Pre-Feasibility Assessment for Integration of Wood-Fired Heating Systems Final Report

July 24, 2012

Nenana City School District
City of Nenana
Nenana, Alaska

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Nenana School District
City of Nenana

In partnership with
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Alaska Wood Energy Development Task Group

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1.0 Executive Summary

The following assessment was commissioned to determine the preliminary technical and economic feasibility of integrating a wood fired heating system at the Nenana School, School Administration, School Warehouse, School Living Center, Nenana Native Council Day Care, Nenana Fire Department, Nenana Water Plant, and the Meda Lord Senior Center in Nenana, Alaska.

The following tables summarize the current fuel use and the potential wood fuel use:

Table 1.1 - Annual Fuel Use Summary

Facility Name	Fuel Type	Avg. Use (Gallons)	Current Cost/Gal.	Annual Cost
School	Fuel Oil	34,000	$3.60	$122,400
School Admin	Fuel Oil	1,600	$3.60	$5,760
School Whse.	Fuel Oil	4,200	$3.60	$15,120
Student Living Center	Fuel Oil	28,800	$3.60	$103,680
NNC Day Care	Fuel Oil	4550	$3.60	$16,380
Water Plant	Fuel Oil	10700	$3.60	$38,520
Fire Dept.	Fuel Oil	3950	$3.60	$14,220
Meda Lord Senior Center	Fuel Oil	6566	$4.00	$26,264

Table 1. 2 - Annual Wood Fuel Use Summary

	Fuel Oil (Gallons)	Cord Wood (Cords)	Wood Pellets (Tons)	Chipped/ Ground Wood (Tons)
School (S)	34,000	297.1	270.9	373.8
School Admin (SA)	1,600	14.0	12.7	17.6
School Warehouse (SW)	4,200	36.7	33.5	46.2
School Living Center (SLC)	28,800	251.7	229.4	316.6
Nenana Native Council Day Care (DC)	4,550	39.8	36.2	50.0
City Water Plant (WP)	10,700	93.5	85.2	117.6
City Fire Dept (FD)	3,950	34.5	31.5	43.4
Meda Lord Senior Center (ML)	6566	57.4	52.3	72.2
S + SA	35,600	311.1	283.6	391.3
S + SA + SW	39,800	347.8	317.1	437.5
S + SA + SW + DC	44,350	387.6	353.3	487.5
S + SA + SW + DC + WP	55,050	481.1	438.6	605.2
S + SA + SW + DC + WP + FD	59,000	515.6	470.0	648.6
S + SA + SW + DC + WP + FD + SLC	87,800	767.3	699.5	1037.3
S + SA + SW + SLC	68,600	599.5	546.5	754.1

Note: Wood fuel use assumes offsetting 85% of the current energy use.

Based on the potential wood fuel use, all options except the Meda Lord Senior Center will evaluate wood chip and wood pellet boilers. Because of the smaller fuel use, the Meda Lord Senior Center will evaluate a cord wood boiler system.

Wood Chip Boiler Options:

- A.1: Nenana School only.
- A.2: Nenana School, Administration Building, and Warehouse.
- A.3: Nenana School, Administration Building, Warehouse, and NNC Daycare.
- A.4: Nenana School, Administration Building, Warehouse, NNC Daycare, and Water Plant.
- A.5: Nenana School, Administration Building, Warehouse, NNC Daycare, Water Plant, and Fire Department.
- A.6: Nenana School, Administration Building, Warehouse, and Living Center.

Wood Pellet Boiler Options:

- B.1: Nenana School only.

Cord Wood Boiler Options:

- C.1: Meda Lord Senior Center only.

The following table summarizes the economic evaluation for each option:

Table 1.3 - Economic Evaluation Summary
Nenana Biomass Heating System

	Project Cost	Year 1 Operating Savings	NPV 30 yr at 3%	NPV 20 yr at 3%	20 Yr B/C Ratio	30 Yr B/C Ratio	ACF YR 20	ACF YR 30	YR ACF=PC
A.1	$1,780,000	$59,208	$2,832,089	$1,616,943	0.91	1.59	$2,303,414	$4,911,172	18
A.2	$1,960,000	$72,175	$3,385,501	$1,940,341	0.99	1.73	$2,761,778	$5,862,829	17
A.3	$2,150,000	$81,506	$3,795,177	$2,177,730	1.01	1.77	$3,098,786	$6,569,425	16
A.4	$2,590,000	$99,342	$4,638,894	$2,656,188	1.03	1.79	$3,780,882	$8,035,572	16
A.5	$2,680,000	$106,772	$4,975,009	$2,849,249	1.06	1.86	$4,055,426	$8,617,079	16
A.6	$2,860,000	$112,808	$5,441,730	$3,085,014	1.08	1.90	$4,399,622	$9,458,385	16
B.1	$1,300,000	$7,206	$1,289,692	$590,490	0.45	0.99	$882,087	$2,389,469	24
C.1	$280,000	-$1,773	$220,868	$88,173	0.31	0.79	$137,198	$423,622	26

Connecting the school with several nearby buildings with a wood fired district heating system appears to be an economically viable project. With the current economic assumptions, the school alone and the school combined with the administration building and the school warehouse don't quite meet the minimum 20 year B/C ratio of 1.0 However, when adding in the daycare, the water plant, and fire department, all these incremental options have 20 year B/C ratios greater than 1.0. The additional energy saved by connecting several buildings together offsets the significant additional cost of underground piping and pumping costs. The best option was A.6 which connected the

school with the administration building, the school warehouse, and the student living center. Even with the significant piping costs, the extra pumping energy, and the extra wood fuel needed to offset the heat loss of the long pipe runs, this option remains the strongest relative to the other options.

2.0 Introduction

The following assessment was commissioned to determine the preliminary technical and economic feasibility of integrating a wood fired heating system at the Nenana School, School Administration, School Warehouse, School Living Center, Nenana Native Council Day Care, Nenana Fire Department, Nenana Water Plant, and the Meda Lord Senior Center in Nenana, Alaska.

3.0 Existing Building Systems

The School District is responsible for the School, School Administration, School Warehouse, and Student Living Center. The City of Nenana is responsible for the Water Plant and Fire Department. The Nenana Native Council is responsible for the Day Care and the Alaska Interior Regional Housing Authority is responsible for the Meda Lord Senior Center. There is a high level of cooperation amongst all the organizations and by extension with the Toghotthele Native Corporation which currently operates a lumber mill and is capable of providing chipped or ground wood fuel for use in future wood fired boiler projects.

The Nenana School is a wood framed and steel stud building constructed in 1955 and expanded in 1966 and 1986. The gymnasium is a wood framed and steel stud building constructed in 1972 and was connected to the main school during the 1986 addition. The entire facility is approximately 70,860 square feet. There are two boiler rooms in the facility: one in the original school building and one in the gym. In a major mechanical system retrofit to occurred approximately 15 years ago, new heating water mains were installed throughout the facility, and the boilers were re-piped to provide heat to this main loop. That work allows any boiler to provide heat to the entire facility. In the original building boiler room there are two 2,503,000 Btu/hr output hot water boilers. These boilers appear to be approximately 15 years old and are in good condition. In the gym boiler room there are two 950,000 Btu/hr output hot water boilers. These boilers appeared to be original to the gym construction and are in fair condition. Each boiler room has a large approximately 500 gallon indirect domestic hot water heater using boiler water as the heating source.

The Nenana School Administration Building is a wood framed modular building constructed in 2005. The facility is approximately 2,480 square feet and is heated by a 196,000 Btu/hr output hot water boiler. The boiler is original to the building and in good condition. The heating system infrastructure is original to the building and in good condition.

The Nenana School Warehouse is a prefabricated metal building with interior insulation on metal wall panels on a concrete slab on grade constructed in 1982. The facility is approximately 6,500 square feet and is heated by one 236,000 Btu/hr output and one 212,000 Btu/hr output hot water boilers. Domestic hot water is provided by a 30 gallon electric water heater rated at 5.5 KW input. One boiler is original to the building and is in fair condition, and the other boiler is new, installed within the past year. The heating system infrastructure is original to the building and in fair condition.

The Nenana Student Living Center is a wood framed dormitory building constructed in 2002 with approximately 88 sleeping rooms and 44 shared restroom/shower facilities. The facility is approximately 32,700 square feet and is heated by a 1,372,000 Btu/hr output hot water boiler. Domestic hot water is provided by a 623,000 Btu/hr fuel oil fired hot water heater with a 85 gallon storage tank. The existing boiler and hot water heater are original

to the building and in good condition. The heating system infrastructure is original to the building and in good condition.

The Nenana Water Plant is a wood framed building constructed in the mid 1970's and houses equipment required to store, heat, and pump the community water system. The facility is approximately 5,000 square feet and utilizes a 1,110,000 Btu/hr output hot water boiler. The existing boiler is original to the building and is in fair condition. The heating system infrastructure is original to the building and in fair condition.

The Nenana Fire Department is a metal building constructed in early 1980's. The facility is approximately 4,000 square feet and is heated by two 272,000 Btu/hr output hot water boilers. Domestic hot water is provided by a 40 gallon electric water heater rated at 4.5 KW input. The existing boilers are approximately 9 years old and in good condition. The heating system infrastructure is original to the building an in fair condition. The building was not reviewed during the field visit because CTA had gathered data during a trip to Nenana in December, 2011. The feasibility assessment of the facility is included in this report.

The Meda Lord Senior Center is a wood framed building constructed in 1993. The facility is approximately 13,000 square feet and is heated by three 488,000 Btu/hr output hot water boilers. Domestic hot water is provided by a 155 gallon indirect water heater using boiler water as the heating source. The existing boilers are original to the building and in fair condition. The heating system infrastructure is original to the building and in fair condition.

Facilities Dropped from Feasibility Study
The Nenana Library was not reviewed during the field visit due to the small size and low fuel use.

Facilities Added to Feasibility Study
The Nenana Native Council Day Care was added to the potential facilities during the site visit. The building is a wood framed building constructed in 2006. The facility is approximately 6,500 square feet and is heated by a 347,000 Btu/hr output hot water boiler. Domestic hot water is provided by a 120 gallon indirect water heater using boiler water as the heating source. The existing boiler is original to the building and is in good condition. The heating system infrastructure is original to the building and in good condition.

4.0 Energy Use

Fuel use summaries for the facilities were provided and the following table summarizes the data:

Table 4.1 - Annual Fuel Use Summary

Facility Name	Fuel Type	Avg. Use (Gallons)	Current Cost/Gal.	Annual Cost
School	Fuel Oil	34,000	$3.60	$122,400
School Admin	Fuel Oil	1,600	$3.60	$5,760
School Whse.	Fuel Oil	4,200	$3.60	$15,120
Student Living Center	Fuel Oil	28,800	$3.60	$103,680
NNC Day Care	Fuel Oil	4550	$3.60	$16,380
Water Plant	Fuel Oil	10700	$3.60	$38,520
Fire Dept.	Fuel Oil	3950	$3.60	$14,220
Meda Lord Senior Center	Fuel Oil	6566	$4.00	$26,264

Electrical energy consumption will increase with the installation of the wood fired boiler system because of the power needed for the biomass boiler components such as augers, conveyors, draft fans, etc. and the additional pumps needed to integrate into the existing heating systems. The cash flow analysis accounts for the additional electrical energy consumption and reduces the annual savings accordingly.

5.0 Biomass Boiler Size

The following table summarized the connected load of fuel fired boilers and domestic water heaters:

Table 5.1 - Connected Boiler Load Summary

			Output MBH	Peak Load Factor	Likely System Peak MBH
School	Boiler A	Fuel Oil	2503	0.66	1652
	Boiler B	Fuel Oil	2503	0.66	1652
	Boiler C	Fuel Oil	950	0.66	627
	Boiler D	Fuel Oil	950	0.66	627
Total			6906		4558
School Admin	Boiler	Fuel Oil	196	1.00	196
School Warehouse	Boiler	Fuel Oil	236	0.67	158
	Boiler	Fuel Oil	212	0.67	142
Total					300
School Living Center	Boiler	Fuel Oil	1372	1.00	1372
	DWH	Fuel Oil	623	1.00	623
Total					1995

Table 5.1 - Connected Boiler Load Summary					
Nenana NC Day Care	Boiler	Fuel Oil	347	1.00	347
City Water Plant	Boiler	Fuel Oil	1110	1.00	1110
City Fire Dept	Boiler	Fuel Oil	272	0.60	163
	Boiler	Fuel Oil	272	0.60	163
Total					326
Meda Lord Sr. Center	Boiler 1	Fuel Oil	488	0.66	322
	Boiler 2	Fuel Oil	488	0.66	322
	Boiler 3	Fuel Oil	488	0.66	322
Total			1464		966
Total Of All Buildings			**13010**		**9799**

Typically a wood heating system is sized to meet approximately 85% of the typical annual heating energy use of the building. The existing heating boilers would be used for the other 15% of the time during peak heating conditions, during times when the biomass boiler is down for servicing, and during swing months when only a few hours of heating each day are required. Recent energy models have found that a boiler sized at 50% to 60% of the building peak load will typically accommodate 85% of the boiler run hours. Several projects are under consideration in Nenana, therefore the boiler size will vary with each option as noted below.

Table 5.2 - Proposed Biomass Boiler Size			
	Likely System Peak MBH	Biomass Boiler Factor	Biomass Boiler Size MBH
School (S) (Option 1)	4558	0.6	2735
School Admin (SA)	196	0.6	118
School Warehouse (SW)	300	0.6	180
School Living Center (SLC)	1995	0.6	1197
Nenana Native Council Day Care (DC)	347	0.6	208
City Water Plant (WP)	1110	0.6	666
City Fire Dept (FD)	326	0.6	196
Meda Lord Senior Center (ML)	966	0.6	580
S + SA	4754	0.6	2852
S + SA + SW (Option 2)	5054	0.6	3032
S + SA + SW + DC (Option 3)	5401	0.6	3241
S + SA + SW + DC + WP (Option 4)	6511	0.6	3907
S + SA + SW + DC + WP + FD (Option 5)	6838	0.6	4103
S + SA + SW + DC + WP + FD + SLC	9799	0.6	5879
S + SA + SW + SLC (Option 6)	7049	0.6	4229

A district system around the school will be evaluated. Stand-alone systems for the Student Living Center and the Meda Lord Senior Center will also be evaluated since these buildings are so far from the school.

6.0 Wood Fuel Use

The types of wood fuel available in the area include cord wood, wood pellets, and chipped/ground wood fuel. The estimated amount of wood fuel needed of each wood fuel type for each building was calculated and is listed below:

Table 6.1 - Annual Wood Fuel Use Summary

	Fuel Oil (Gallons)	Cord Wood (Cords)	Wood Pellets (Tons)	Chipped/ Ground Wood (Tons)
School (S)	34,000	297.1	270.9	373.8
School Admin (SA)	1,600	14.0	12.7	17.6
School Warehouse (SW)	4,200	36.7	33.5	46.2
School Living Center (SLC)	28,800	251.7	229.4	316.6
Nenana Native Council Day Care (DC)	4,550	39.8	36.2	50.0
City Water Plant (WP)	10,700	93.5	85.2	117.6
City Fire Dept (FD)	3,950	34.5	31.5	43.4
Meda Lord Senior Center (ML)	6566	57.4	52.3	72.2
S + SA	35,600	311.1	283.6	391.3
S + SA + SW	39,800	347.8	317.1	437.5
S + SA + SW + DC	44,350	387.6	353.3	487.5
S + SA + SW + DC + WP	55,050	481.1	438.6	605.2
S + SA + SW + DC + WP + FD	59,000	515.6	470.0	648.6
S + SA + SW + DC + WP + FD + SLC	87,800	767.3	699.5	1037.3
S + SA + SW + SLC	68,600	599.5	546.5	754.1

Note: Wood fuel use assumes offsetting 85% of the current energy use.

The amount of wood fuel shown in the table is for offsetting 85% of the total fuel oil use. The moisture content of the wood fuels and the overall wood burning system efficiencies were accounted for in these calculations. The existing fuel oil boilers were assumed to be 80% efficient. Cord wood was assumed to be 20% moisture content (MC) with a system efficiency of 65%. Wood pellets were assumed to be 7% MC with a system efficiency of 70%. Chipped/ground fuel was assumed to be 30% MC with a system efficiency of 65%.

The primary project is the school. As can be seen from the potential wood fuel use, the volume of wood is such that a cord wood system is not really practical and further analysis will look at pellet and chipped/ground fuel options. A cord wood only system for the Meda Lord Senior Center will be evaluated since it would be a stand-alone system.

Toghotthele Corporation owns 138,000 acres of land, of which most of it is forested. There are also State lands around Nenana. With some recent wild fires, there is some desire in the area to thin some of the forests around the city to create fire breaks. The agricultural area to the west is also planned to be opened up in the next few years, and there will be

significant amount of wood to be removed as this land is developed. Toghotthele is actively managing their land and is currently logging some of it. They are looking into purchasing more logging equipment and even a chipper. If a biomass project was to develop, Toghotthele would likely be the entity to provide the wood. Wood pellets are also available from Superior Pellet Fuels out of North Pole and can be trucked down the Parks Highway. There appears to be a sufficient supply of wood fuel to support a wood fired boiler for this community.

The unit fuel costs for fuel oil and the different fuel types were calculated and equalized to dollars per million Btu ($/MMBtu) to allow for direct comparison. The Delivered $/MMBtu is the cost of the fuel based on what is actually delivered to the heating system, which includes all the inefficiencies of the different systems. The Gross $/MMBtu is the cost of the fuel based on raw fuel, or the higher heating value and does not account for any system inefficiencies. The following table summarizes the equalized fuel costs at different fuel unit costs:

Table 6.2 - Unit Fuel Costs Equalized to $/MMBtu

Fuel Type	Units	Gross Btu/unit	System Efficiency	Net System Btu/unit	$/unit	Delivered $/MMBtu	Gross $/MMBtu
Fuel Oil	gal	134500	0.8	107600	$3.60	$33.46	$26.77
					$4.00	$37.17	$29.74
					$4.50	$41.82	$33.46
Cord Wood	cords	16173800	0.65	10512970	$200.00	$19.02	$12.37
					$250.00	$23.78	$15.46
					$300.00	$28.54	$18.55
Pellets	tons	16400000	0.7	11480000	$300.00	$26.13	$18.29
					$350.00	$30.49	$21.34
					$400.00	$34.84	$24.39
Chips	tons	10800000	0.65	7020000	$75.00	$10.68	$6.94
					$100.00	$14.25	$9.26
					$125.00	$17.81	$11.57

7.0 Boiler Plant Location and Site Access

None of the existing boiler rooms are large enough to fit a new biomass boiler so a new stand alone boiler plant would be required. The existing gravel parking lot west of the Administration building has been identified as the preferred location for a central heating plant. A stand alone plant for the Meda Lord Senior Center would be located on the west side of the building.

Any type of biomass boiler system will require access by delivery vehicles, typically 40 foot long chips vans or some similar type of trailer. Wood fuel is likely to be chipped or ground by the Toghotthele Native Corporation and delivered to a central boiler plant. The proposed plant location includes access from three adjacent streets and is in close proximity to each of the potential facilities with the exception of the Student Living Center and the Meda Lord Senior Center. Nenana is on the Parks Highway, so highway access is good.

8.0 Integration with Existing Heating Systems

Integration of a wood fired boiler system would be relatively straight forward in each location. The field visit confirmed the location of each boiler room in order to identify an approximate point of connection from a district heating loop to each existing building. Connections would typically be achieved with artic pipe extended to the face of each building, and extended up the exterior surface of the building in order to penetrate exterior wall into the boiler room. Once hot supply and return piping enters the existing boiler room it would be connected to existing supply and return lines in appropriate locations in order to utilize existing pumping systems within each building.

9.0 Air Quality Permits

Resource System Group has done a preliminary review of potential air quality issues in the area. Interior Alaska is prone to meteorological conditions that create thermal inversions, which are unfavorable for the dispersion of emissions. Since this plant will be located at a school and is also located in the populated area, the air quality will likely be scrutinized and modeling of emissions, the stack height, and of air pollution control devices is recommended. Due to the high percentage of “calms” during the winter in interior Alaska, all options at the school include the cost of an electrostatic precipitator (ESP). The proposed boiler size at this location is small enough, that the boiler is not likely to require any State or Federal permits. See the air quality memo in Appendix D.

10.0 Wood Heating Options

The technologies available to produce heating energy from wood based biomass are varied in their approach, but largely can be separated into three types of heating plants: cord wood, wood pellet and wood chip/ground wood fueled. See Appendix E for these summaries.

Based on the potential wood fuel use, all options except the Meda Lord Senior Center will evaluate wood chip and wood pellet boilers. Because of the smaller fuel use, the Meda Lord Senior Center will evaluate a cord wood boiler system.

Wood Chip Boiler Options:

- A.1: Nenana School only.
- A.2: Nenana School, Administration Building, and Warehouse.
- A.3: Nenana School, Administration Building, Warehouse, and NNC Daycare.
- A.4: Nenana School, Administration Building, Warehouse, NNC Daycare, and Water Plant.
- A.5: Nenana School, Administration Building, Warehouse, NNC Daycare, Water Plant, and Fire Department.
- A.6: Nenana School, Administration Building, Warehouse, and Living Center.

Wood Pellet Boiler Options:

- B.1: Nenana School only.

Cord Wood Boiler Options:

- C.1: Meda Lord Senior Center only.

All wood chip and pellet options assume a central boiler plant is used and located next to the Administration building. All “A” options assume a new stand-alone boiler plant is

constructed to house the boiler and chip storage. Option B.1 assumes a new stand-alone boiler plant is constructed to house the boiler with an exterior silo or silos. The cord wood boiler option would be installed in a freestanding building with interior cordwood fuel storage.

11.0 Estimated Costs

The total project costs are at a preliminary design level and are based on RS Means and recent biomass project bid data. The estimates are shown in the appendix. These costs are conservative and if a deeper level feasibility analysis is undertaken and/or further design occurs, the costs may be able to be reduced.

12.0 Economic Analysis Assumptions

The cash flow analysis assumes fuel oil at $3.60/gal, electricity at $0.28/kwh, wood pellets delivered at $325/ton, and wood chips delivered at $75/ton. The fuel oil, electricity, and cord wood costs were based on utility bills and reports form the end users. Chipped and ground wood fuel costs are estimates based on Toghotthele Corporation's estimates of delivered costs. Pellet costs were obtained from Superior Pellet Fuels.

It is assumed that the biomass boiler would supplant 85% of the estimated heating use, and the existing heating systems would heat the remaining 15%. Each option assumes the total project can be funded with grants and non obligated capital money. The following inflation rates were used: O&M - 2%, Fossil Fuel – 5%, Wood Fuel – 3%, Discount Rate for NPV calculation – 3%. The fossil fuel inflation rate is based on the DOE EIA website. DOE is projecting a slight plateau with a long term inflation of approximately 5%. As a point of comparison, oil prices have increased at an annual rate over 8% since 2001.

The analysis also accounts for additional electrical energy required for the wood fired boiler system as well as the system pumps to distribute heating hot water to the buildings. Wood fired boiler systems also will require more maintenance, and these additional maintenance costs are also factored into the analysis. In the different central plant options, there are significant runs of underground pipe to connect to the City Water Plant and to the Student Living Center. The amount of heat energy lost in these long runs was estimated and the additional required heating energy was added to the boiler plant load, that is, the boiler plant was assumed to burn more chips to accommodate the piping heat losses.

13.0 Results of Evaluation

The following table summarizes the economic evaluation for each option:

Table 13.1 - Economic Evaluation Summary
Nenana Biomass Heating System

	Project Cost	Year 1 Operating Savings	NPV 30 yr at 3%	NPV 20 yr at 3%	20 Yr B/C Ratio	30 Yr B/C Ratio	ACF YR 20	ACF YR 30	YR ACF=PC
A.1	$1,780,000	$59,208	$2,832,089	$1,616,943	0.91	1.59	$2,303,414	$4,911,172	18
A.2	$1,960,000	$72,175	$3,385,501	$1,940,341	0.99	1.73	$2,761,778	$5,862,829	17
A.3	$2,150,000	$81,506	$3,795,177	$2,177,730	1.01	1.77	$3,098,786	$6,569,425	16
A.4	$2,590,000	$99,342	$4,638,894	$2,656,188	1.03	1.79	$3,780,882	$8,035,572	16
A.5	$2,680,000	$106,772	$4,975,009	$2,849,249	1.06	1.86	$4,055,426	$8,617,079	16
A.6	$2,860,000	$112,808	$5,441,730	$3,085,014	1.08	1.90	$4,399,622	$9,458,385	16
B.1	$1,300,000	$7,206	$1,289,692	$590,490	0.45	0.99	$882,087	$2,389,469	24
C.1	$280,000	-$1,773	$220,868	$88,173	0.31	0.79	$137,198	$423,622	26

The benefit to cost ratio (B/C) takes the net present value (NPV) of the net energy savings and divides it by the construction cost of the project. A B/C ratio greater than or equal to 1.0 indicates an economically advantageous project.

Accumulated cash flow (ACF) is another evaluation measure that is calculated in this report and is similar to simple payback with the exception that accumulated cash flow takes the cost of financing and fuel escalation into account. For many building owners, having the accumulated cash flow equal the project cost within 15 years is considered necessary for implementation. If the accumulated cash flow equals project cost in 20 years or more, that indicates a challenged project. Positive accumulated cash flow should also be considered an avoided cost as opposed to a pure savings.

Because a school is part of this project, a life cycle cost analysis following the requirements of the State of Alaska Department of Education & Early Development was completed and the data is summarized in the following table:

Table 13.2 - Life Cycle Costs of Project Alternatives

	Alternate #1 Existing Boiler	Alternate #2 Wood Chip Boiler (A.2)
Initial Investment Cost	$0	$1,960,000
Operations Cost	$3,360,393	$854,631
Maintenance & Repair Cost	$0	$56,725
Replacement Cost	$0	$0
Residual Value	$0	$0
Total Life Cycle Cost	$3,360,393	$2,871,356

14.0 Project Funding

The Nenana City School District and the City of Nenana may pursue a biomass project grant from the Alaska Energy Authority.

The Nenana City School District and the City of Nenana could also enter into a performance contract for the project. Companies such as Siemens, McKinstry, Johnson Controls and Chevron have expressed an interest in participating in funding projects of all sizes throughout Alaska. This allows the facility owner to pay for the project entirely from the guaranteed energy savings, and to minimize the project funds required to initiate the project. The scope of the project may be expanded to include additional energy conservation measures such as roof and wall insulation and upgrading mechanical systems.

15.0 Summary

Connecting the school with several nearby buildings with a wood fired district heating system appears to be an economically viable project. With the current economic assumptions, the school alone and the school combined with the administration building and the school warehouse don't quite meet the minimum 20 year B/C ratio of 1.0 However, when adding in the daycare, the water plant, and fire department, all these incremental options have 20 year B/C ratios greater than 1.0. The additional energy saved by connecting several buildings together offsets the significant additional cost of underground piping and pumping costs. The best option was A.6 which connected the school with the administration building, the school warehouse, and the student living center. Even with the significant piping costs, the extra pumping energy, and the extra wood fuel needed to offset the heat loss of the long pipe runs, this option remains the strongest relative to the other options.

Additional sensitivity analysis has been performed and is attached. Using option A.6 as the basis of the analysis, the B/C ratio will exceed 1.0 if wood fuel prices stay below $85/ton.

The analysis also shows that a central plant with a pellet boiler is not viable, nor is a stand-alone cord wood boiler system for the Meda Lord Senior Center.

Recommended Actions

Most grant programs will likely require a full feasibility assessment. A full assessment would provide more detail on the air quality issues, wood fuel resources, review the pipe routing and potential underground conflicts, and develop a schematic design of the boiler plant including wood storage size, and schematic design of the heating systems integration. These schematic designs will also help obtain more accurate costs. Since several options appear to be viable, more investigation should be engaged to determine the best project to proceed with.

APPENDIX A

Preliminary Estimates of Probable Cost

Preliminary Estimates of Probable Cost
Biomass Heating Options
Nenana, AK

Chip Option A.1 - School Integration

Chip Storage/ Boiler Building:	$270,000
Wood Heating & Wood Handling System:	$325,000
Stack/Air Pollution Control Device:	$180,000
Mechanical/Electrical within Boiler Building:	$150,000
Underground Piping	$60,000
School Integration	$50,000
Subtotal:	$1,035,000
30% Remote Factor	$310,500
Subtotal:	$1,345,500
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$201,825
Subtotal:	$1,547,325
15% Contingency:	$232,099
Total Project Costs	**$ 1,779,424**

Chip Option A.2 - S + SA +SW

Chip Storage/ Boiler Building:	$270,000
Wood Heating & Wood Handling System:	$325,000
Stack/Air Pollution Control Device:	$180,000
Mechanical/Electrical within Boiler Building:	$150,000
Underground Piping	$115,000
School Integration	$50,000
Warehouse and Administration Integration	$51,000
Subtotal:	$1,141,000
30% Remote Factor	$342,300
Subtotal:	$1,483,300
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$222,495
Subtotal:	$1,705,795
15% Contingency:	$255,869
Total Project Costs	**$ 1,961,664**

Preliminary Estimates of Probable Cost
Biomass Heating Options
Nenana, AK

Chip Option A.3 - S + SA + SW + DC

Chip Storage/ Boiler Building:	$270,000
Wood Heating & Wood Handling System:	$325,000
Stack/Air Pollution Control Device:	$180,000
Mechanical/Electrical within Boiler Building:	$150,000
Underground Piping	$180,000
School Integration	$50,000
Warehouse and Administration Integration	$51,000
Day Care Integration	$44,000
Subtotal:	$1,250,000
30% Remote Factor	$375,000
Subtotal:	$1,625,000
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$243,750
Subtotal:	$1,868,750
15% Contingency:	$280,313
Total Project Costs	**$ 2,149,063**

Chip Option A.4 - S + SA + SW + DC + WP

Chip Storage/ Boiler Building:	$270,000
Wood Heating & Wood Handling System:	$325,000
Stack/Air Pollution Control Device:	$180,000
Mechanical/Electrical within Boiler Building:	$150,000
Underground Piping	$390,000
School Integration	$50,000
Warehouse and Administration Integration	$51,000
Day Care Integration	$44,000
Water Plant Integration	$46,500
Subtotal:	$1,506,500
30% Remote Factor	$451,950
Subtotal:	$1,958,450
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$293,768
Subtotal:	$2,252,218
15% Contingency:	$337,833
Total Project Costs	**$ 2,590,050**

Preliminary Estimates of Probable Cost
Biomass Heating Options
Nenana, AK

Chip Option A.5 - S + SA + SW + DC + WP + FH

Chip Storage/ Boiler Building:	$270,000
Wood Heating & Wood Handling System:	$325,000
Stack/Air Pollution Control Device:	$180,000
Mechanical/Electrical within Boiler Building:	$150,000
Underground Piping	$400,000
School Integration	$50,000
Warehouse and Administration Integration	$51,000
Day Care Integration	$44,000
Water Plant Integration	$46,500
Fire Hall Integration	$43,000
Subtotal:	$1,559,500
30% Remote Factor	$467,850
Subtotal:	$2,027,350
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$304,103
Subtotal:	$2,331,453
15% Contingency:	$349,718
Total Project Costs	**$ 2,681,170**

Chip Option A.6 - S + SA +SW + SLC

Chip Storage/ Boiler Building:	$270,000
Wood Heating & Wood Handling System:	$325,000
Stack/Air Pollution Control Device:	$180,000
Mechanical/Electrical within Boiler Building:	$150,000
Underground Piping	$590,000
School Integration	$50,000
Warehouse and Administration Integration	$51,000
SLC Integration	$47,500
Subtotal:	$1,663,500
30% Remote Factor	$499,050
Subtotal:	$2,162,550
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$324,383
Subtotal:	$2,486,933
15% Contingency:	$373,040
Total Project Costs	**$ 2,859,972**

Preliminary Estimates of Probable Cost
Biomass Heating Options
Nenana, AK

Pellet Option B.1 - School Integration

Boiler Building and Silo:	$180,000
Wood Heating & Wood Handling System:	$265,000
Stack/Air Pollution Control Device:	$50,000
Mechanical/Electrical within Boiler Building:	$150,000
Underground Piping	$60,000
School Integration	$50,000
Subtotal:	$755,000
30% Remote Factor	$226,500
Subtotal:	$981,500
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$147,225
Subtotal:	$1,128,725
15% Contingency:	$169,309
Total Project Costs	**$ 1,298,034**

Cord Wood Option C.1 - Meda Lord Senior Center

Biomass Boiler Building:	$97,500
Wood Heating and Cord Wood Storage	$16,000
Stack:	$2,200
Mechanical/Electrical within Boiler Building:	$20,200
Underground Piping	$12,000
MLSC Integration	$14,500
Subtotal:	$162,400
30% Remote Factor	$48,720
Subtotal:	$211,120
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$31,668
Subtotal:	$242,788
15% Contingency:	$36,418
Total Project Costs	**$ 279,206**

APPENDIX B

Cash Flow Analysis
&
Economic Sensitivity Analysis

Nenana School

Nenana, Alaska

Option A.1

Wood Chip Boiler

Date: July 24, 2012
Analyst: CTA Architects Engineers - Nick Salmon & Nathan Ratz

EXISTING CONDITIONS	**School**	**Admin**	**Warehouse**	**Daycare**	**Total**
Existing Fuel Type:	Fuel Oil	Fuel Oil	Fuel Oil	Fuel Oil	
Fuel Units:	gal	gal	gal	gal	
Current Fuel Unit Cost:	$3.60	$3.60	$3.60	$3.60	
Estimated Average Annual Fuel Usage:	34,000				34,000
Annual Heating Costs:	$122,400	$0	$0	$0	$122,400
ENERGY CONVERSION (to 1,000,000 Btu; or 1 dkt)					
Fuel Heating Value (Btu/unit of fuel):	134500	134500	134500	134500	
Current Annual Fuel Volume (Btu):	4,573,000,000	0	0	0	
Assumed efficiency of existing heating system (%):	80%	80%	80%	80%	
Net Annual Energy Produced (Btu):	3,658,400,000	0	0	0	3,658,400,000

WOOD FUEL COST	**Wood Chips**
$/ton:	$75.00
Assumed efficiency of wood heating system (%):	65%
PROJECTED WOOD FUEL USAGE	
Estimated Btu content of wood fuel (Btu/lb) - **Assumed 30% MC**	6400
Tons of wood fuel to supplant net equivalent of 100% annual heating load.	440
Tons of wood fuel to supplant net equivalent of 85% annual heating load.	374
25 ton chip van loads to supplant net equivalent of 85% annual heating load.	15

Project Capital Cost	**-$1,780,000**

Project Financing Information	
Percent Financed	**0.0%**
Amount Financed	$0
Amount of Grants	$1,780,000
Interest Rate	5.00%
Term	10
Annual Finance Cost (years)	$0

Additional Power Use		
Est. Pwr Use	40000	kWh
Elec Rate	$0.280	/kWh

Additional Maintenance					
Type	Hr/Wk	Wk/Yr	Total Hr	Wage/Hr	Total
Biomass System	4.0	40	160	$20.00	$3,200
Other	0.0	40	0	$20.00	$0
1st 2 Year Learning	3.0	40	120	$20.00	$2,400

		Net Benefit	B/C Ratio
Simple Payback: Total Project Cost/Year One Operating Cost Savings:	30.1 years		
Net Present Value (30 year analysis):	$2,832,089	$1,052,089	1.59
Net Present Value (20 year analysis):	$1,616,943	-$163,057	0.91
Year Accumulated Cash Flow > 0	#N/A		
Year Accumulated Cash Flow > Project Capital Cost	18		

Inflation Factors	
O&M Inflation Rate	2.0%
Fossil Fuel Inflation Rate	5.0%
Wood Fuel Inflation Rate	3.0%
Electricity Inflation Rate	3.0%
Discount Rate for Net Present Value Calculation	3.0%

Cash flow Descriptions	Unit Costs	Heating Source Proportion	Annual Heating Source Volumes	Heating Units	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 20	Year 25	Year 30
Existing Heating System Operating Costs																						
Displaced heating costs	$3.60		34000	gal	$122,400	$128,520	$134,946	$141,693	$148,778	$156,217	$164,028	$172,229	$180,841	$189,883	$199,377	$209,346	$219,813	$230,803	$242,344	$309,299	$394,752	$503,815
Displaced heating costs	$3.60		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Displaced heating costs	$3.60		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Displaced heating costs	$3.60		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Biomass System Operating Costs																						
Wood Fuel ($/ton, delivered to boiler site)	$75.00	85%	374	tons	$28,032	$28,873	$29,739	$30,631	$31,550	$32,496	$33,471	$34,475	$35,510	$36,575	$37,672	$38,802	$39,966	$41,165	$42,400	$49,154	$56,982	$66,058
Small load existing fuel	$3.60	15%	5100	gal	$18,360	$19,278	$20,242	$21,254	$22,317	$23,433	$24,604	$25,834	$27,126	$28,482	$29,907	$31,402	$32,972	$34,621	$36,352	$46,395	$59,213	$75,572
Small load existing fuel	$3.60	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Small load existing fuel	$3.60	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Small load existing fuel	$3.60	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Additional Operation and Maintenance Costs					$3,200	$3,264	$3,329	$3,396	$3,464	$3,533	$3,604	$3,676	$3,749	$3,824	$3,901	$3,979	$4,058	$4,140	$4,222	$4,662	$5,147	$5,683
Additional Operation and Maintenance Costs First 2 years					$2,400	$2,448																
Additional Electrical Cost	$0.280				$11,200	$11,536	$11,882	$12,239	$12,606	$12,984	$13,373	$13,775	$14,188	$14,613	$15,052	$15,503	$15,969	$16,448	$16,941	$19,639	$22,767	$26,394
Annual Operating Cost Savings					***$59,208***	***$63,121***	***$69,754***	***$74,174***	***$78,842***	***$83,771***	***$88,975***	***$94,469***	***$100,268***	***$106,388***	***$112,845***	***$119,659***	***$126,848***	***$134,430***	***$142,428***	***$189,449***	***$250,643***	***$330,108***
Financed Project Costs - Principal and Interest					***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***								
Displaced System Replacement Costs (year one only)					***0***																	
Net Annual Cash Flow					***59,208***	***63,121***	***69,754***	***74,174***	***78,842***	***83,771***	***88,975***	***94,469***	***100,268***	***106,388***	***112,845***	***119,659***	***126,848***	***134,430***	***142,428***	***189,449***	***250,643***	***330,108***
Accumulated Cash Flow					***59,208***	***122,330***	***192,084***	***266,258***	***345,100***	***428,871***	***517,846***	***612,315***	***712,583***	***818,970***	***931,816***	***1,051,475***	***1,178,323***	***1,312,753***	***1,455,181***	***2,303,414***	***3,427,827***	***4,911,172***

Nenana School + Admin + Warehouse

Nenana, Alaska

Option A.2

Wood Chip Boiler

Date: July 24, 2012
Analyst: CTA Architects Engineers - Nick Salmon & Nathan Ratz

EXISTING CONDITIONS	**School**	**Admin**	**Warehouse**	**Daycare**	**Total**
Existing Fuel Type:	Fuel Oil	Fuel Oil	Fuel Oil	Fuel Oil	
Fuel Units:	gal	gal	gal	gal	
Current Fuel Unit Cost:	$3.60	$3.60	$3.60	$3.60	
Estimated Average Annual Fuel Usage:	34,000	1,600	4,200		39,800
Annual Heating Costs:	$122,400	$5,760	$15,120	$0	$143,280
ENERGY CONVERSION (to 1,000,000 Btu; or 1 dkt)					
Fuel Heating Value (Btu/unit of fuel):	134500	134500	134500	134500	
Current Annual Fuel Volume (Btu):	4,573,000,000	215,200,000	564,900,000	0	
Assumed efficiency of existing heating system (%):	80%	80%	80%	80%	
Net Annual Energy Produced (Btu):	3,658,400,000	172,160,000	451,920,000	0	4,282,480,000

WOOD FUEL COST	**Wood Chips**
$/ton:	$75.00
Assumed efficiency of wood heating system (%):	65%
PROJECTED WOOD FUEL USAGE	
Estimated Btu content of wood fuel (Btu/lb) - **Assumed 30% MC**	6400
Tons of wood fuel to supplant net equivalent of 100% annual heating load.	515
Tons of wood fuel to supplant net equivalent of 85% annual heating load.	438
25 ton chip van loads to supplant net equivalent of 85% annual heating load.	18

Project Capital Cost	**-$1,960,000**

Project Financing Information	
Percent Financed	**0.0%**
Amount Financed	$0
Amount of Grants	$1,960,000
Interest Rate	5.00%
Term	10
Annual Finance Cost (years)	$0

Simple Payback: Total Project Cost/Year One Operating Cost Savings:	27.2 years		
Net Present Value (30 year analysis):	$3,385,501	Net Benefit	B/C Ratio
Net Present Value (20 year analysis):	$1,940,341	$1,425,501	1.73
Year Accumulated Cash Flow > 0	#N/A	-$19,659	0.99
Year Accumulated Cash Flow > Project Capital Cost	17		

Additional Power Use		
Est. Pwr Use	40000	kWh
Elec Rate	$0.280	/kWh

Additional Maintenance					
Type	Hr/Wk	Wk/Yr	Total Hr	Wage/Hr	Total
Biomass System	4.0	40	160	$20.00	$3,200
Other	0.0	40	0	$20.00	$0
1st 2 Year Learning	3.0	40	120	$20.00	$2,400

Inflation Factors	
O&M Inflation Rate	2.0%
Fossil Fuel Inflation Rate	5.0%
Wood Fuel Inflation Rate	3.0%
Electricity Inflation Rate	3.0%
Discount Rate for Net Present Value Calculation	3.0%

Cash flow Descriptions	Unit Costs	Heating Source Proportion	Annual Heating Source Volumes	Heating Units	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 20	Year 25	Year 30
Existing Heating System Operating Costs																						
Displaced heating costs	$3.60		34000	gal	$122,400	$128,520	$134,946	$141,693	$148,778	$156,217	$164,028	$172,229	$180,841	$189,883	$199,377	$209,346	$219,813	$230,803	$242,344	$309,299	$394,752	$503,815
Displaced heating costs	$3.60		1600	gal	$5,760	$6,048	$6,350	$6,668	$7,001	$7,351	$7,719	$8,105	$8,510	$8,936	$9,382	$9,852	$10,344	$10,861	$11,404	$14,555	$18,577	$23,709
Displaced heating costs	$3.60		4200	gal	$15,120	$15,876	$16,670	$17,503	$18,378	$19,297	$20,262	$21,275	$22,339	$23,456	$24,629	$25,860	$27,153	$28,511	$29,937	$38,207	$48,764	$62,236
Displaced heating costs	$3.60		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Biomass System Operating Costs																						
Wood Fuel ($/ton, delivered to boiler site)	$75.00	85%	438	tons	$32,813	$33,798	$34,812	$35,856	$36,932	$38,040	$39,181	$40,356	$41,567	$42,814	$44,099	$45,422	$46,784	$48,188	$49,633	$57,539	$66,703	$77,327
Small load existing fuel	$3.60	15%	5100	gal	$18,360	$19,278	$20,242	$21,254	$22,317	$23,433	$24,604	$25,834	$27,126	$28,482	$29,907	$31,402	$32,972	$34,621	$36,352	$46,395	$59,213	$75,572
Small load existing fuel	$3.60	15%	240	gal	$864	$907	$953	$1,000	$1,050	$1,103	$1,158	$1,216	$1,277	$1,340	$1,407	$1,478	$1,552	$1,629	$1,711	$2,183	$2,786	$3,556
Small load existing fuel	$3.60	15%	630	gal	$2,268	$2,381	$2,500	$2,625	$2,757	$2,895	$3,039	$3,191	$3,351	$3,518	$3,694	$3,879	$4,073	$4,277	$4,490	$5,731	$7,315	$9,335
Small load existing fuel	$3.60	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Additional Operation and Maintenance Costs					$3,200	$3,264	$3,329	$3,396	$3,464	$3,533	$3,604	$3,676	$3,749	$3,824	$3,901	$3,979	$4,058	$4,140	$4,222	$4,662	$5,147	$5,683
Additional Operation and Maintenance Costs First 2 years					$2,400	$2,448																
Additional Electrical Cost	$0.280				$11,200	$11,536	$11,882	$12,239	$12,606	$12,984	$13,373	$13,775	$14,188	$14,613	$15,052	$15,503	$15,969	$16,448	$16,941	$19,639	$22,767	$26,394
Annual Operating Cost Savings					***$72,175***	***$76,832***	***$84,248***	***$89,494***	***$95,033***	***$100,879***	***$107,049***	***$113,561***	***$120,432***	***$127,681***	***$135,329***	***$143,395***	***$151,903***	***$160,875***	***$170,335***	***$225,913***	***$298,161***	***$391,893***
Financed Project Costs - Principal and Interest					***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***								
Displaced System Replacement Costs (year one only)					***0***																	
Net Annual Cash Flow					***72,175***	***76,832***	***84,248***	***89,494***	***95,033***	***100,879***	***107,049***	***113,561***	***120,432***	***127,681***	***135,329***	***143,395***	***151,903***	***160,875***	***170,335***	***225,913***	***298,161***	***391,893***
Accumulated Cash Flow					***72,175***	***149,006***	***233,254***	***322,748***	***417,781***	***518,660***	***625,710***	***739,271***	***859,703***	***987,384***	***1,122,713***	***1,266,108***	***1,418,010***	***1,578,885***	***1,749,220***	***2,761,778***	***4,100,544***	***5,862,829***

Nenana School Buildings + Daycare

Nenana, Alaska

Option A.3

Wood Chip Boiler

Date: July 24, 2012
Analyst: CTA Architects Engineers - Nick Salmon & Nathan Ratz

EXISTING CONDITIONS	**School**	**Admin**	**Warehouse**	**Daycare**	**Total**
Existing Fuel Type:	Fuel Oil	Fuel Oil	Fuel Oil	Fuel Oil	
Fuel Units:	gal	gal	gal	gal	
Current Fuel Unit Cost:	$3.60	$3.60	$3.60	$3.60	
Estimated Average Annual Fuel Usage:	34,000	1,600	4,200	4,550	44,350
Annual Heating Costs:	$122,400	$5,760	$15,120	$16,380	$159,660
ENERGY CONVERSION (to 1,000,000 Btu; or 1 dkt)					
Fuel Heating Value (Btu/unit of fuel):	134500	134500	134500	134500	
Current Annual Fuel Volume (Btu):	4,573,000,000	215,200,000	564,900,000	611,975,000	
Assumed efficiency of existing heating system (%):	80%	80%	80%	80%	
Net Annual Energy Produced (Btu):	3,658,400,000	172,160,000	451,920,000	489,580,000	4,772,060,000

WOOD FUEL COST	**Wood Chips**
$/ton:	$75.00
Assumed efficiency of wood heating system (%):	65%
PROJECTED WOOD FUEL USAGE	
Estimated Btu content of wood fuel (Btu/lb) - **Assumed 30% MC**	6400
Tons of wood fuel to supplant net equivalent of 100% annual heating load.	574
Tons of wood fuel to supplant net equivalent of 85% annual heating load.	488
25 ton chip van loads to supplant net equivalent of 85% annual heating load.	20

Project Capital Cost	**-$2,150,000**

Project Financing Information	
Percent Financed	**0.0%**
Amount Financed	$0
Amount of Grants	$2,150,000
Interest Rate	5.00%
Term	10
Annual Finance Cost (years)	$0

Additional Power Use		
Est. Pwr Use	43000	kWh
Elec Rate	$0.280	/kWh

Additional Maintenance					
Type	Hr/Wk	Wk/Yr	Total Hr	Wage/Hr	Total
Biomass System	4.0	40	160	$20.00	$3,200
Other	0.0	40	0	$20.00	$0
1st 2 Year Learning	3.0	40	120	$20.00	$2,400

Simple Payback: Total Project Cost/Year One Operating Cost Savings:	26.4 years	Net Benefit	B/C Ratio
Net Present Value (30 year analysis):	$3,795,177	$1,645,177	1.77
Net Present Value (20 year analysis):	$2,177,730	$27,730	1.01
Year Accumulated Cash Flow > 0	#N/A		
Year Accumulated Cash Flow > Project Capital Cost	16		

Inflation Factors	
O&M Inflation Rate	2.0%
Fossil Fuel Inflation Rate	5.0%
Wood Fuel Inflation Rate	3.0%
Electricity Inflation Rate	3.0%
Discount Rate for Net Present Value Calculation	3.0%

Cash flow Descriptions	**Unit Costs**	**Heating Source Proportion**	**Annual Heating Source Volumes**	**Heating Units**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**	**Year 20**	**Year 25**	**Year 30**
Existing Heating System Operating Costs																						
Displaced heating costs	$3.60		34000	gal	$122,400	$128,520	$134,946	$141,693	$148,778	$156,217	$164,028	$172,229	$180,841	$189,883	$199,377	$209,346	$219,813	$230,803	$242,344	$309,299	$394,752	$503,815
Displaced heating costs	$3.60		1600	gal	$5,760	$6,048	$6,350	$6,668	$7,001	$7,351	$7,719	$8,105	$8,510	$8,936	$9,382	$9,852	$10,344	$10,861	$11,404	$14,555	$18,577	$23,709
Displaced heating costs	$3.60		4200	gal	$15,120	$15,876	$16,670	$17,503	$18,378	$19,297	$20,262	$21,275	$22,339	$23,456	$24,629	$25,860	$27,153	$28,511	$29,937	$38,207	$48,764	$62,236
Displaced heating costs	$3.60		4550	gal	$16,380	$17,199	$18,059	$18,962	$19,910	$20,905	$21,951	$23,048	$24,201	$25,411	$26,681	$28,015	$29,416	$30,887	$32,431	$41,391	$52,827	$67,422
Biomass System Operating Costs																						
Wood Fuel ($/ton, delivered to boiler site)	$75.00	85%	488	tons	$36,565	$37,662	$38,792	$39,955	$41,154	$42,389	$43,660	$44,970	$46,319	$47,709	$49,140	$50,614	$52,133	$53,697	$55,307	$64,117	$74,329	$86,167
Small load existing fuel	$3.60	15%	5100	gal	$18,360	$19,278	$20,242	$21,254	$22,317	$23,433	$24,604	$25,834	$27,126	$28,482	$29,907	$31,402	$32,972	$34,621	$36,352	$46,395	$59,213	$75,572
Small load existing fuel	$3.60	15%	240	gal	$864	$907	$953	$1,000	$1,050	$1,103	$1,158	$1,216	$1,277	$1,340	$1,407	$1,478	$1,552	$1,629	$1,711	$2,183	$2,786	$3,556
Small load existing fuel	$3.60	15%	630	gal	$2,268	$2,381	$2,500	$2,625	$2,757	$2,895	$3,039	$3,191	$3,351	$3,518	$3,694	$3,879	$4,073	$4,277	$4,490	$5,731	$7,315	$9,335
Small load existing fuel	$3.60	15%	683	gal	$2,457	$2,580	$2,709	$2,844	$2,986	$3,136	$3,293	$3,457	$3,630	$3,812	$4,002	$4,202	$4,412	$4,633	$4,865	$6,209	$7,924	$10,113
Additional Operation and Maintenance Costs					$3,200	$3,264	$3,329	$3,396	$3,464	$3,533	$3,604	$3,676	$3,749	$3,824	$3,901	$3,979	$4,058	$4,140	$4,222	$4,662	$5,147	$5,683
Additional Operation and Maintenance Costs First 2 years					$2,400	$2,448																
Additional Electrical Cost	$0.280				$12,040	$12,401	$12,773	$13,156	$13,551	$13,958	$14,376	$14,808	$15,252	$15,709	$16,181	$16,666	$17,166	$17,681	$18,212	$21,112	$24,475	$28,373
Annual Operating Cost Savings					***$81,506***	***$86,722***	***$94,727***	***$100,595***	***$106,789***	***$113,326***	***$120,225***	***$127,505***	***$135,187***	***$143,290***	***$151,837***	***$160,853***	***$170,360***	***$180,386***	***$190,957***	***$253,044***	***$333,731***	***$438,382***
Financed Project Costs - Principal and Interest					***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***								
Displaced System Replacement Costs (year one only)					***0***																	
Net Annual Cash Flow					***81,506***	***86,722***	***94,727***	***100,595***	***106,789***	***113,326***	***120,225***	***127,505***	***135,187***	***143,290***	***151,837***	***160,853***	***170,360***	***180,386***	***190,957***	***253,044***	***333,731***	***438,382***
Accumulated Cash Flow					***81,506***	***168,228***	***262,955***	***363,550***	***470,339***	***583,665***	***703,890***	***831,396***	***966,582***	***1,109,872***	***1,261,710***	***1,422,562***	***1,592,923***	***1,773,309***	***1,964,266***	***3,098,786***	***4,597,653***	***6,569,425***

Nenana School Buildings + Daycare + Water Plant

Nenana, Alaska

Option A.4

Wood Chip Boiler

Date: July 24, 2012
Analyst: CTA Architects Engineers - Nick Salmon & Nathan Ratz

EXISTING CONDITIONS	**School Bldgs**	**Daycare**	**Water Plant**	**Fire Dept**	**Total**
Existing Fuel Type:	Fuel Oil	Fuel Oil	Fuel Oil	Fuel Oil	
Fuel Units:	gal	gal	gal	gal	
Current Fuel Unit Cost:	$3.60	$3.60	$3.60	$3.60	
Estimated Average Annual Fuel Usage:	39,800	4,550	10,700		55,050
Annual Heating Costs:	$143,280	$16,380	$38,520	$0	$198,180
ENERGY CONVERSION (to 1,000,000 Btu; or 1 dkt)					
Fuel Heating Value (Btu/unit of fuel):	134500	134500	134500	134500	
Current Annual Fuel Volume (Btu):	5,353,100,000	611,975,000	1,439,150,000	0	
Assumed efficiency of existing heating system (%):	80%	80%	80%	80%	
Net Annual Energy Produced (Btu):	4,282,480,000	489,580,000	1,151,320,000	0	5,923,380,000

WOOD FUEL COST	**Wood Chips**
$/ton:	$75.00
Assumed efficiency of wood heating system (%):	65%
PROJECTED WOOD FUEL USAGE	
Estimated Btu content of wood fuel (Btu/lb) - **Assumed 30% MC**	6400
Tons of wood fuel to supplant net equivalent of 100% annual heating load.	712
Tons of wood fuel to supplant net equivalent of 85% annual heating load.	605
25 ton chip van loads to supplant net equivalent of 85% annual heating load.	24

Project Capital Cost	**-$2,590,000**

Project Financing Information	
Percent Financed	**0.0%**
Amount Financed	$0
Amount of Grants	$2,590,000
Interest Rate	5.00%
Term	10
Annual Finance Cost (years)	$0

Additional Power Use		
Est. Pwr Use	50000	kWh
Elec Rate	$0.280	/kWh

Additional Maintenance					
Type	Hr/Wk	Wk/Yr	Total Hr	Wage/Hr	Total
Biomass System	4.0	40	160	$20.00	$3,200
Other	0.0	40	0	$20.00	$0
1st 2 Year Learning	3.0	40	120	$20.00	$2,400

Simple Payback: Total Project Cost/Year One Operating Cost Savings:	26.1 years		
Net Present Value (30 year analysis):	$4,638,894	Net Benefit	B/C Ratio
Net Present Value (20 year analysis):	$2,656,188	$2,048,894	1.79
Year Accumulated Cash Flow > 0	#N/A	$66,188	1.03
Year Accumulated Cash Flow > Project Capital Cost	16		

Inflation Factors	
O&M Inflation Rate	2.0%
Fossil Fuel Inflation Rate	5.0%
Wood Fuel Inflation Rate	3.0%
Electricity Inflation Rate	3.0%
Discount Rate for Net Present Value Calculation	3.0%

Cash flow Descriptions	Unit Costs	Heating Source Proportion	Annual Heating Source Volumes	Heating Units	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 20	Year 25	Year 30
Existing Heating System Operating Costs																						
Displaced heating costs	$3.60		39800	gal	$143,280	$150,444	$157,966	$165,865	$174,158	$182,866	$192,009	$201,609	$211,690	$222,274	$233,388	$245,057	$257,310	$270,176	$283,685	$362,061	$462,092	$589,760
Displaced heating costs	$3.60		4550	gal	$16,380	$17,199	$18,059	$18,962	$19,910	$20,905	$21,951	$23,048	$24,201	$25,411	$26,681	$28,015	$29,416	$30,887	$32,431	$41,391	$52,827	$67,422
Displaced heating costs	$3.60		10700	gal	$38,520	$40,446	$42,468	$44,592	$46,821	$49,162	$51,620	$54,202	$56,912	$59,757	$62,745	$65,882	$69,176	$72,635	$76,267	$97,338	$124,231	$158,554
Displaced heating costs	$3.60		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Biomass System Operating Costs																						
Wood Fuel ($/ton, delivered to boiler site)	$75.00	85%	660	tons	$49,511	$50,997	$52,527	$54,103	$55,726	$57,397	$59,119	$60,893	$62,720	$64,601	$66,539	$68,535	$70,592	$72,709	$74,891	$86,819	$100,647	$116,677
Small load existing fuel	$3.60	15%	5970	gal	$21,492	$22,567	$23,695	$24,880	$26,124	$27,430	$28,801	$30,241	$31,753	$33,341	$35,008	$36,759	$38,597	$40,526	$42,553	$54,309	$69,314	$88,464
Small load existing fuel	$3.60	15%	683	gal	$2,457	$2,580	$2,709	$2,844	$2,986	$3,136	$3,293	$3,457	$3,630	$3,812	$4,002	$4,202	$4,412	$4,633	$4,865	$6,209	$7,924	$10,113
Small load existing fuel	$3.60	15%	1605	gal	$5,778	$6,067	$6,370	$6,689	$7,023	$7,374	$7,743	$8,130	$8,537	$8,964	$9,412	$9,882	$10,376	$10,895	$11,440	$14,601	$18,635	$23,783
Small load existing fuel	$3.60	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Additional Operation and Maintenance Costs					$3,200	$3,264	$3,329	$3,396	$3,464	$3,533	$3,604	$3,676	$3,749	$3,824	$3,901	$3,979	$4,058	$4,140	$4,222	$4,662	$5,147	$5,683
Additional Operation and Maintenance Costs First 2 years					$2,400	$2,448																
Additional Electrical Cost	$0.280				$14,000	$14,420	$14,853	$15,298	$15,757	$16,230	$16,717	$17,218	$17,735	$18,267	$18,815	$19,379	$19,961	$20,559	$21,176	$24,549	$28,459	$32,992
Annual Operating Cost Savings					***$99,342***	***$105,747***	***$115,011***	***$122,209***	***$129,809***	***$137,833***	***$146,303***	***$155,243***	***$164,678***	***$174,634***	***$185,137***	***$196,218***	***$207,907***	***$220,235***	***$233,236***	***$309,643***	***$409,025***	***$538,024***
Financed Project Costs - Principal and Interest					***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***								
Displaced System Replacement Costs (year one only)					***0***																	
Net Annual Cash Flow					***99,342***	***105,747***	***115,011***	***122,209***	***129,809***	***137,833***	***146,303***	***155,243***	***164,678***	***174,634***	***185,137***	***196,218***	***207,907***	***220,235***	***233,236***	***309,643***	***409,025***	***538,024***
Accumulated Cash Flow					***99,342***	***205,088***	***320,099***	***442,308***	***572,117***	***709,950***	***856,254***	***1,011,497***	***1,176,175***	***1,350,809***	***1,535,946***	***1,732,164***	***1,940,071***	***2,160,306***	***2,393,542***	***3,780,882***	***5,616,846***	***8,035,572***

Nenana School Buildings + Daycare + Water Plant + Fire Dept.

Nenana, Alaska

Option A.5

Wood Chip Boiler

Date: July 24, 2012
Analyst: CTA Architects Engineers - Nick Salmon & Nathan Ratz

EXISTING CONDITIONS	**School Bldgs**	**Daycare**	**Water Plant**	**Fire Dept**	**Total**
Existing Fuel Type:	Fuel Oil	Fuel Oil	Fuel Oil	Fuel Oil	
Fuel Units:	gal	gal	gal	gal	
Current Fuel Unit Cost:	$3.60	$3.60	$3.60	$3.60	
Estimated Average Annual Fuel Usage:	39,800	4,550	10,700	3,950	59,000
Annual Heating Costs:	$143,280	$16,380	$38,520	$14,220	$212,400
ENERGY CONVERSION (to 1,000,000 Btu; or 1 dkt)					
Fuel Heating Value (Btu/unit of fuel):	134500	134500	134500	134500	
Current Annual Fuel Volume (Btu):	5,353,100,000	611,975,000	1,439,150,000	531,275,000	
Assumed efficiency of existing heating system (%):	80%	80%	80%	80%	
Net Annual Energy Produced (Btu):	4,282,480,000	489,580,000	1,151,320,000	425,020,000	6,348,400,000

WOOD FUEL COST	**Wood Chips**
$/ton:	$75.00
Assumed efficiency of wood heating system (%):	65%
PROJECTED WOOD FUEL USAGE	
Estimated Btu content of wood fuel (Btu/lb) - **Assumed 30% MC**	6400
Tons of wood fuel to supplant net equivalent of 100% annual heating load.	763
Tons of wood fuel to supplant net equivalent of 85% annual heating load.	649
25 ton chip van loads to supplant net equivalent of 85% annual heating load.	26

Project Capital Cost	**-$2,680,000**

Project Financing Information	
Percent Financed	**0.0%**
Amount Financed	$0
Amount of Grants	$2,680,000
Interest Rate	5.00%
Term	10
Annual Finance Cost (years)	$0

Additional Power Use		
Est. Pwr Use	55000	kWh
Elec Rate	$0.280	/kWh

Additional Maintenance					
Type	Hr/Wk	Wk/Yr	Total Hr	Wage/Hr	Total
Biomass System	4.0	40	160	$20.00	$3,200
Other	0.0	40	0	$20.00	$0
1st 2 Year Learning	3.0	40	120	$20.00	$2,400

Simple Payback: Total Project Cost/Year One Operating Cost Savings:	25.1 years		
Net Present Value (30 year analysis):	$4,975,009	Net Benefit	B/C Ratio
Net Present Value (20 year analysis):	$2,849,249	$2,295,009	1.86
Year Accumulated Cash Flow > 0	#N/A	$169,249	1.06
Year Accumulated Cash Flow > Project Capital Cost	16		

Inflation Factors	
O&M Inflation Rate	2.0%
Fossil Fuel Inflation Rate	5.0%
Wood Fuel Inflation Rate	3.0%
Electricity Inflation Rate	3.0%
Discount Rate for Net Present Value Calculation	3.0%

Cash flow Descriptions	**Unit Costs**	**Heating Source Proportion**	**Annual Heating Source Volumes**	**Heating Units**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**	**Year 20**	**Year 25**	**Year 30**
Existing Heating System Operating Costs																						
Displaced heating costs	$3.60		39800	gal	$143,280	$150,444	$157,966	$165,865	$174,158	$182,866	$192,009	$201,609	$211,690	$222,274	$233,388	$245,057	$257,310	$270,176	$283,685	$362,061	$462,092	$589,760
Displaced heating costs	$3.60		4550	gal	$16,380	$17,199	$18,059	$18,962	$19,910	$20,905	$21,951	$23,048	$24,201	$25,411	$26,681	$28,015	$29,416	$30,887	$32,431	$41,391	$52,827	$67,422
Displaced heating costs	$3.60		10700	gal	$38,520	$40,446	$42,468	$44,592	$46,821	$49,162	$51,620	$54,202	$56,912	$59,757	$62,745	$65,882	$69,176	$72,635	$76,267	$97,338	$124,231	$158,554
Displaced heating costs	$3.60		3950	gal	$14,220	$14,931	$15,678	$16,461	$17,284	$18,149	$19,056	$20,009	$21,009	$22,060	$23,163	$24,321	$25,537	$26,814	$28,155	$35,933	$45,861	$58,531
Biomass System Operating Costs																						
Wood Fuel ($/ton, delivered to boiler site)	$75.00	85%	704	tons	$52,768	$54,351	$55,982	$57,661	$59,391	$61,173	$63,008	$64,898	$66,845	$68,850	$70,916	$73,043	$75,235	$77,492	$79,816	$92,529	$107,267	$124,351
Small load existing fuel	$3.60	15%	5970	gal	$21,492	$22,567	$23,695	$24,880	$26,124	$27,430	$28,801	$30,241	$31,753	$33,341	$35,008	$36,759	$38,597	$40,526	$42,553	$54,309	$69,314	$88,464
Small load existing fuel	$3.60	15%	683	gal	$2,457	$2,580	$2,709	$2,844	$2,986	$3,136	$3,293	$3,457	$3,630	$3,812	$4,002	$4,202	$4,412	$4,633	$4,865	$6,209	$7,924	$10,113
Small load existing fuel	$3.60	15%	1605	gal	$5,778	$6,067	$6,370	$6,689	$7,023	$7,374	$7,743	$8,130	$8,537	$8,964	$9,412	$9,882	$10,376	$10,895	$11,440	$14,601	$18,635	$23,783
Small load existing fuel	$3.60	15%	593	gal	$2,133	$2,240	$2,352	$2,469	$2,593	$2,722	$2,858	$3,001	$3,151	$3,309	$3,474	$3,648	$3,831	$4,022	$4,223	$5,390	$6,879	$8,780
Additional Operation and Maintenance Costs					$3,200	$3,264	$3,329	$3,396	$3,464	$3,533	$3,604	$3,676	$3,749	$3,824	$3,901	$3,979	$4,058	$4,140	$4,222	$4,662	$5,147	$5,683
Additional Operation and Maintenance Costs First 2 years					$2,400	$2,448																
Additional Electrical Cost	$0.280				$15,400	$15,862	$16,338	$16,828	$17,333	$17,853	$18,388	$18,940	$19,508	$20,094	$20,696	$21,317	$21,957	$22,615	$23,294	$27,004	$31,305	$36,291
Annual Operating Cost Savings					***$106,772***	***$113,642***	***$123,397***	***$131,113***	***$139,260***	***$147,861***	***$156,941***	***$166,524***	***$176,637***	***$187,309***	***$198,568***	***$210,445***	***$222,974***	***$236,188***	***$250,124***	***$332,021***	***$438,541***	***$576,802***
Financed Project Costs - Principal and Interest					***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***								
Displaced System Replacement Costs (year one only)					***0***																	
Net Annual Cash Flow					***106,772***	***113,642***	***123,397***	***131,113***	***139,260***	***147,861***	***156,941***	***166,524***	***176,637***	***187,309***	***198,568***	***210,445***	***222,974***	***236,188***	***250,124***	***332,021***	***438,541***	***576,802***
Accumulated Cash Flow					***106,772***	***220,414***	***343,810***	***474,923***	***614,183***	***762,044***	***918,985***	***1,085,509***	***1,262,146***	***1,449,455***	***1,648,023***	***1,858,468***	***2,081,442***	***2,317,630***	***2,567,755***	***4,055,426***	***6,023,947***	***8,617,079***

Nenana School + Admin+ Warehouse + Student Living Center

Nenana, Alaska

Option A.6

Wood Chip Boiler

Date: July 24, 2012
Analyst: CTA Architects Engineers - Nick Salmon & Nathan Ratz

EXISTING CONDITIONS	**School**	**Admin**	**Warehouse**	**SLC**	**Total**
Existing Fuel Type:	Fuel Oil	Fuel Oil	Fuel Oil	Fuel Oil	
Fuel Units:	gal	gal	gal	gal	
Current Fuel Unit Cost:	$3.60	$3.60	$3.60	$3.60	
Estimated Average Annual Fuel Usage:	34,000	1,600	4,200	28,800	68,600
Annual Heating Costs:	$122,400	$5,760	$15,120	$103,680	$246,960
ENERGY CONVERSION (to 1,000,000 Btu; or 1 dkt)					
Fuel Heating Value (Btu/unit of fuel):	134500	134500	134500	134500	
Current Annual Fuel Volume (Btu):	4,573,000,000	215,200,000	564,900,000	3,873,600,000	
Assumed efficiency of existing heating system (%):	80%	80%	80%	80%	
Net Annual Energy Produced (Btu):	3,658,400,000	172,160,000	451,920,000	3,098,880,000	7,381,360,000

WOOD FUEL COST	**Wood Chips**
$/ton:	$75.00
Assumed efficiency of wood heating system (%):	65%
PROJECTED WOOD FUEL USAGE	
Estimated Btu content of wood fuel (Btu/lb) - **Assumed 30% MC**	6400
Tons of wood fuel to supplant net equivalent of 100% annual heating load.	887
Tons of wood fuel to supplant net equivalent of 85% annual heating load.	754
25 ton chip van loads to supplant net equivalent of 85% annual heating load.	30

Project Capital Cost	**-$2,860,000**

Project Financing Information	
Percent Financed	**0.0%**
Amount Financed	$0
Amount of Grants	$2,860,000
Interest Rate	5.00%
Term	10
Annual Finance Cost (years)	$0

Additional Power Use		
Est. Pwr Use	90000	kWh
Elec Rate	$0.280	/kWh

Additional Maintenance					
Type	Hr/Wk	Wk/Yr	Total Hr	Wage/Hr	Total
Biomass System	4.0	40	160	$20.00	$3,200
Other	0.0	40	0	$20.00	$0
1st 2 Year Learning	3.0	40	120	$20.00	$2,400

Simple Payback: Total Project Cost/Year One Operating Cost Savings:	25.4 years		
Net Present Value (30 year analysis):	$5,441,730	Net Benefit	B/C Ratio
Net Present Value (20 year analysis):	$3,085,014	$2,581,730	1.90
Year Accumulated Cash Flow > 0	#N/A	$225,014	1.08
Year Accumulated Cash Flow > Project Capital Cost	16		

Inflation Factors	
O&M Inflation Rate	2.0%
Fossil Fuel Inflation Rate	5.0%
Wood Fuel Inflation Rate	3.0%
Electricity Inflation Rate	3.0%
Discount Rate for Net Present Value Calculation	3.0%

Cash flow Descriptions	Unit Costs	Heating Source Proportion	Annual Heating Source Volumes	Heating Units	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 20	Year 25	Year 30
Existing Heating System Operating Costs																						
Displaced heating costs	$3.60		34000	gal	$122,400	$128,520	$134,946	$141,693	$148,778	$156,217	$164,028	$172,229	$180,841	$189,883	$199,377	$209,346	$219,813	$230,803	$242,344	$309,299	$394,752	$503,815
Displaced heating costs	$3.60		1600	gal	$5,760	$6,048	$6,350	$6,668	$7,001	$7,351	$7,719	$8,105	$8,510	$8,936	$9,382	$9,852	$10,344	$10,861	$11,404	$14,555	$18,577	$23,709
Displaced heating costs	$3.60		4200	gal	$15,120	$15,876	$16,670	$17,503	$18,378	$19,297	$20,262	$21,275	$22,339	$23,456	$24,629	$25,860	$27,153	$28,511	$29,937	$38,207	$48,764	$62,236
Displaced heating costs	$3.60		28800	gal	$103,680	$108,864	$114,307	$120,023	$126,024	$132,325	$138,941	$145,888	$153,183	$160,842	$168,884	$177,328	$186,194	$195,504	$205,279	$261,994	$334,378	$426,761
Biomass System Operating Costs																						
Wood Fuel ($/ton, delivered to boiler site)	$75.00	85%	884	tons	$66,308	$68,297	$70,346	$72,456	$74,630	$76,869	$79,175	$81,550	$83,997	$86,517	$89,112	$91,786	$94,539	$97,375	$100,297	$116,271	$134,790	$156,259
Small load existing fuel	$3.60	15%	5100	gal	$18,360	$19,278	$20,242	$21,254	$22,317	$23,433	$24,604	$25,834	$27,126	$28,482	$29,907	$31,402	$32,972	$34,621	$36,352	$46,395	$59,213	$75,572
Small load existing fuel	$3.60	15%	240	gal	$864	$907	$953	$1,000	$1,050	$1,103	$1,158	$1,216	$1,277	$1,340	$1,407	$1,478	$1,552	$1,629	$1,711	$2,183	$2,786	$3,556
Small load existing fuel	$3.60	15%	630	gal	$2,268	$2,381	$2,500	$2,625	$2,757	$2,895	$3,039	$3,191	$3,351	$3,518	$3,694	$3,879	$4,073	$4,277	$4,490	$5,731	$7,315	$9,335
Small load existing fuel	$3.60	15%	4320	gal	$15,552	$16,330	$17,146	$18,003	$18,904	$19,849	$20,841	$21,883	$22,977	$24,126	$25,333	$26,599	$27,929	$29,326	$30,792	$39,299	$50,157	$64,014
Additional Operation and Maintenance Costs					$3,200	$3,264	$3,329	$3,396	$3,464	$3,533	$3,604	$3,676	$3,749	$3,824	$3,901	$3,979	$4,058	$4,140	$4,222	$4,662	$5,147	$5,683
Additional Operation and Maintenance Costs First 2 years					$2,400	$2,448																
Additional Electrical Cost	$0.280				$25,200	$25,956	$26,735	$27,537	$28,363	$29,214	$30,090	$30,993	$31,923	$32,880	$33,867	$34,883	$35,929	$37,007	$38,117	$44,188	$51,226	$59,385
Annual Operating Cost Savings					***$112,808***	***$120,447***	***$131,022***	***$139,615***	***$148,697***	***$158,296***	***$168,439***	***$179,154***	***$190,473***	***$202,427***	***$215,051***	***$228,380***	***$242,452***	***$257,306***	***$272,983***	***$365,326***	***$485,836***	***$642,716***
Financed Project Costs - Principal and Interest					***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***								
Displaced System Replacement Costs (year one only)					***0***																	
Net Annual Cash Flow					***112,808***	***120,447***	***131,022***	***139,615***	***148,697***	***158,296***	***168,439***	***179,154***	***190,473***	***202,427***	***215,051***	***228,380***	***242,452***	***257,306***	***272,983***	***365,326***	***485,836***	***642,716***
Accumulated Cash Flow					***112,808***	***233,255***	***364,277***	***503,892***	***652,590***	***810,886***	***979,324***	***1,158,478***	***1,348,951***	***1,551,378***	***1,766,430***	***1,994,810***	***2,237,262***	***2,494,568***	***2,767,551***	***4,399,622***	***6,575,026***	***9,458,385***

Nenana School

Nenana, Alaska

Option B.1

Wood Pellet Boiler

Date: July 24, 2012
Analyst: CTA Architects Engineers - Nick Salmon & Nathan Ratz

EXISTING CONDITIONS	**School**				**Total**
Existing Fuel Type:	Fuel Oil	Fuel Oil	Fuel Oil	Fuel Oil	
Fuel Units:	gal	gal	gal	gal	
Current Fuel Unit Cost:	$3.60	$3.60	$3.60	$3.60	
Estimated Average Annual Fuel Usage:	34,000				34,000
Annual Heating Costs:	$122,400	$0	$0	$0	$122,400
ENERGY CONVERSION (to 1,000,000 Btu; or 1 dkt)					
Fuel Heating Value (Btu/unit of fuel):	134500	134500	134500	134500	
Current Annual Fuel Volume (Btu):	4,573,000,000	0	0	0	
Assumed efficiency of existing heating system (%):	80%	80%	80%	80%	
Net Annual Energy Produced (Btu):	3,658,400,000	0	0	0	3,658,400,000

WOOD FUEL COST	**Wood Pellets**
$/ton:	$325.00
Assumed efficiency of wood heating system (%):	70%
PROJECTED WOOD FUEL USAGE	
Estimated Btu content of wood fuel (Btu/lb) - **Assumed 7% MC**	8200
Tons of wood fuel to supplant net equivalent of 100% annual heating load.	319
Tons of wood fuel to supplant net equivalent of 85% annual heating load.	271
25 ton chip van loads to supplant net equivalent of 85% annual heating load.	11

Project Capital Cost	**-$1,300,000**

Project Financing Information	
Percent Financed	**0.0%**
Amount Financed	$0
Amount of Grants	$1,300,000
Interest Rate	5.00%
Term	10
Annual Finance Cost (years)	$0

Additional Power Use		
Est. Pwr Use	20000	kWh
Elec Rate	$0.280	/kWh

Additional Maintenance					
Type	Hr/Wk	Wk/Yr	Total Hr	Wage/Hr	Total
Biomass System	2.0	40	80	$20.00	$1,600
Other	0.0	40	0	$20.00	$0
1st 2 Year Learning	2.0	40	80	$20.00	$1,600

		Net Benefit	B/C Ratio
Simple Payback: Total Project Cost/Year One Operating Cost Savings:	180.4 years		
Net Present Value (30 year analysis):	$1,289,692	-$10,308	0.99
Net Present Value (20 year analysis):	$590,490	-$709,510	0.45
Year Accumulated Cash Flow > 0	#N/A		
Year Accumulated Cash Flow > Project Capital Cost	24		

Inflation Factors	
O&M Inflation Rate	2.0%
Fossil Fuel Inflation Rate	5.0%
Wood Fuel Inflation Rate	3.0%
Electricity Inflation Rate	3.0%
Discount Rate for Net Present Value Calculation	3.0%

Cash flow Descriptions	Unit Costs	Heating Source Proportion	Annual Heating Source Volumes	Heating Units	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 20	Year 25	Year 30
Existing Heating System Operating Costs																						
Displaced heating costs	$3.60		34000	gal	$122,400	$128,520	$134,946	$141,693	$148,778	$156,217	$164,028	$172,229	$180,841	$189,883	$199,377	$209,346	$219,813	$230,803	$242,344	$309,299	$394,752	$503,815
Displaced heating costs	$3.60		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Displaced heating costs	$3.60		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Displaced heating costs	$3.60		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Biomass System Operating Costs																						
Wood Fuel ($/ton, delivered to boiler site)	$325.00	85%	271	tons	$88,034	$90,675	$93,396	$96,197	$99,083	$102,056	$105,117	$108,271	$111,519	$114,865	$118,311	$121,860	$125,516	$129,281	$133,160	$154,369	$178,955	$207,458
Small load existing fuel	$3.60	15%	5100	gal	$18,360	$19,278	$20,242	$21,254	$22,317	$23,433	$24,604	$25,834	$27,126	$28,482	$29,907	$31,402	$32,972	$34,621	$36,352	$46,395	$59,213	$75,572
Small load existing fuel	$3.60	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Small load existing fuel	$3.60	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Small load existing fuel	$3.60	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Additional Operation and Maintenance Costs					$1,600	$1,632	$1,665	$1,698	$1,732	$1,767	$1,802	$1,838	$1,875	$1,912	$1,950	$1,989	$2,029	$2,070	$2,111	$2,331	$2,573	$2,841
Additional Operation and Maintenance Costs First 2 years					$1,600	$1,632																
Additional Electrical Cost	$0.280				$5,600	$5,768	$5,941	$6,119	$6,303	$6,492	$6,687	$6,887	$7,094	$7,307	$7,526	$7,752	$7,984	$8,224	$8,471	$9,820	$11,384	$13,197
Annual Operating Cost Savings					***$7,206***	***$9,535***	***$13,703***	***$16,425***	***$19,343***	***$22,470***	***$25,818***	***$29,399***	***$33,227***	***$37,317***	***$41,683***	***$46,343***	***$51,312***	***$56,608***	***$62,251***	***$96,385***	***$142,627***	***$204,746***
Financed Project Costs - Principal and Interest					***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***								
Displaced System Replacement Costs (year one only)					***0***																	
Net Annual Cash Flow					***7,206***	***9,535***	***13,703***	***16,425***	***19,343***	***22,470***	***25,818***	***29,399***	***33,227***	***37,317***	***41,683***	***46,343***	***51,312***	***56,608***	***62,251***	***96,385***	***142,627***	***204,746***
Accumulated Cash Flow					***7,206***	***16,741***	***30,443***	***46,868***	***66,211***	***88,681***	***114,499***	***143,897***	***177,124***	***214,441***	***256,124***	***302,467***	***353,778***	***410,387***	***472,637***	***882,087***	***1,497,212***	***2,389,469***

Meda Lord Senior Center

Nenana, Alaska

Option C.1

Cord Wood Boiler

Date: July 24, 2012
Analyst: CTA Architects Engineers - Nick Salmon & Nathan Ratz

EXISTING CONDITIONS	**MLSC**				**Total**
Existing Fuel Type:	Fuel Oil	Fuel Oil	Fuel Oil	Fuel Oil	
Fuel Units:	gal	gal	gal	gal	
Current Fuel Unit Cost:	$3.60	$3.60	$3.60	$3.60	
Estimated Average Annual Fuel Usage:	6,566				6,566
Annual Heating Costs:	$23,638	$0	$0	$0	$23,638
ENERGY CONVERSION (to 1,000,000 Btu; or 1 dkt)					
Fuel Heating Value (Btu/unit of fuel):	134500	134500	134500	134500	
Current Annual Fuel Volume (Btu):	883,127,000	0	0	0	
Assumed efficiency of existing heating system (%):	80%	80%	80%	80%	
Net Annual Energy Produced (Btu):	706,501,600	0	0	0	706,501,600

WOOD FUEL COST	**Cord Wood**
$/ton:	$200.00
Assumed efficiency of wood heating system (%):	65%
PROJECTED WOOD FUEL USAGE	
Estimated Btu content of wood fuel (Btu/lb) - **Assumed 20% MC, 6,700 Btu/lb x 28.4 lb/cf x 85 cf**	16,173,800
Cords of wood fuel to supplant net equivalent of 100% annual heating load.	67
Cords of wood fuel to supplant net equivalent of 85% annual heating load.	57
25 ton chip van loads to supplant net equivalent of 85% annual heating load.	N/A

Project Capital Cost	**-$280,000**

Project Financing Information	
Percent Financed	**0.0%**
Amount Financed	$0
Amount of Grants	$280,000
Interest Rate	5.00%
Term	10
Annual Finance Cost (years)	$0

Additional Power Use		
Est. Pwr Use	3000	kWh
Elec Rate	$0.280	/kWh

Additional Maintenance					
Type	Hr/Wk	Wk/Yr	Total Hr	Wage/Hr	Total
Biomass System	10.0	40	400	$20.00	$8,000
Other	0.0	40	0	$20.00	$0
1st 2 Year Learning	2.0	40	80	$20.00	$1,600

		Net Benefit	B/C Ratio
Simple Payback: Total Project Cost/Year One Operating Cost Savings:	-158.0 years		
Net Present Value (30 year analysis):	$220,868	-$59,132	0.79
Net Present Value (20 year analysis):	$88,173	-$191,827	0.31
Year Accumulated Cash Flow > 0	5		
Year Accumulated Cash Flow > Project Capital Cost	26		

Inflation Factors	
O&M Inflation Rate	2.0%
Fossil Fuel Inflation Rate	5.0%
Wood Fuel Inflation Rate	3.0%
Electricity Inflation Rate	3.0%
Discount Rate for Net Present Value Calculation	3.0%

Cash flow Descriptions	Unit Costs	Heating Source Proportion	Annual Heating Source Volumes	Heating Units	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 20	Year 25	Year 30
Existing Heating System Operating Costs																						
Displaced heating costs	$3.60		6566	gal	$23,638	$24,819	$26,060	$27,363	$28,732	$30,168	$31,677	$33,260	$34,924	$36,670	$38,503	$40,428	$42,450	$44,572	$46,801	$59,731	$76,234	$97,296
Displaced heating costs	$3.60		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Displaced heating costs	$3.60		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Displaced heating costs	$3.60		0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Biomass System Operating Costs																						
Wood Fuel ($/ton, delivered to boiler site)	$200.00	85%	57	cords	$11,424	$11,767	$12,120	$12,484	$12,858	$13,244	$13,641	$14,051	$14,472	$14,906	$15,354	$15,814	$16,289	$16,777	$17,281	$20,033	$23,224	$26,923
Small load existing fuel	$3.60	15%	985	gal	$3,546	$3,723	$3,909	$4,105	$4,310	$4,525	$4,751	$4,989	$5,239	$5,500	$5,775	$6,064	$6,367	$6,686	$7,020	$8,960	$11,435	$14,594
Small load existing fuel	$3.60	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Small load existing fuel	$3.60	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Small load existing fuel	$3.60	15%	0	gal	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Additional Operation and Maintenance Costs					$8,000	$8,160	$8,323	$8,490	$8,659	$8,833	$9,009	$9,189	$9,373	$9,561	$9,752	$9,947	$10,146	$10,349	$10,556	$11,654	$12,867	$14,207
Additional Operation and Maintenance Costs First 2 years					$1,600	$1,632																
Additional Electrical Cost	$0.280				$840	$865	$891	$918	$945	$974	$1,003	$1,033	$1,064	$1,096	$1,129	$1,163	$1,198	$1,234	$1,271	$1,473	$1,708	$1,980
Annual Operating Cost Savings					***-$1,773***	***-$1,328***	***$817***	***$1,368***	***$1,959***	***$2,592***	***$3,271***	***$3,998***	***$4,775***	***$5,606***	***$6,493***	***$7,440***	***$8,450***	***$9,527***	***$10,674***	***$17,611***	***$27,000***	***$39,592***
Financed Project Costs - Principal and Interest					***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***								
Displaced System Replacement Costs (year one only)					***0***																	
Net Annual Cash Flow					***(1,773)***	***(1,328)***	***817***	***1,368***	***1,959***	***2,592***	***3,271***	***3,998***	***4,775***	***5,606***	***6,493***	***7,440***	***8,450***	***9,527***	***10,674***	***17,611***	***27,000***	***39,592***
Accumulated Cash Flow					***(1,773)***	***(3,100)***	***(2,284)***	***(916)***	***1,043***	***3,635***	***6,906***	***10,905***	***15,680***	***21,286***	***27,779***	***35,220***	***43,670***	***53,196***	***63,870***	***137,198***	***252,302***	***423,622***

Economic Sensitiviy Analysis
Nenana Biomass Heating System

Line No.	Project Cost	Fuel Oil Usage Gal	Fuel Oil Unit Cost $/Gal.	Estimated Power Use kwh	Wood Fuel Cost $/cord ton	Simple Payback yrs	O&M Inflation	Fuel Oil & Elec Inflation	Wood Fuel Inflation	Biomass Weekly O&M Hrs	Additional O&M	Year 1 Operating Savings	NPV 30 yr at 3%	NPV 20 yr at 3%	20 Yr B/C Ratio	30 Yr B/C Ratio	ACF YR 20	ACF YR 30	YR ACF=PC
	All Options - Base Cases																		
A.1	$1,780,000	34,000	$3.60	40,000	$75	30.1	2.0%	5.0%	3.0%	4.0	$3,200	$59,208	$2,832,089	$1,616,943	0.91	1.59	$2,303,414	$4,911,172	18
A.2	$1,960,000	39,800	$3.60	40,000	$75	27.2	2.0%	5.0%	3.0%	4.0	$3,200	$72,175	$3,385,501	$1,940,341	0.99	1.73	$2,761,778	$5,862,829	17
A.3	$2,150,000	44,350	$3.60	43,000	$75	26.4	2.0%	5.0%	3.0%	4.0	$3,200	$81,506	$3,795,177	$2,177,730	1.01	1.77	$3,098,786	$6,569,425	16
A.4	$2,590,000	55,050	$3.60	50,000	$75	26.1	2.0%	5.0%	3.0%	4.0	$3,200	$99,342	$4,638,894	$2,656,188	1.03	1.79	$3,780,882	$8,035,572	16
A.5	$2,680,000	59,000	$3.60	55,000	$75	25.1	2.0%	5.0%	3.0%	4.0	$3,200	$106,772	$4,975,009	$2,849,249	1.06	1.86	$4,055,426	$8,617,079	16
A.6	$2,860,000	68,600	$3.60	90,000	$75	25.4	2.0%	5.0%	3.0%	4.0	$3,200	$112,808	$5,441,730	$3,085,014	1.08	1.90	$4,399,622	$9,458,385	16
B.1	$1,300,000	34,000	$3.60	20,000	$325	180.4	2.0%	5.0%	3.0%	2.0	$1,600	$7,206	$1,289,692	$590,490	0.45	0.99	$882,087	$2,389,469	24
C.1	$280,000	6,566	$3.60	3,000	$200	-158.0	2.0%	5.0%	3.0%	10.0	$8,000	-$1,773	$220,868	$88,173	0.31	0.79	$137,198	$423,622	26
1	**Option A.6 is the strongest economic case and will be used for further sensitivity analysis.**																		
2																			
3	**A.6 - Adjusting Fuel Oil Inflation Rate**																		
4	$2,680,000	59,000	$3.60	55,000	$75	25.1	2.0%	5.0%	3.0%	4.0	$3,200	$106,772	$4,975,009	$2,849,249	1.06	1.86	$4,055,426	$8,617,079	16
5	$2,860,000	68,600	$3.60	90,000	$75	25.4	2.0%	6.0%	3.0%	4.0	$3,200	$112,808	$6,808,757	$3,589,605	1.26	2.38	$5,180,433	$12,107,386	15
6	$2,860,000	68,600	$3.60	90,000	$75	25.4	2.0%	7.0%	3.0%	4.0	$3,200	$112,808	$8,459,179	$4,157,775	1.45	2.96	$6,064,159	$15,340,638	14
7	$2,860,000	68,600	$3.60	90,000	$75	25.4	2.0%	8.0%	3.0%	4.0	$3,200	$112,808	$10,455,463	$4,797,897	1.68	3.66	$7,064,717	$19,291,766	13
8	$2,860,000	68,600	$3.60	90,000	$75	25.4	2.0%	9.0%	3.0%	4.0	$3,200	$112,808	$12,874,011	$5,519,433	1.93	4.50	$8,197,877	$24,124,941	12
9	$2,860,000	68,600	$3.60	90,000	$75	25.4	2.0%	10.0%	3.0%	4.0	$3,200	$112,808	$15,808,228	$6,333,076	2.21	5.53	$9,481,488	$30,041,735	12
10																			
11	**A.6 - Adjusting Fuel Oil Cost**																		
12	$2,860,000	68,600	$3.50	90,000	$75	26.7	2.0%	5.0%	3.0%	4.0	$3,200	$106,977	$5,214,151	$2,948,258	1.03	1.82	$4,206,814	$9,070,980	16
13	$2,860,000	68,600	$3.75	90,000	$75	23.5	2.0%	5.0%	3.0%	4.0	$3,200	$121,555	$5,783,098	$3,290,148	1.15	2.02	$4,688,833	$10,039,492	15
14	$2,860,000	68,600	$4.00	90,000	$75	21.0	2.0%	5.0%	3.0%	4.0	$3,200	$136,132	$6,352,045	$3,632,039	1.27	2.22	$5,170,852	$11,008,005	14
15	$2,860,000	68,600	$4.50	90,000	$75	17.3	2.0%	5.0%	3.0%	4.0	$3,200	$165,287	$7,489,940	$4,315,821	1.51	2.62	$6,134,890	$12,945,029	13
16	$2,860,000	68,600	$5.00	90,000	$75	14.7	2.0%	5.0%	3.0%	4.0	$3,200	$194,442	$8,627,835	$4,999,603	1.75	3.02	$7,098,928	$14,882,054	11
17																			
18	**A.6 - Adjusting Wood Fuel Cost**																		
19	$2,860,000	68,600	$3.60	90,000	$75	25.4	2.0%	5.0%	3.0%	4.0	$3,200	$112,808	$5,441,730	$3,085,014	1.08	1.90	$4,399,622	$9,458,385	16
20	$2,860,000	68,600	$3.60	90,000	$85	27.5	2.0%	5.0%	3.0%	4.0	$3,200	$103,967	$5,184,223	$2,913,343	1.02	1.81	$4,162,059	$9,037,768	16
21	$2,860,000	68,600	$3.60	90,000	$100	31.5	2.0%	5.0%	3.0%	4.0	$3,200	$90,705	$4,797,964	$2,655,837	0.93	1.68	$3,805,716	$8,406,843	17
22	$2,860,000	68,600	$3.60	90,000	$110	34.9	2.0%	5.0%	3.0%	4.0	$3,200	$81,864	$4,540,457	$2,484,166	0.87	1.59	$3,568,153	$7,986,226	18
23																			

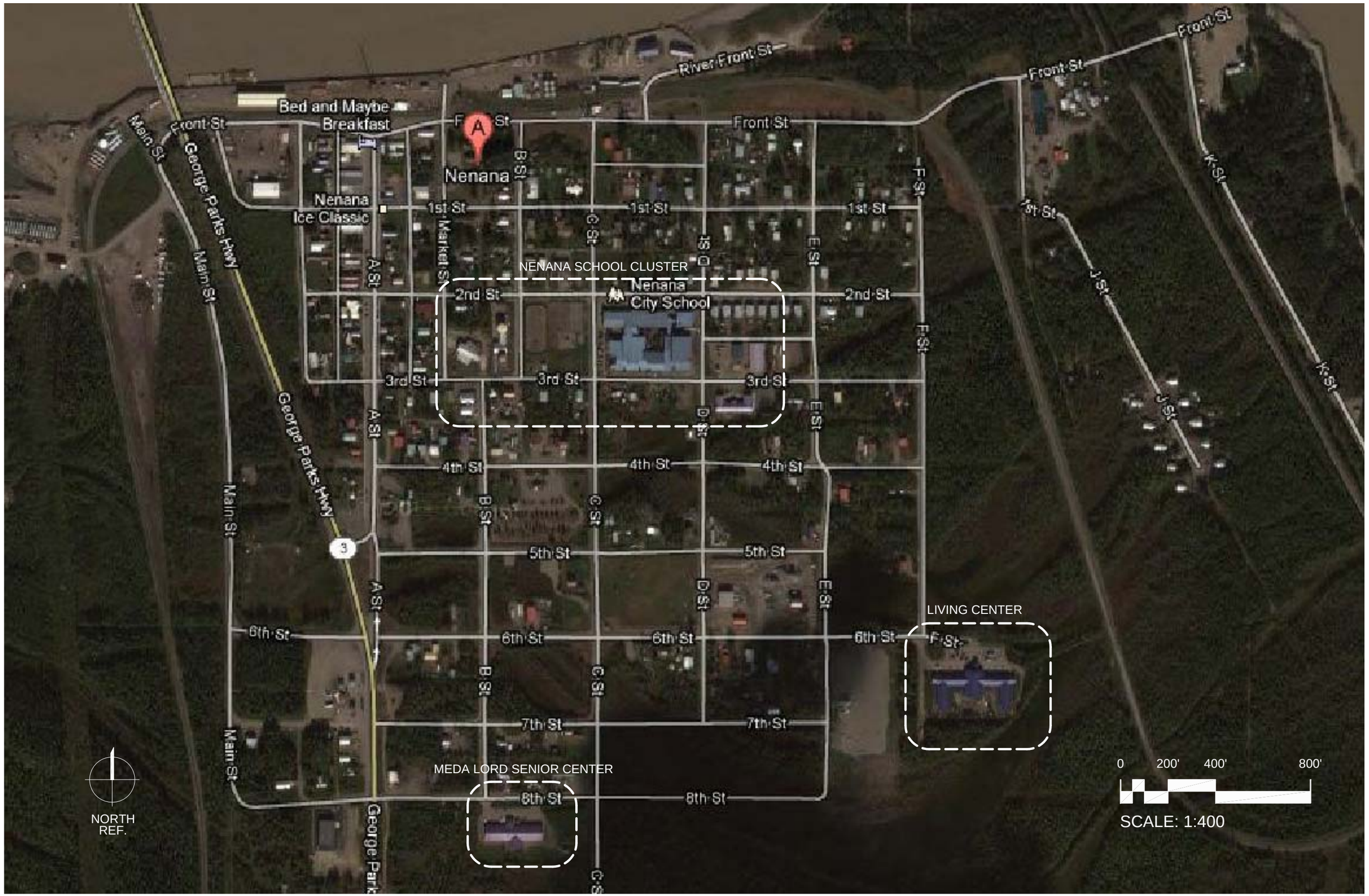
24 NPV: Net Present Value ACF: Accumulated Cash Flow YR ACF=PC : Year Accumulated Cash Flow equals Project Cost

CTA

July 24, 2012

APPENDIX C

Site Plan



Drawn By SSF
Checked By NRH
Date 07/24/2012
CTA # FEDC
Cad File: J:\NENANA

BIOMASS PRE-FEASIBILITY ASSESSMENT
NENANA OVERVIEW
NENANA, ALASKA

CTA
MISSOULA, MT
(406)728-9522
Fax (406)728-8287

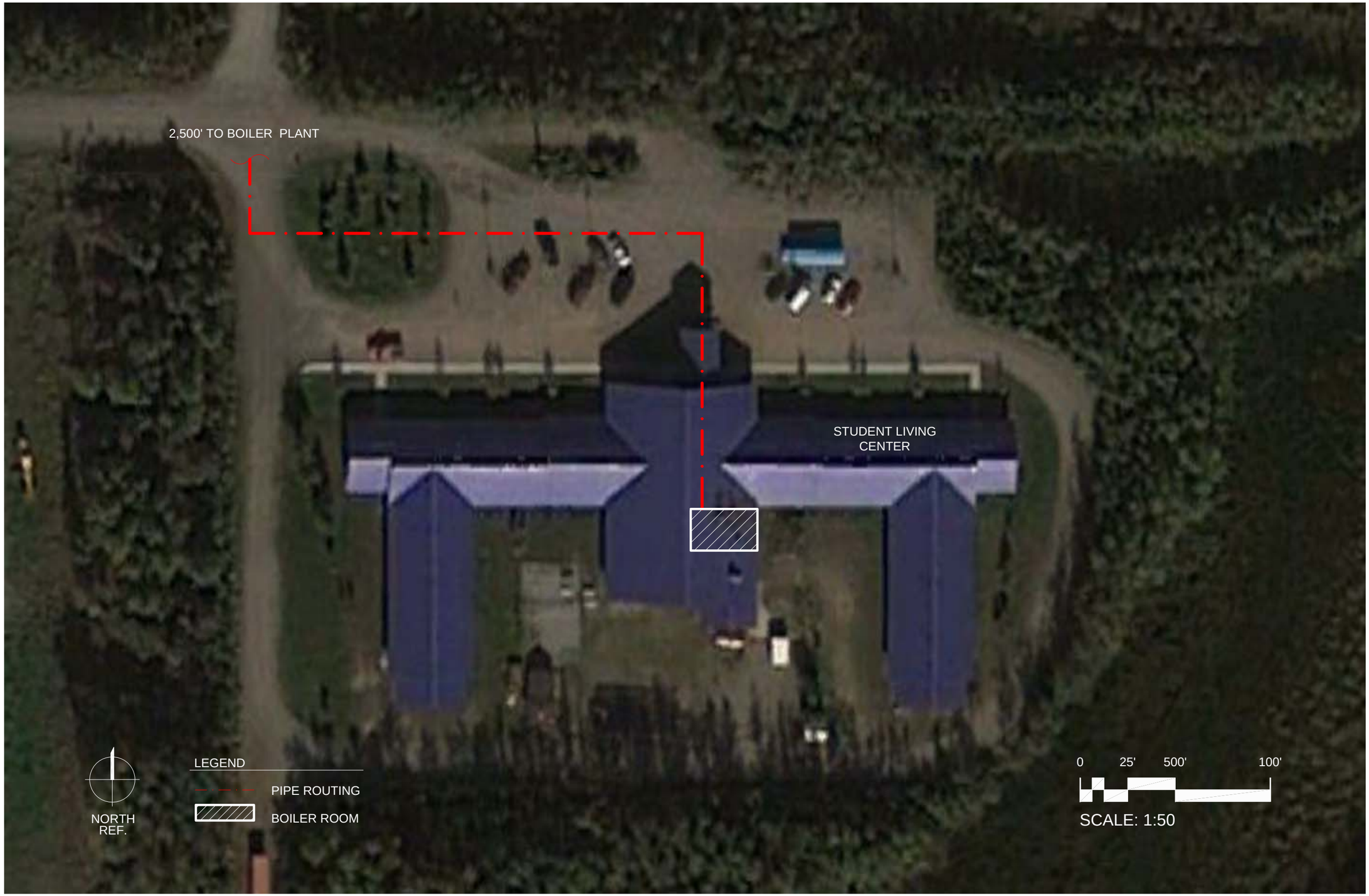
SITE PLAN

Drawn By SSF
Checked By NHR
Date 07/24/2012
CTA # FEDC
Cad File: J:\NENANA

BIOMASS PRE FEASIBILITY ASSESSMENT
NENANA SCHOOL CLUSTER
NENANA, ALASKA

CTA
MISSOULA, MT
(406)728-9522
Fax (406)728-8287

SITE PLAN

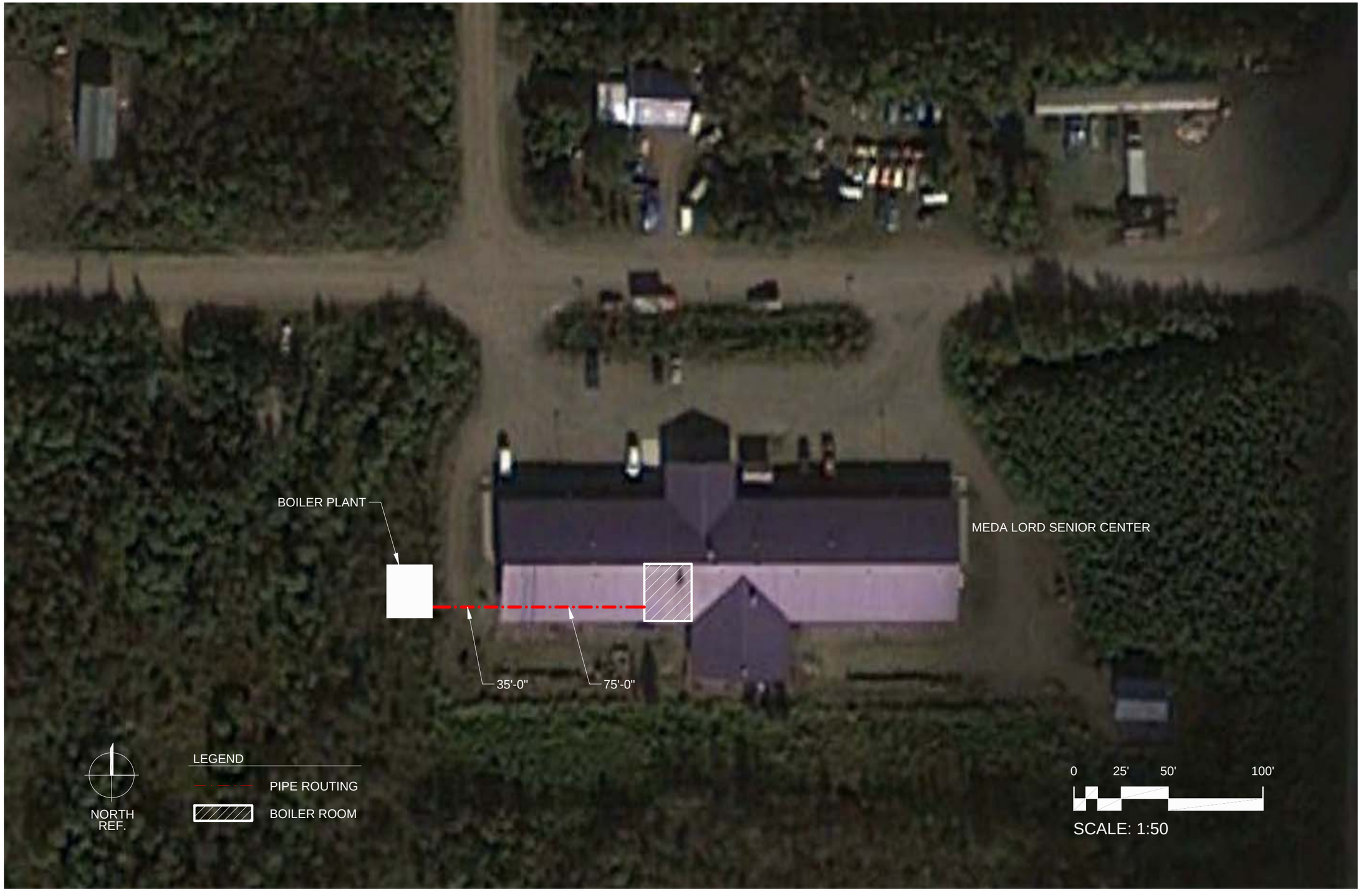


Drawn By SSF
Checked By NHR
Date 07/24/2012
CTA # FEDC
Cad File: J:\NENANA\

BIOMASS PRE-FEASIBILITY ASSESSMENT
STUDENT LIVING CENTER
NENANA, ALASKA

CTA
MISSOULA, MT
(406)728-9522
Fax (406)728-8287

SITE PLAN



Drawn By SSF
Checked By NHR
Date 07/24/2012
CTA # FEDC
Cad File: J:\NENANA

BIOMASS PRE-FEASIBILITY ASSESSMENT
NENANA MEDA LORD SENIOR CENTER
NENANA, ALASKA

CTA
MISSOULA, MT
(406)728-9522
Fax (406)728-8287

SITE PLAN

APPENDIX D

Air Quality Report

To:	Nick Salmon
From:	John Hinckley
Subject:	Fairbanks Cluster Feasibility Study
Date:	24 July 2012

INTRODUCTION

At your request, RSG has conducted an air quality feasibility study for three biomass energy installations in Manley, Minto and Nenana. These sites are located in the interior of Alaska near Fairbanks. The following equipment is proposed:

- Minto - one 300,000 Btu/hr (heat output) cord wood boiler at the Minto Health Clinic.
- Manley - one 150,000 Btu/hr (heat output) cord wood boiler at the Village Express Maintenance Shop.
- Nenana – one 4,200,000 Btu/hr (heat output) wood chip boiler at the Nenana School.

MINTO STUDY AREA

A USGS map of the Minto study area is provided in Figure 1 below. As shown, the area is flat with much low-lying areas to the east and hilly to the west. The site is adjacent to a hillside. The area is relatively sparsely populated. Our review of the area did not reveal any significant emission sources or ambient air quality issues.

55 Railroad Row ▪ White River Junction, Vermont 05001
TEL 802.295.4999 ▪ FAX 802.295.1006 ▪ www.rsginc.com

Figure 1: USGS Map Illustrating the Minto Study Area

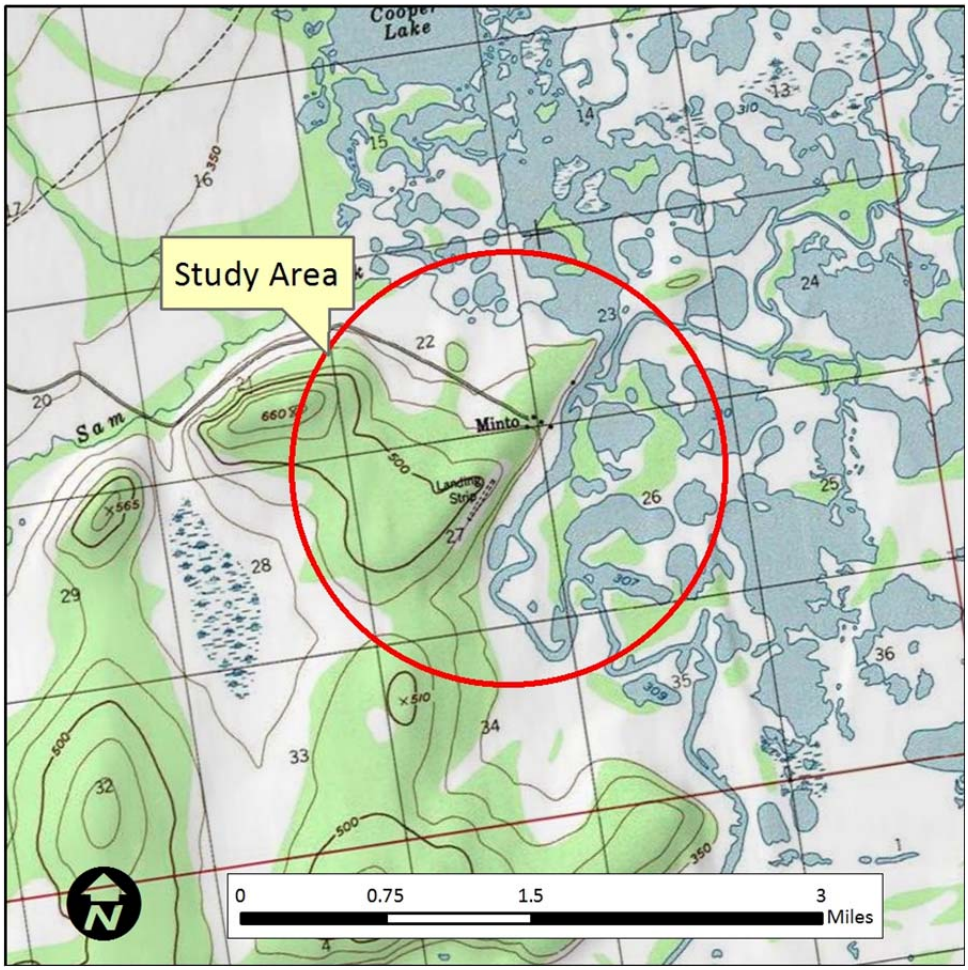


Figure 2 shows CTA Architects' plan of the location of the proposed biomass facility and the surrounding buildings in Minto. The site is relatively flat and sparsely populated with buildings. The facility will be located in a remote building on the southeast side of two buildings. The precise dimensions of that building, the stack location and dimensions, and the biomass equipment specifications have not been determined. The degree of separation of the biomass building from the other buildings will create a buffer for emissions dispersion.

Figure 2: Location of Proposed Facility in Minto

A USGS map of the Manley study area is provided Figure 3. As shown, the area is hilly to mountainous to the north and flat to the south. The site is near the higher terrain to the north. The area is relatively sparsely populated. Our review of the area did not reveal any significant emission sources or ambient air quality issues.

Figure 3: USGS Map Illustrating the Manley Hot Springs Study Area

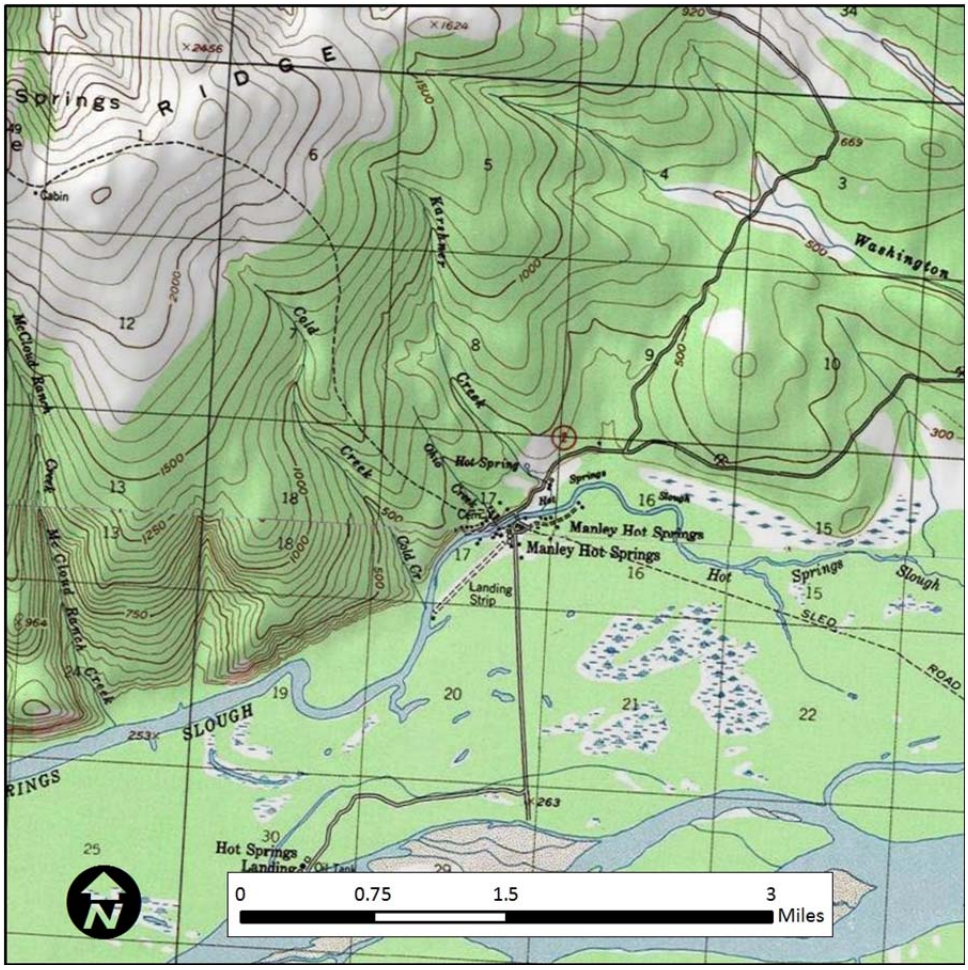


Figure 4 shows CTA Architects' plan of the location of the proposed biomass facility and the surrounding buildings. The site is surrounded by forest, relatively flat and has only a few buildings. The facility will be located in a new building on the west side of the site. A generator building is also indicated on the plan. The precise dimensions of that building, the stack location and dimensions, and the biomass equipment specifications have not been determined.

Figure 4: Location of Proposed Facility in Manley

A USGS map of the Nenana study area is provided Figure 3. As shown, the area is hilly to mountainous to the north and flat to the south and northeast. The site is across the river from higher terrain to the north. The area is moderately populated relative to the other sites discussed. Our review of the area did not reveal any significant emission sources or ambient air quality issues.

Figure 5: USGS Map Illustrating the Nenana Study Area

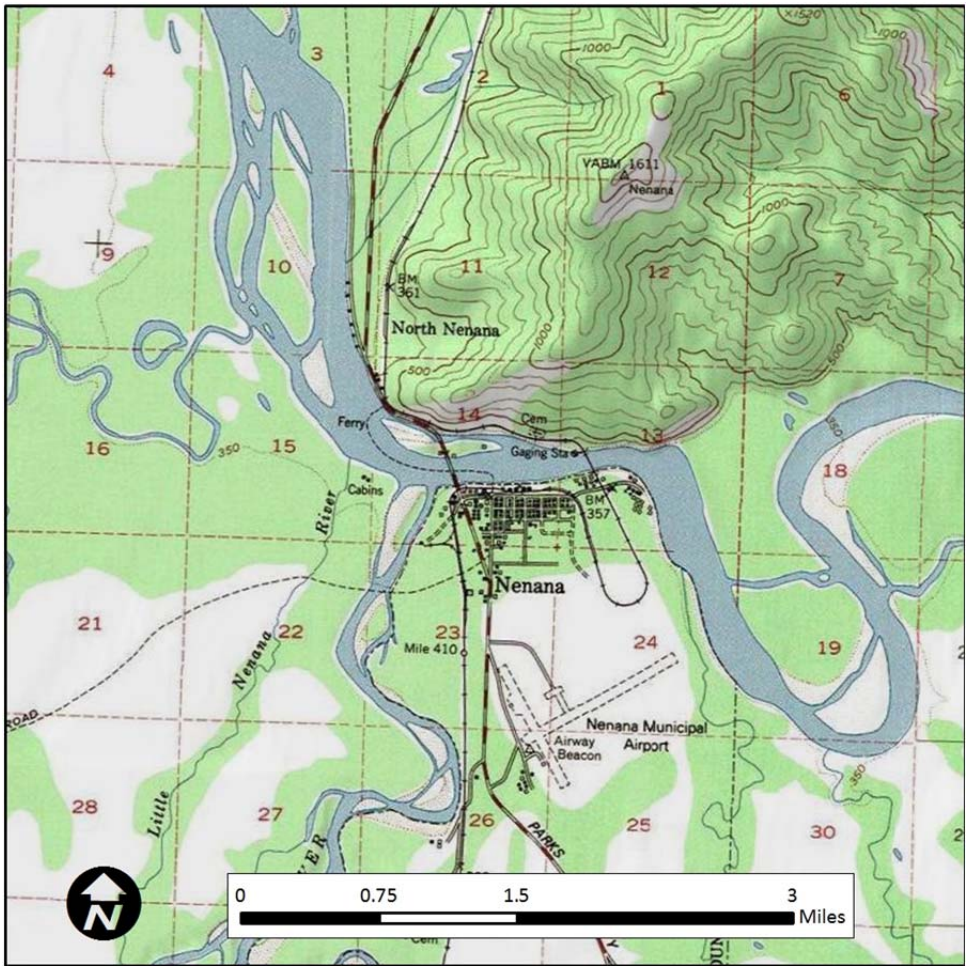
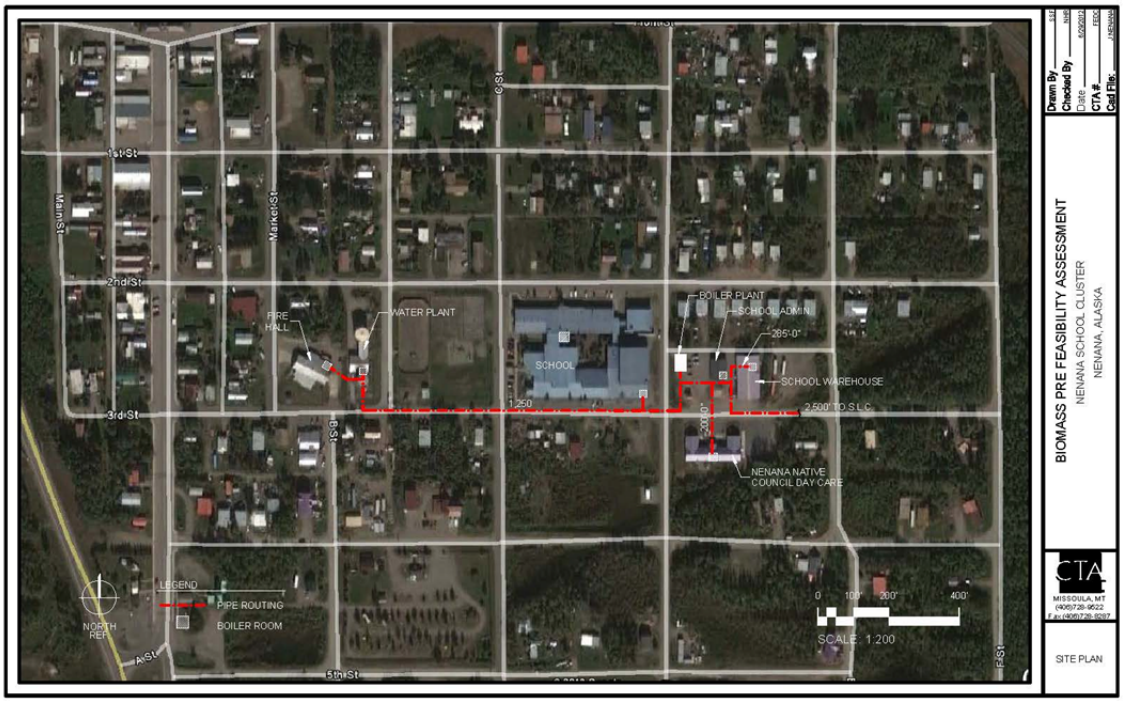


Figure 6 shows CTA Architects' plan of the location of the proposed biomass facility at the Nenana School and the surrounding buildings. The site is relatively flat and relatively densely populated with one to two story tall buildings. The proposed biomass equipment will be installed in a remote building located to the east of the school. This will provide a buffer for dispersion of air emissions between the stack and surrounding buildings. The precise stack location and dimensions, and the biomass equipment specifications have not been determined.

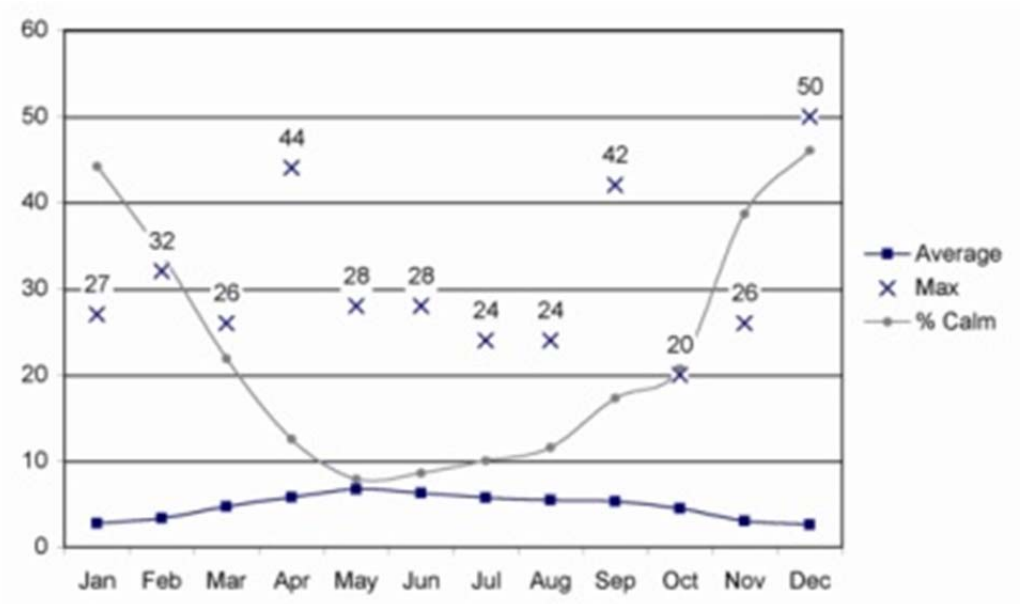
Figure 6: Overview of Nenana School Cluster Site



METEOROLOGY

Meteorological data from Fairbanks, AK was reviewed to develop an understanding of weather conditions. While Fairbanks is approximately 90 miles, 50 miles, and 45 miles away from Manley, Minto, and Nenana respectively, it is located in a similar climactic zone (Alaska Interior) and is therefore a good proxy of weather in those locations. As shown, there is a relatively high percentage of "calms" or times when the wind is not blowing during the colder months.[1] These conditions create thermal inversions which are unfavorable for the dispersion of emissions.

Figure 7: Wind Speed Data from Fairbanks, AK



DESIGN & OPERATION RECOMMENDATIONS

The following are suggested for designing the stack:

[1] See: http://climate.gi.alaska.edu/Climate/Wind/Speed/Fairbanks/FAI.html

- Burn natural wood, whose characteristics (moisture content, bark content, species, geometry) results in optimal combustion in the equipment selected for the project.
- Do not install a rain cap above the stack. Rain caps obstruct vertical airflow and reduce dispersion of emissions.
- Construct the stack to at least 1.5 times the height of the tallest roofline of the adjacent building. Hence, a 20 foot roofline would result in a minimum 30 foot stack.
- Operate and maintain the boiler according to manufacturer's recommendations.
- Perform a tune-up at least every other year as per manufacturer's recommendations and EPA guidance (see below for more discussion of EPA requirements)
- Conduct regular observations of stack emissions. If emissions are not characteristic of good boiler operation, make corrective actions.
- For the Nenana School: while there are no state or federal requirements mandating advanced emission control from and ESP or baghouse, we feel advanced emission control should be strongly considered. Alternatively, the school should consider using pellets in lieu of wood chips.

STATE AND FEDERAL PERMIT REQUIREMENTS

This project will not require an air pollution control permit from the Alaska Department of Environmental Quality given the boilers' relatively small size and corresponding quantity of emissions. However, this project will be subject to new proposed requirements in the federal "Area Source Rule" (40 CFR 63 JJJJJJ). A federal permit is not needed. However, there are various record keeping, reporting and operation and maintenance requirements which must be performed to demonstrate compliance with the requirements in the Area Source Rule. The proposed changes have not been finalized. Until that time, the following requirements are applicable:

- Submit initial notification form to EPA within 120 days of startup.
- Complete biennial tune ups per EPA method.
- Submit tune-up forms to EPA.

Please note the following:

- Oil and coal fired boilers are also subject to this rule.
- Gas fired boilers are not subject to this rule.
- More requirements are applicable to boilers equal to or greater than 10 MMBtu/hr heat input. These requirements typically warrant advanced emission controls, such as a baghouse or an electrostatic precipitator (ESP).

The compliance guidance documents and compliance forms can be obtained on the following EPA web page: http://www.epa.gov/boilercompliance/

SUMMARY

RSG has completed an air quality feasibility study for Minto, Manley, and Nenana, Alaska. The boilers are not subject to state permitting requirements, but are subject to federal requirements. Design criteria have been suggested to minimize emissions and maximize dispersion.

The following conditions suggest advanced emission control devices (ESP, baghouse) are not mandatory:

1. The wood boilers, with the exception of the boiler at Nenana, will be relatively small emission sources.
2. The wood boilers will be located in a separate building which will create a dispersion buffer between the boiler stack and the building.
3. There are no applicable federal or state emission limits.

Sustained poor meteorology suggests emissions should be minimized as much as possible.

Given these findings, we would recommend at minimum the following be done to minimize emissions:

1. Nenana: consider burning pellets in lieu of wood chips or consider advanced emission control. If wood chips are preferable, consider conducting air dispersion modeling to determine the stack height and degree of emission control.
2. While not mandatory, we recommend exploring the possibility of a cyclone or multi-cyclone technology for control of fly ash and larger particulate emissions for all the aforementioned boilers.
3. Obtain a not-to-exceed emission guarantees from boiler equipment vendors.

We also recommend developing a compliance plan for the aforementioned federal requirements.

Please contact me if you have any comments or questions.

APPENDIX E

Wood Fired Heating Technologies

WOOD FIRED HEATING TECHNOLOGIES

CTA has developed wood-fired heating system projects using cord wood, wood pellet and wood chips as the primary feedstock. A summary of each system type with the benefits and disadvantages is noted below.

Cord Wood

Cord wood systems are hand-stoked wood boilers with a limited heat output of 150,000-200,000 British Thermal Units per hour (Btu/hour). Cord wood systems are typically linked to a thermal storage tank in order to optimize the efficiency of the system and reduce the frequency of stoking. Cord wood boiler systems are also typically linked to existing heat distribution systems via a heat exchanger. Product data from Garn, HS Tarm and KOB identify outputs of 150,000-196,000 Btu/hr based upon burning eastern hardwoods and stoking the boiler on an hourly basis. The cost and practicality of stoking a wood boiler on an hourly basis has led most operators of cord wood systems to integrate an adjacent thermal storage tank, acting similar to a battery, storing heat for later use. The thermal storage tank allows the wood boiler to be stoked to a high fire mode 3 times per day while storing heat for distribution between stoking. Cord wood boilers require each piece of wood to be hand fed into the firebox, hand raking of the grates and hand removal of ash. Ash is typically cooled in a barrel before being stock piled and later broadcast as fertilizer.

Cordwood boilers are manufactured by a number of European manufacturers and an American manufacturer with low emissions. These manufacturers currently do not fabricate equipment with ASME (American Society of Mechanical Engineers) certifications. When these non ASME boilers are installed in the United States, atmospheric boilers rather than pressurized boilers are utilized. Atmospheric boilers require more frequent maintenance of the boiler chemicals.

Emissions from cord wood systems are typically as follows:

PM2.5	>0.08 lb/MMbtu
NOx	0.23 lb/MMbtu
SO2	0.025 lb/MMbtu
CO2	195 lb/MMbtu

Benefits:

Small size
Lower cost
Local wood resource
Simple to operate

Disadvantages:

Hand fed - a large labor commitment
Typically atmospheric boilers (not ASME rated)
Thermal Storage is required

Wood Pellet

Wood pellet systems can be hand fed from 40 pound bags, hand shoveled from 2,500 pound sacks of wood pellets, or automatically fed from an adjacent agricultural silo with a capacity of 30-40 tons. Pellet boilers systems are typically linked to existing heat distribution systems via a heat exchanger. Product data from KOB, Forest Energy and Solagen identify outputs of 200,000-5,000,000 Btu/hr based upon burning pellets made from waste products from the western timber industry. A number of pellet fuel manufacturers produce all tree pellets utilizing bark and needles. All tree pellets have significantly higher ash content, resulting in more frequent ash removal. Wood pellet boilers typically require hand raking of the grates and hand removal of ash 2-3 times a week. Automatic ash removal can be integrated into pellet boiler systems. Ash is typically cooled in a barrel before being stock piled and later broadcast as fertilizer. Pellet storage is very economical. Agricultural bin storage exterior to the building is inexpensive and quick to install. Material conveyance is also borrowed from agricultural technology. Flexible conveyors allow the storage to be located 20 feet or more from the boiler with a single auger.

Emissions from wood pellet systems are typically as follows:

PM2.5	>0.09 lb/MMbtu
NOx	0.22 lb/MMbtu
SO2	0.025 lb/MMbtu
CO2	220 lb/MMbtu

Benefits:

Smaller size (relative to a chip system)
Consistent fuel and easy economical storage of fuel
Automated

Disadvantages:

Higher system cost
Higher cost wood fuel ($/MMBtu)

Wood Chip

Chip systems utilize wood fuel that is either chipped or ground into a consistent size of 2-4 inches long and 1-2 inches wide. Chipped and ground material includes fine sawdust and other debris. The quality of the fuel varies based upon how the wood is processed between the forest and the facility. Trees which are harvested in a manner that minimizes contact with the ground and run through a chipper or grinder directly into a clean chip van are less likely to be contaminated with rocks, dirt and other debris. The quality of the wood fuel will also be impacted by the types of screens placed on the chipper or grinder. Fuel can be screened to reduce the quantity of fines which typically become airborne during combustion and represent lost heat and increased particulate emissions.

Chipped fuel is fed from the chip van into a metering bin, or loaded into a bunker with a capacity of 60 tons or more. Wood chip boilers systems are typically linked to existing heat distribution systems via a heat exchanger. Product data from Hurst, Messersmith and Biomass Combustion Systems identify outputs of 1,000,000 - 50,000,000 Btu/hr based upon burning western wood fuels. Wood chip boilers typically require hand raking of the grates and hand removal of ash daily. Automatic ash removal can be integrated into wood chip boiler systems. Ash is typically cooled in a barrel before being stock piled and later broadcast as fertilizer.

Emissions from wood chip systems are typically as follows:

PM2.5	0.21 lb/MMbtu
NOx	0.22 lb/MMbtu
SO2	0.025 lb/MMbtu
CO2	195 lb/MMbtu

Benefits:

Lowest fuel cost of three options ($/MMBtu)
Automated
Can use local wood resources

Disadvantages:

Highest initial cost of three types
Larger fuel storage required
Less consistent fuel can cause operational and performance issues