, 2017	ENW.WENW03015-02

Figure 1

W:\Projects\VAN\62566\WENW03015-02\GIS\Maps\WENW03015-02_Figure01_Teslin.mxd modified 3/31/2017 by morgan.zonderva n



LEGEND

- Study Area
- Community
- Road
- Watercourse
- Waterbody
- Provincial Boundary

Areas of Potential Clearing

- Timber Harvest Plan
- Fuel Abatement Area
- Active Quartz or Placer Claim
- Quarry or Gravel Pit Lease/Reservation/Disposition

NOTES
Base data source:
CanVec 1:1M
Areas of potential clearing assembled from various Geomatics Yukon datasets (accessed February 2017)

STATUS
ISSUED FOR REVIEW

BIOMASS FEEDSTOCK RECOVERY & TRANSPORT ASSESSMENT, HAINES JUNCTION AND TESLIN

Areas of Potential Clearing within the Haines Junction Study Area

PROJECTION	DATUM	CLIENT
Yukon Albers	NAD83	Yukon Government

Scale: 1:1,000,000
20 10 0 20
Kilometres

TETRA TECH

FILE NO.
WENW03015-02_Figure02_HainesJunction.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	MEZ	SL	PO	0

DATE	PROJECT NO.
March 31, 2017	ENW.WENW03015-02

Figure 2

W:\Projects\VAN\62566\WENW03015-02\GIS\Maps\WENW03015-02_Figure02_HainesJunction.mxd modified 3/31/2017 by morgan.zondervan

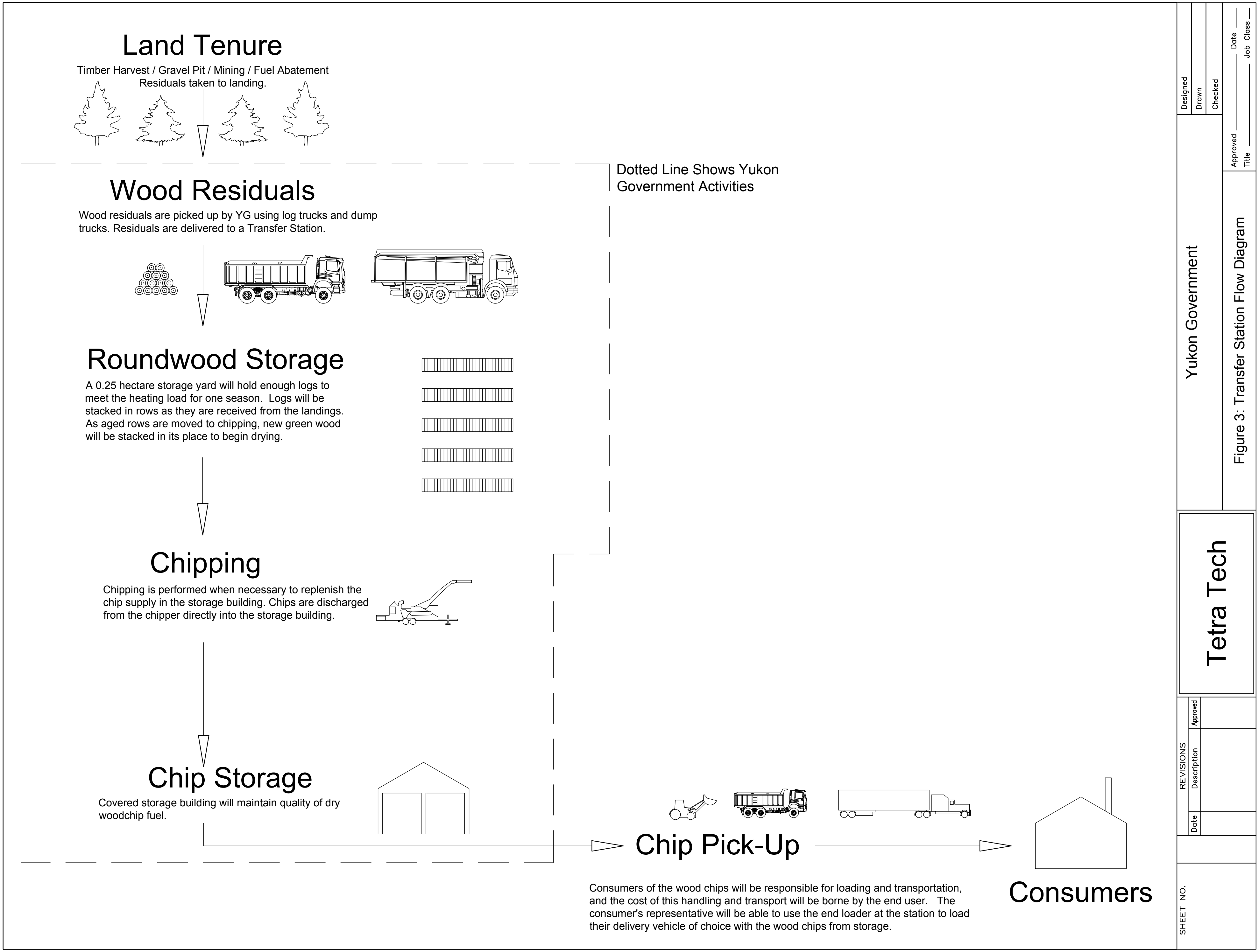
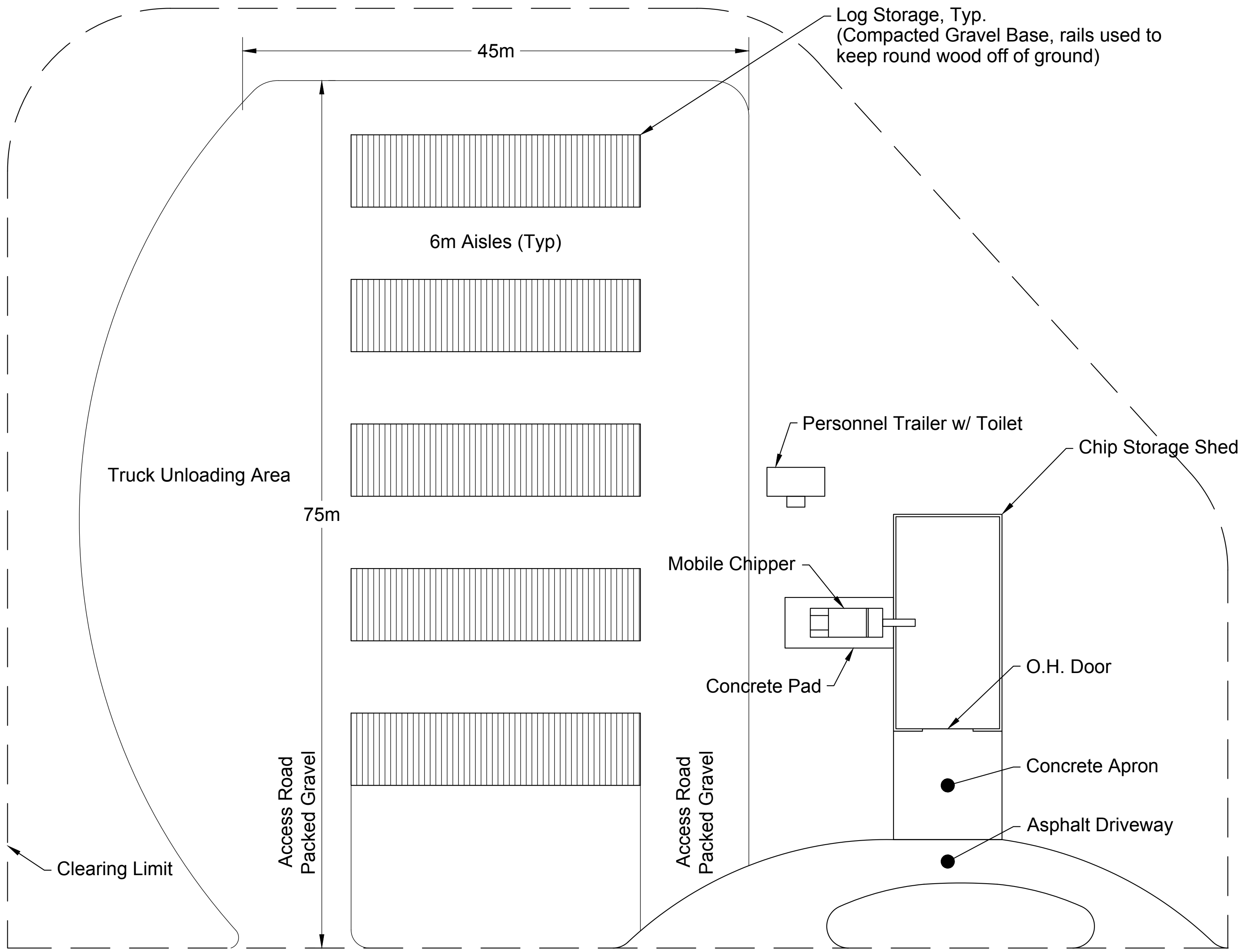


Figure 3: Transfer Station Flow Diagram



Transfer Station Site Plan

Notes:
1) Actual Site arrangement would depend on site selected.
2) Basic Area required is 0.5 hectares, but may change depending on final site selected

Yukon Government

Figure 4: Transfer Station Site Plan

Tetra Tech

Designed | Drawn | Checked | Date | Job Class | Approved | Title

REVISIONS | Date | Description | Approved

SHEET NO.

Log Truck with Knuckleboom Loader
(Image courtesy Bear Creek Logging)

Figure 5

Wheel Loader with Log Grapple
(Image courtesy Bob Adams, Flickr, CC BY-SA 2.0)

Figure 6

Cat 579C Knuckleboom Log Loader
(Image courtesy Caterpillar)

Figure 7

Bandit 2290 Drum Chipper
(Image courtesy Bandit Industries Inc.)

Figure 8

APPENDIX A
TETRA TECH'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOENVIRONMENTAL REPORT – GOVERNMENT OF YUKON

This report incorporates and is subject to these "General Conditions".

1.1 USE OF REPORT AND OWNERSHIP

This report pertains to a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment.

This report and the assessments and recommendations contained in it are intended for the sole use of TETRA TECH's client. TETRA TECH does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than TETRA TECH's Client unless otherwise authorized in writing by TETRA TECH. Any unauthorized use of the report is at the sole risk of the user.

1.2 ALTERNATE REPORT FORMAT

Where TETRA TECH submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed TETRA TECH's instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by TETRA TECH shall be deemed to be the original for the Project.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.

1.4 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of the report, TETRA TECH may rely on information provided by persons other than the Client. While TETRA TECH endeavours to verify the accuracy of such information when instructed to do so by the Client, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

APPENDIX B
TRANSFER STATION CAPITAL COST ESTIMATE

Transfer Station Capital Cost Estimate

Site Work - Cost for Each Transfer Station (0.5 hectare)	Cost	
Clearing and Grubbing	$	16,000
Grading and Leveling	$	7,000
Compacted Gravel Base	$	11,000
Log Stack End Stanchions	$	13,000
Asphalt Paving	$	17,000
Slab for Chipper	$	10,000
Apron Slab for Loading	$	19,000
Total Site Work	**$**	**93,000**
Structures - Per Transfer Station		
Chip Storage Building	$	228,000
Personnel Trailer	$	25,000
Total Structures	**$**	**253,000**
Sub-Total (Site Work & Structures)	$	346,000
Contractor profit, overhead, and insurance 16%	*$*	*55,360*
Total General Contract	**$**	**401,360**
Professional Services [2] 10%	*$*	*40,136*
Contingency 15%	*$*	*66,224*
Total Construction Cost per Transfer Station	**$**	**507,720**
Equipment - Per Transfer Station		
Loader (used 3 cubic meter bucket and log grapple, 3 tonne net payload)	$	100,000
Log Deck Loader (Used, for feeding chipper)	$	80,000
Diesel Storage Tank W/ Dispenser (2082 liters)	$	9,000
Total Equipment Cost per Transfer station	**$**	**189,000**
Equipment - Shared by Transfer Stations		
Chipper	$	689,000
Teslin Transfer Station	**$**	**696,720**
Haines Junction Transfer Station	**$**	**696,720**
Two Transfer Stations and Chipper	$	2,082,440

Notes:

1 - Costs are approximate.

2 - Professional Services includes engineering, permitting, legal, and project management.

3 - Values given in Canadian dollars. Currency exchage rate of 1.3 applied to US dollars.