BETHEL HEIGHTS WATER DISTRIBUTION AND SEWER COLLECTION SYSTEM IMPROVEMENTS

PRELIMINARY ENGINEERING REPORT

Bethel, Alaska

December 2019

BETHEL HEIGHTS WATER DISTRIBUTION AND SEWER COLLECTION SYSTEM IMPROVEMENTS

Preliminary Engineering Report

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APPENDICES

Appendix 1: Alternatives Memo

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ACRONYMS

A……Amp
AC..... Alaska Commercial Supply
ADEC……Alaska Department of Environmental Conservation
amsl ..... above mean sea level
APE .....Area of Potential Effect
ASHA……Alaska State Housing Authority
AVCP……Association of Village Council Presidents
BHWTP..... Bethel Heights Water Treatment Plant
CIPP……Cured-In-Place Pipe
City .....City of Bethel
CSWTP..... City Subdivision Water Treatment Plant
DLWD ..... Alaska Department of Labor and Workforce Development
DOT&PF .....State of Alaska Department of Transportation and Public Facilities
DPW .....City of Bethel Department of Public Works
FAA……Federal Aviation Administration
FEMA.....Federal Emergency Management Agency
GPM .....gallons per minute
HDPE……High Density Polyethylene
HP……Horsepower
IPaC.....USFWS Information for Planning and Conservation
LCG…… Larsen Consulting Group
LKSD…… Lower Kuskokwim School District
MOE……Margin of Error
O&M ..... operations and maintenance
PER .....Preliminary Engineering Report
PJCP ..... Dr. Paul John Calricaraq Project
QFC#2 ..... Quick Food Center No. 2 (lift station)
R&R .....repairs and replacement
USFWS.....United States Fish and Wildlife Service
V……Volt
YK.....Yukon-Kuskokwim
YKHC..... Yukon Kuskokwim Health Corporation

EXECUTIVE SUMMARY

This Preliminary Engineering Report has been prepared for the City of Bethel in accordance with United States Department of Agriculture Rural Utilities Services Bulletin 1780-4.

This Preliminary Engineering Report was developed to assess alternatives for improving water and sewer service to the area of Bethel known as Bethel Heights. While many households in Bethel are part of the hauled system, meaning haul trucks deliver water and collect wastewater, approximately 310 water and sewer users in the Bethel Heights neighborhood are part of Bethel's piped water and sewer system. The gravity sewer system is degraded, and various components of the potable water distribution system are corroding after nearly 40 years of service. These deficiencies have prompted the City of Bethel to consider rehabilitation and improvement options for the existing Bethel Heights systems.

Approximately 25 households in Bethel Heights neighborhood are not connected to the piped water and sewer network and are still on the truck-haul system. Delivering water and sewer services through the truck-haul system is nearly three times as costly per unit volume as compared to service through the piped network. This large operational cost difference has contributed to the City's desire to transfer additional homes and high-density neighborhoods to the piped network. The water system improvement project provides a timely and cost-efficient opportunity to expand the piped network to the residences still on hauled water service.

This Preliminary Engineering Report recommends constructing a Loop C extension which splits the existing Loop A water line into two independent loops, construction of 2,100 linear feet of additional water and sewer main, including 25 new services, and performing spot repair of the water and sewer main and services identified by the City as having high incidence of freezing or other ongoing maintenance issues.

The capital costs of the recommended alternative are broken into three phases to lessen the funding burden each year. The capital cost for each phase is estimated to be $1,702,000, $4,375,000, and $4,927,000, respectively, which equates to $11,004,000. It is assumed each phase would be constructed in consecutive fiscal years. The operational and maintenance costs of the existing Bethel Heights piped and hauled water system are estimated to decrease from $2,122,000 to $1,390,000. Total lifecycle costs are estimated to be $40.8 million.

1.0 INTRODUCTION

The City of Bethel (City) retained DOWL to provide engineering services related to providing water and sewer services to residents located in Bethel Heights, located between Ridgecrest Drive, Akakeek Street, and Ptarmigan Street in Bethel, AK.

The Bethel Heights neighborhood consists of approximately 350 predominantly residential parcels. Most residences in the neighborhood currently have piped water delivery and sewer collection. This neighborhood contains some commercial users, such as AC Quickstop, Russian Orthodox Church, Bethel Regional High School, Gladys Jung Elementary School, and a radio station. The City haul trucks distribute water and collect sewage from approximately 25 lots in this neighborhood which are not connected to the pipe network. This type of delivery and collection is more expensive for the homeowner than the piped water and sewer alternative. The piped system is easier to maintain and more efficient to operate for the City than the hauled system; however, the existing gravity sewer system is severely deteriorated due to differential settling, and the water pipes are corroded, resulting in increased operations and maintenance costs as well as poor water quality.

The purpose of this project is to provide the Bethel Heights neighborhood with an improved water and sewer system with the lowest life cycle costs for the City and the users.

Through the development of this Preliminary Engineering Report (PER), several pipe repair and replacement options were considered, as well as extending the pipes to the households on the haul system and phasing the project out over several years. The PER also examines the life cycle cost of continuing to operate and maintain the existing water and gravity sewer systems.

2.0 PROJECT PLANNING AREA

2.1 Location

The City of Bethel is a Second-Class City located in the Yukon Delta National Wildlife Refuge at the mouth of the Kuskokwim River, 40 miles inland from the Bering Sea (60.7968, -161.7714). It is the largest community in Western Alaska by population and is approximately 44 square miles. Figure 1 shows the proposed project vicinity.

The City is located along the Kuskokwim River, in a treeless subarctic tundra floodplain terrain characterized as poorly drained with a shallow permafrost table. The topography is generally flat, with grades ranging from zero to seven percent. Along Bethel's waterfront and townsite, the soils are poorly drained silts, with permafrost depth ranging from 30 to 40 feet. Further inland from the river, the ground is usually saturated or covered with surface water or sandy soils covered with silt loams and 12 inches of peaty mat. Vegetation is typically low-growing shrubs, grasses, and mats of moss and lichens.

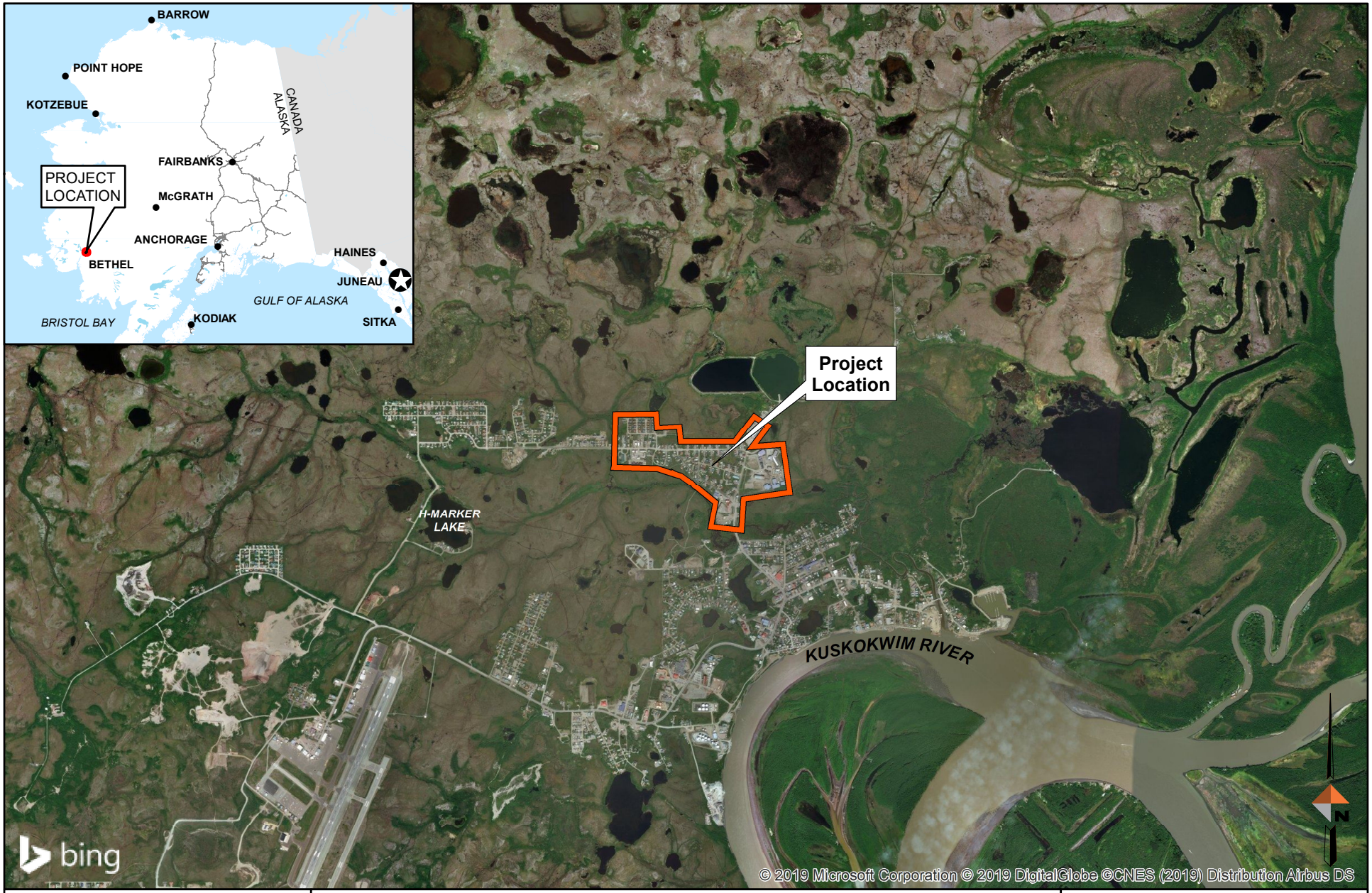
Bethel can experience flooding by the Kuskokwim River. Flooding in 1985 was three to four feet deep, which resulted in the flooding of several homes, while the flooding in 1988 was approximately five feet deep and flooded 600 homes. Bethel experiences constant erosion from the Kuskokwim River as it is located on the eroding bend of the river.

Bethel averages 16 inches of rain and 50 inches of snow per year. The temperature ranges from 42°F to 62°F in the summer to -2°F to 19°F in the winter.

Most land around Bethel has permafrost with combinations of wet and dry tundra. The permafrost conditions, poor surface drainage, proximity to the Kuskokwim River flood impact area, wind direction, and the presence of wetlands make much of the land around Bethel difficult to develop. Development in Bethel has resulted in a community with a small downtown and a gridded road system with concentrated mixed-use development. There is a limited supply of private land, and much of the private land is Native allotments. Native allotments pose difficulties for development. It can often take the Bureau of Indian Affairs years to research title and process a land sale. Land ownership is often held by more than 20 people, which can cause coordination and agreement complications, especially if one of the co-owners moves away or passes away. Additionally, Native allotments are often exempt from local land use regulations, which can result in a lack of reserved land for utility easements.

The community of Bethel is a major transportation hub for the Yukon-Kuskokwim (YK) Delta. The YK Delta has a population of about 26,000 people in its 56 remote villages. The hub nature of the community of Bethel makes it the most important in the region for connection between smaller villages.

Bethel's economy is highly dependent on governmental services and the subsequent wages from government employment. Government jobs make up to 50 percent of the jobs in Bethel. Natural resources also play a significant role in the Bethel economy, as many of the residents rely on fishing and hunting for subsistence. Bethel has a small tourism industry that attracts people for birdwatching and sport fishing. The City of Bethel provides many services to its citizens, including water treatment and distribution, sewage collection and treatment, fire and police services, and solid-waste collection and disposal.



DOWL

Location Vicinity Map

Bethel Heights Water & Sewer Improvements

Bethel, Alaska

PROJECT	1529.50144.01
DATE	Apr 29, 2019
FIGURE	1

Miles

0 250 500

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Bethel is situated along the Kuskokwim River. The Kuskokwim River is the second largest river in Alaska and is the primary river for shipping during the summer. During the winter, it freezes to form a 150-mile ice road that connects surrounding villages. Bethel has a well-used system of trails and boardwalks between buildings within the City, as well as access to surrounding communities. During the winter, the trails are used by snowmachines, dogsleds, cross-country skiers, and pedestrians. During the summer, the trails are used by All-Terrain Vehicles, bicycles, and pedestrians. Since 2008, the public bus system has been providing approximately 150 rides per day.

The Port of Bethel operates a small boat harbor, with dry land storage and approximately 5,000 feet of moorage along the seawall. Bethel's port serves more communities and passengers than any other in Western Alaska. The Bethel Airport is served by two major passenger airlines, two cargo carriers, and multiple air taxi services. It is a regional transportation center and is the third busiest airport in terms of landings and take-offs in Alaska.

2.2 Environmental Resources Present

2.2.1 Land Use/Ownership

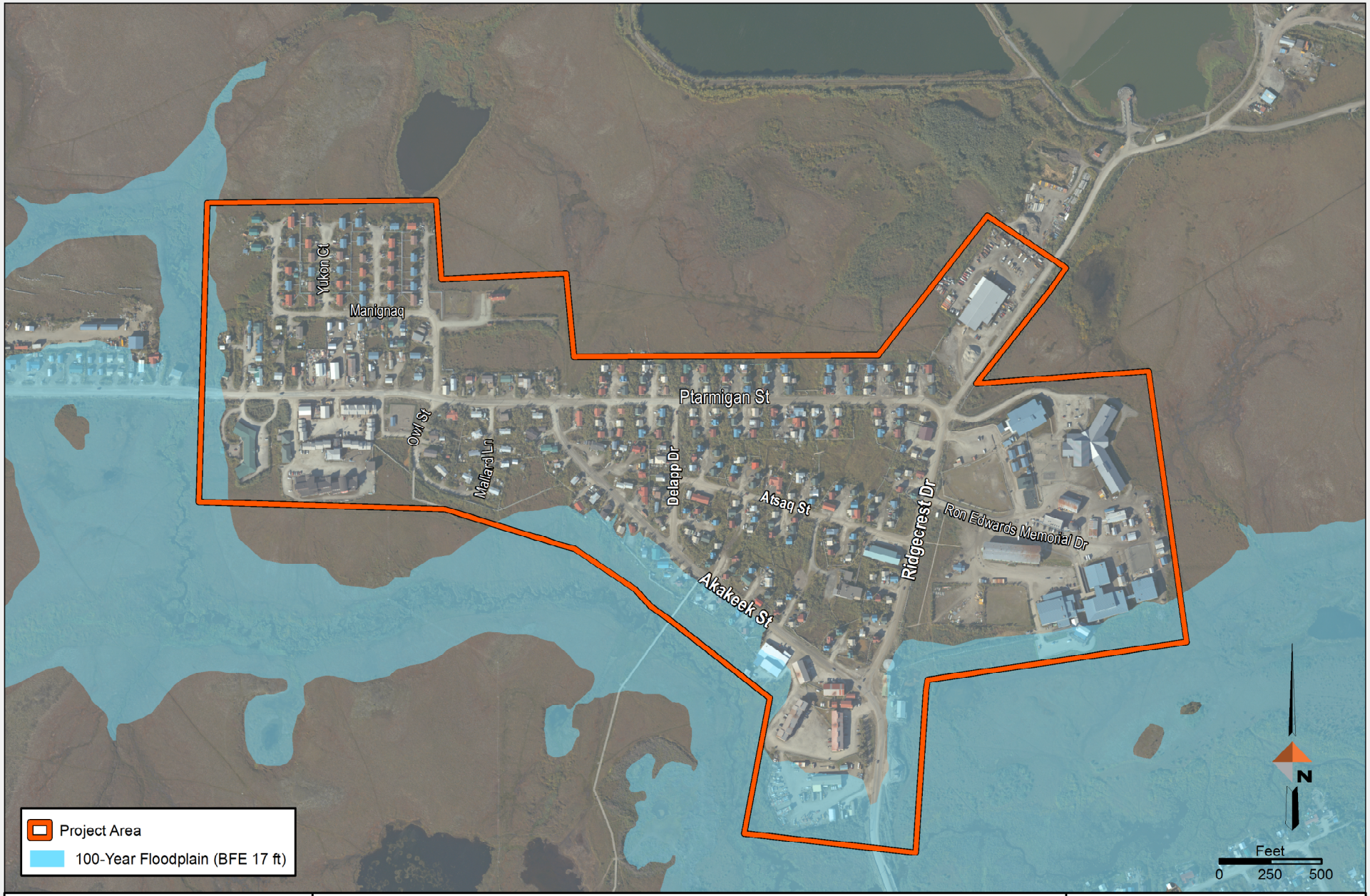
Ownership and land use for the area were determined from the City of Bethel Comprehensive Plan 2035 (Agnew::Beck 2011). Land within Bethel is generally owned by the City, the Bethel Native Corporation, and other private land-owners including native allottees. Land use within Bethel is a mix of open space, public lands and institutions, residential, general use, industrial, and some preservation. There are no farmlands of prime, unique, or statewide importance present in the project area. No formally classified land or federal lands exist within the municipal limits.

2.2.2 Wetlands

A review of the United States Fish and Wildlife Service (USFWS) National Wetlands Inventory showed no wetland information for the region. However, the project area is within the Subarctic Coastal Plain Ecoregion (Gallant, et al. 1995), which is characterized by low relief, the predominance of wetlands, and braided or meandering streams and rivers. Permafrost is widespread and vegetative cover generally consists of wet graminoid herbaceous communities. Therefore, wetlands are likely present in undeveloped areas.

2.2.3 Floodplains

The Federal Emergency Management Agency (FEMA) has mapped flood hazards for Bethel related to the Kuskokwim River floodplain. According to FEMA Map Panels 0201040041C and 0201040042C (revised 8/25/2009) the base 100-year flood elevation of the floodplain in Bethel is 17 feet above mean sea level (amsl) (Figure 2).



DOWL

Floodplains

Bethel Heights Water & Sewer Improvements

Bethel, Alaska

PROJECT	1529.50144.01
DATE	Jun 10, 2019

FIGURE 2

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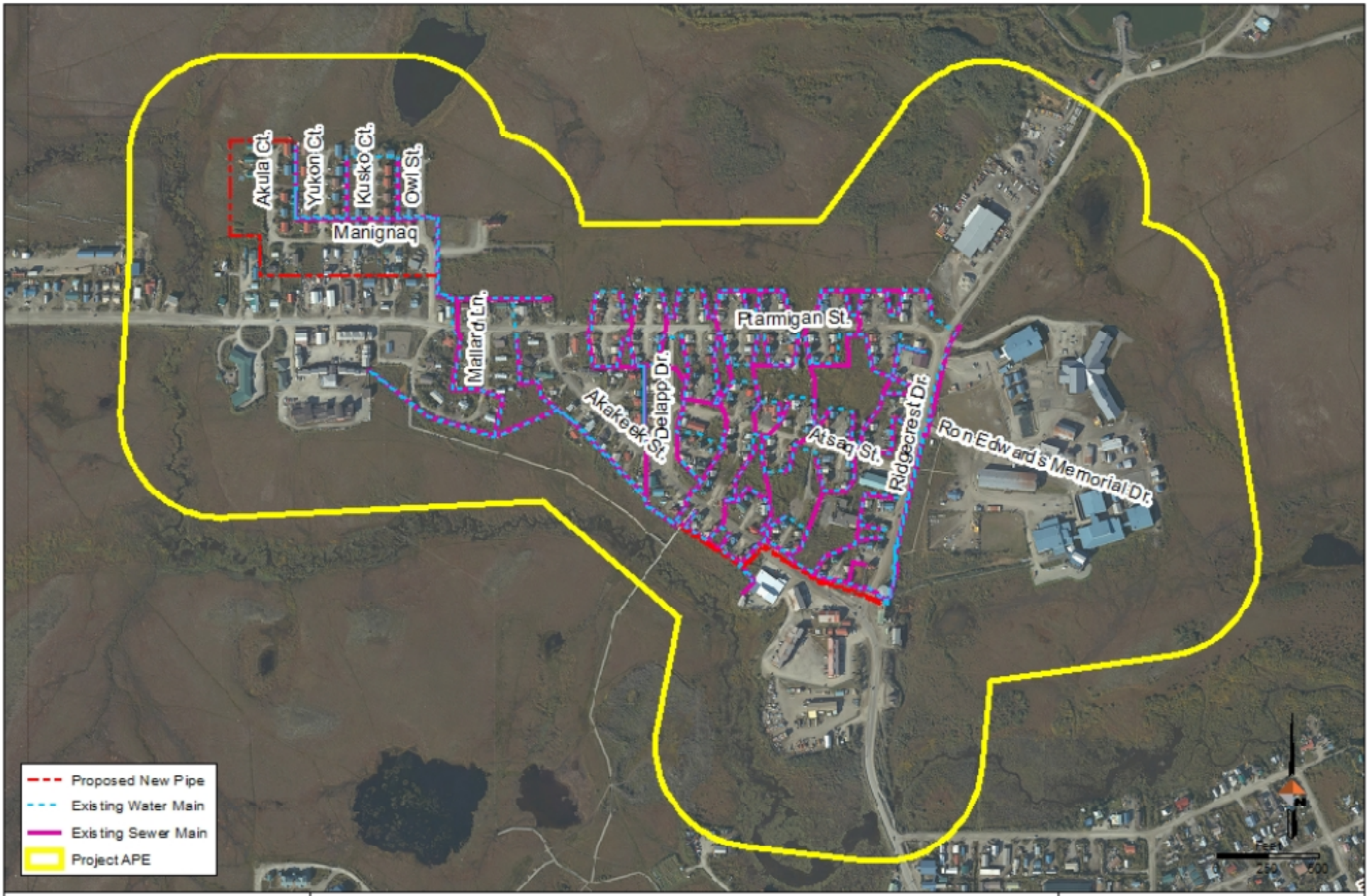
2.2.4 Endangered Species

A search of the USFWS Information for Planning and Conservation (IPaC) online database indicated no threatened or endangered species exist within the proposed project limits and the resource was not evaluated further. IPaC identifies 13 species of migratory birds known to occur within the proposed project limits. USFWS-recommended vegetation clearing avoidance window is May 5 to July 25.

2.2.5 Cultural Resources and Historic Sites

The Area of Potential Effect (APE) encompasses direct impact areas where ground disturbing activities may occur, staging areas temporarily disturbed during construction, and a 500-foot buffer to evaluate potential indirect impacts (Figure 3). A search of the Alaska Heritage Resources Survey was conducted in December 2018 to identify previously recorded sites. Thirteen resources were located within one mile of the APE. The majority of the resources have been determined not eligible or have no determination of eligibility for the National Register of Historic Places. No sites are located within the APE or within 1,500 feet of the APE boundary.

The project impacts to subsurface sediments will be limited to supports for the piping, as it will be constructed in existing and proposed easements between property parcels and along roadsides. This APE has been previously disturbed with alleyways and existing water and sewer pipes and tanks.



DOWL

Project APE
Bethel Heights Water & Sewer Improvements
Bethel, Alaska

PROJECT	1529.50144.01
DATE	May 13, 2019

FIGURE 3

2.2.6 General Fish and Wildlife

There are no Essential Fish Habitat or Habitat Areas of Particular Concern in the waterbody nearest the proposed project area: Brown's Slough. Brown's Slough is anadromous (335-10-16600-2621) for sheefish and whitefish. No marine mammals are within the Bethel area. No in-water work will occur as part of the proposed project activities; therefore, impacts to Brown's Slough are not anticipated.

2.3 Growth Areas and Population Trends

2.3.1 Areas of Growth

Growth in Bethel has accelerated due to the high costs of living in surrounding villages. Two of the fastest growing populations have been seniors and the youth. Residential growth is expected to continue within the Tundra Ridge Subdivision, Haroldsen Estates, Kasayuli Subdivision, and in the Nunvak, Ciullkulek, Tanqik, and Blueberry Field Subdivisions.

The construction of the Dr. Paul John Calricaraq Project (PJCP), the new Yukon Kuskokwim Health Corporation (YKHC) clinic, has resulted in recent growth. Once finished (in 2019-2021), the PJCP is expected to bring approximately 300 new full-time jobs to Bethel over 10 years. According to the YKHC project manager, 100 of them will be right away, and the others will be over the following 10 years.

The Donlin Gold mine project is seeking permits for a mine that would potentially bring 3,000 people to the Bethel area. The future impacts of a significant growth event such as this to the potable water and wastewater systems is outside the scope of this PER.

2.3.2 Present and Projected Population

The City of Bethel has a current population of 6,241, with a 1.08:1 male-to-female ratio. During the 1880 census, which was just before the Moravian Church established a mission and gave the City its name, the area that is now Bethel had a population of 41 people. The population of Bethel has steadily increased every year, as shown in Figure 4. Bethel experienced a population growth of 11 percent from 2000 to 2010.

The 2010-2014 American Community Survey determined the median household income (in 2014 inflation-adjusted dollars) of $78,190 (MOE +/-$8,632). The per capita income for Bethel in 2010 from all sources was $31,160. According to the State of Alaska Department of Commerce, Community, and Economic Development, 71% of Bethel residents are employed. Approximately 12.3% of all residents had income below the poverty level.

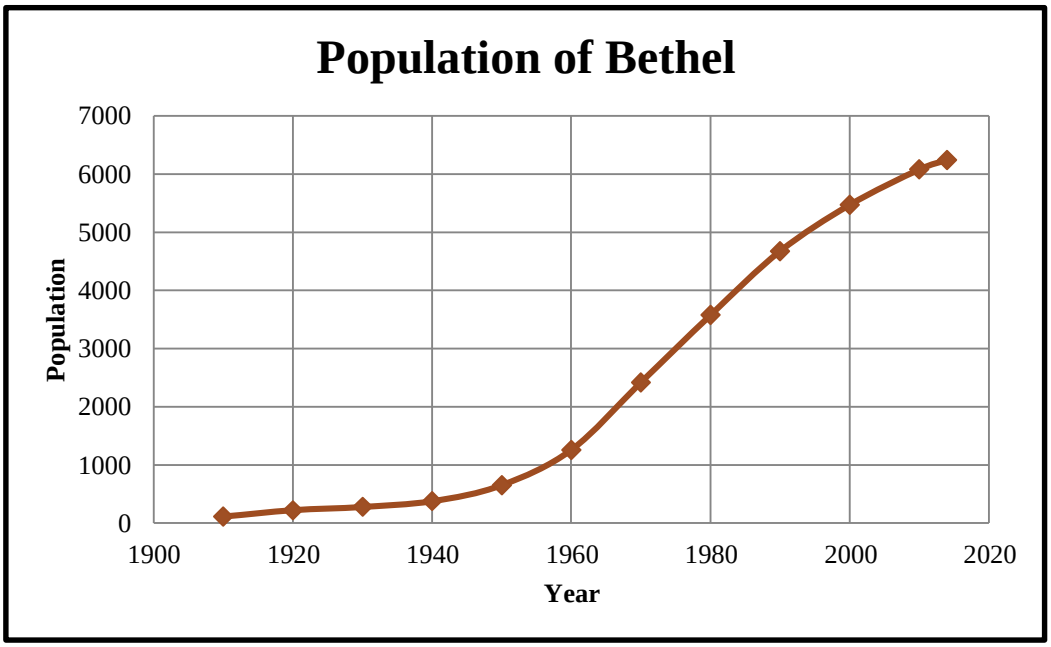


Figure 4: City of Bethel Population: 1910-2015

2.4 Location, History, and Condition of Existing Facilities

There are roughly 1,100 hauled water and sewer customers served by the City's hauled service fleet of water and sewer trucks. In contrast, only about 500 buildings have piped service. The Institutional Corridor project completed in 2018 added capacity for up to 20 additional institutional and commercial services to the City Subdivision piped network. Historically, the use of individual portable waste "honey buckets" for disposing of household sewage was common for residents; however, the City passed an ordinance that for health reasons, residents are no longer allowed to use honey buckets.

2.4.1 Piped Water and Sewer

The primary well for the Bethel Heights Water Treatment Plant (BHWTP) was built in 1969 and a secondary well was constructed in 1999. The BHWTP has a 400 GPM capacity and a 428,000-gallon storage tank, about two to three days' worth, and serves the Bethel Heights neighborhood, the Lower Kuskokwim School District (LKSD) high school and elementary school, LKSD regional offices, the AC Quickstop Laundromat, as well as customers on truck delivery service. According to daily treatment records, and the plant design flow-rates, BHWTP is operating at approximately 20 percent of capacity, which is sufficient excess capacity to handle additional piped water and sewer connections. Both the BHWTP and the City Subdivision Water Treatment Plant (CSWTP) were constructed to serve future piped water and sewer projects.

The BHWTP and water distribution pipes in Bethel Heights were originally constructed in stages spanning from 1976 to 1997, beginning with Loop B which served Alaska State Housing Authority (ASHA) residences. Loop A was constructed and expanded in multiple phases spanning from 1988 to 1997. The sewage lift station and piped wastewater collection in Bethel Heights were constructed in 1970, with modifications and extensions in 1980, 1982, 1986, and 1993.

ASHA/Association of Village Council Presidents (AVCP) Housing (Bethel Heights Subdivision): Two circulating loops, Loops A and B, provide water service to Bethel Heights, Tundra North, and Ptarmigan residential subdivisions. The water lines are pile-supported, and feature insulated arctic pipe construction with 6-inch diameter, and schedule 40 steel carrier pipes. Each loop is served by duplex 20 HP, 250 GPM circulation pumps. Loop A is 20,700 linear feet long and Loop B is 10,500 linear feet long. Hydraulic modeling, as part of a 2008 study by CRW, indicated that discharge pressures as high as 110 PSIG were needed to meet current and future water demands and fire flows, while also providing a minimum overall system pressure of 30 PSIG. This high pressure requirement is due to:

- Disproportionate length of Loop A compared to Loop B resulting in high friction head losses.
- Other friction head losses due to interior pipe roughness, iron oxide deposition, and minor head losses due to many pipe bends and pit orifices.

The City of Bethel subsequently installed pressure gauges at select service connections, which confirmed the modeling results. It was noted that Bethel maintenance staff members would partially close valves at water services experiencing high pressure to throttle flow and reduce pressures within residential plumbing systems. This practice was discontinued.

The CRW study evaluated several distribution alternatives and determined that reducing the length of Loop A by splitting it into two loops, A and C, and replacing the existing steel pipe with high density polyethylene (HDPE) pipe was the most effective approach to reduce system pressures, minimize system head loss and improve water quality.

Existing segments of water Loops A and B and the sewer mains are reaching the end of their useful life. The existing grooved joint couplings on the 6-inch steel pipe have been a source of various pipe breaks when frost heaves deflect pipe joints. The galvanized coating on the interior of the carrier pipe has been documented to be wearing off, allowing corrosion of the iron pipe and adversely impacting water quality (CRW, 2008). Various conditions were observed during a site visit in April of 2019 indicating internal corrosion and deposition of iron oxide scale, and localized external corrosion. The extent of the corrosion on a system wide basis is not well understood at this time. A condition assessment of the entire pipe network is required to definitively determine if isolated areas are corroding or if more uniform pipe degradation is taking place. Figure 5 shows the existing pipe of Loop B galvanized steel arctic insulated pipe. The iron oxide deposition is visible on the pipe interior surface.

Figure 5: Loop B Arctic Pipe Water Main

The City began a corrosion study in 2005 (CRW 2008) to look at water quality in the piped network, and to test the addition of a corrosion and chemical inhibitor as a solution to reduce the amount of iron and manganese in the water. The poor water quality was thought to be the erosion of the galvanized lining in the steel pipe, exposing the steel pipe to the mildly corrosive water. The City implemented a two-year corrosion inhibitor study as a possible option to the costlier alternative of pipe replacement. After two years of monitoring and testing, it was determined that the corrosion inhibitor approach fell short of the desired result. The inhibitor reduced the iron and manganese concentrations in the distribution pipes by nearly half. However, the levels were still far above the State of Alaska's secondary maximum contaminant levels. In 2008, the City completed new road crossing improvements, as well as new equipment upgrades in the BHWTP as part of the 2006 Bethel Heights Piped Water and Sewer Improvements project. Short segments of the old steel water pipe at thirteen road crossings were replaced with HDPE as part of the 2007-2008 upgrade. Improvements to the BHWTP included new distribution pumps, high demand pump, standby generator, new boilers and heating controls.

A 2013 PER by Larsen Consulting Group (LCG 2013) proposed dividing Loop A into two shorter loops, equalizing the loop lengths and reducing system pressures to levels more in line with industry standards. The proposal included replacing the metallic pipes with HDPE pipe to decrease frictional head loss and provide a more efficient hydraulic system.

LKSD School and City Laundromat: Potable water is provided from the BHWTP. The City laundromat and the LKSD school and regional offices are served by two separate circulating water systems. Both water lines are pile-supported, insulated artic pipelines. The City laundromat pipe is served by a 2-1/2-inch diameter copper supply line and 1-inch diameter copper return line. The LKSD school has a 6-inch diameter steel supply line and 3-inch diameter return line. The four apartment complexes at the intersection of Akakeek and Ridgecrest, across from the school, have a well for drinking water but are connected to the piped sewer. The buildings immediately south of these apartments are on both hauled water and sewer.

The City operates a central “backbone” pressurized sewage collection system (force main) that extends from the Bethel Municipal Airport, through the business district, to a facultative lagoon north of the City. The piped system serves commercial, institutional, and some residential facilities located near the force main. Piped sewage is pumped from several pump stations to the Main Lift Station, then via force main to the lagoon. Commercial or residential customer locations not connected to the sewage pipe network are served via a sewage truck-haul system and have wastewater pumped into trucks from individual collection tanks.

Other significant sources of flow entering the sewage collection system include the LKSD, BHWTP backwash, CSWTP backwash, City Center complex, Bethel Hospital, Federal Aviation Administration (FAA) service extension, and the laundromat. Wastewater characteristics in Bethel’s aboveground piping differ from that of a buried collection system because it contains no infiltration and inflow common in older buried systems.

Figure 6: Bethel Heights ASHA Lift Station

The force main trunk line is an above ground pressure pipe with below ground road crossings, a mix of direct-bury and culverts. Along Ridgecrest Drive, the trunk line is under the boardwalk. The trunk line features arctic pipe construction with schedule 40 steel carrier pipes, ranging from 4 to 10 inches in diameter.

The ASHA sewer collection main connects the ASHA Lift Station to the central “backbone” sewer trunk line on the north side of the BHWTP. Upstream of the ASHA Lift Station, the sewer collection main collects gravity sewer flow from the Bethel Heights and Martina Oscar Subdivisions. Two lift stations, located in the AVCP Housing Complex and Martina Oscar Subdivision, collect gravity sewer flow, pumping it to the ASHA Lift Station. The AVCP #1 Lift Station is 100 A, 120/208 V, 3 phase. The AVCP #2 Lift Station is 100 A, 120/240 V, single phase. The lift stations are operating satisfactorily; however, they both lack standby power. The sewer collector line is a pile mounted, insulated 8-inch diameter, schedule 40 steel pipe. The

sewer service lines are pile-mounted insulated 4-inch diameter, schedule 40 steel pipe. The typical pipe cluster in the AVCP Housing area is shown in Figure 7.

Figure 7: Sewer Main & Service Line

Aside from the ASHA Lift Station and the Main Lift Station, other lift stations in the system that pump collected sewage through a force main to another point in the system include:

- Kilbuck Lift Station
- FAA Lift Station
- Quick Food Center (QFC #2) No. 2 Lift Station

Nearly all piped wastewater in Bethel flows through the Main Lift Station, from the central sewer trunk line, ASHA lift station, and laundromat. LKSD school ties into the discharge trunk line after

the Main Lift Station. The Main Lift Station includes three variable speed pumps with a total capacity of 2,130 GPM. It is estimated that this lift station has sufficient capacity throughout its 20-year design life. The influent trunk line is an insulated 8-inch diameter, schedule 40 steel pipe. The discharge trunk line is an insulated 10-inch HDPE pipe.

2.4.2 Hauled Water and Sewer

BHWTP and CSWTP Truck Fill Facilities: Two exterior water truck filling stations with 3 HP pumps are located at the BHWTP as seen in Figure 8. One exterior water truck filling station with 5 HP pumps is located at the CSWTP.

The City's water truck fleet and truck fill facilities provide water distribution for most consumers in Bethel, including approximately 25 properties in Bethel Heights which are not connected to the piped system. Trucks are typically Ford Sterling LT 8500s with an estimated design life of 15 years. Truck components include a 3,000 to 4,000-gallon capacity tank, chassis, motor, cab, heavy duty suspension, pumps, hoses, valves, and monitoring equipment.

Figure 8: Water trucks filling up at Bethel Heights Water Treatment Plant

The trucks each consume an average of 80 gallons of diesel fuel per week and are noted as having poor fuel economy. Truck tanks are insulated, and other truck components have protection against freezing. Trucks are stored in the heated City shop located near BHWTP. A small inventory of truck parts, hand tools, pneumatics and computer diagnostics are on hand for truck service and repair. Typical spare parts on hand include switches, power steering pumps, hydraulic pumps, tires, hoses, hose reels, water pumps, hydraulic motors, air filters, oil filters, and lights. The City reports spending approximately $15,000 (April 2019) monthly on truck repairs and maintenance to keep the haul trucks operational.

Water storage tanks for individual residential and commercial facilities range in size from 500 to 1,500 gallons. Tanks are ordinarily accessible from the exterior and insulated with fiberglass and/or urethane foam. Buried tanks are equipped with heat trace to thaw frozen components. Tanks are built on post and beam or piling with 1- to 2-inch diameter cam lock fittings for water and 3-inch fittings for sewer. Tank sizes vary and are normally built to suit the individual facilities, thereby reducing the City's hauling efficiency. City employees do not enter personal residences to provide water and sewer service.

Service operates on a schedule system, usually once per week. Servicing each facility takes approximately 15 minutes and to serve all customers in Bethel takes approximately six days.

The truck-haul system employs approximately 26 people, with various levels of training and experience depending on position. Service efficiency does not vary from winter to summer. The City reports that the truck-haul system is approaching the point of becoming inadequate to serve community needs.

The cost to deliver the service by pipe is markedly cheaper than the cost to deliver hauled service, and the lower cost is reflected in cheaper rates for piped service. Piped customers pay $176.11/mo. for water service and $49.86/mo. for sewer service, or $225.97 total per month. The average hauled customer pays $350/mo. for both services.

Residents on the piped system tend to use more water, which has been linked to better skin and respiratory health by the World Health Organization.

The actual City cost to produce and deliver water is more dramatic than the above rates indicate. According to the 2013 City of Bethel Rate Study (CH2M Hill 2013), the cost to produce and deliver water via the haul system is $62.04/1,000 gallons. The cost to collect and dispose of sewage via the haul system is $64.05/1,000 gallons. The cost to produce and deliver piped water is $26.18/1,000 gallons. The cost to collect and dispose of sewage via the piped system is $9.52/1,000 gallons.

The City experiences difficulties with the occasional unwillingness of customers to pay, as well as issues of equity in the cost structure. Customers receiving service from the piped system have lower insurance rates due to proximity of fire hydrants. Additionally, piped service residents are un-metered, so they can use as much water as needed, while the haul-system residents are charged by their volumetric water use (based on tank size and number of deliveries per month).

The City's fleet consists of nine water trucks and nine sewer trucks, like the truck shown in Figure 9. Most of the City's fleet is approximately 20 years old and needs replacement. The City received approval to purchase eight new sewage haul trucks through an existing project with USDA Rural Development. The City still needs to replace six water trucks, which is part of a project to install piped water and sewer in The Avenues neighborhood. Three of the water trucks got replaced within the last 5 years.

Recently, the State of Alaska Department of Transportation (DOT&PF) issued warnings to the City following a July 19, 2017 inspection. The City's three-axle haul trucks can only weigh 42,000 pounds in accordance with DOT&PF weight restrictions (17 AAC 25.100(a)). This means that most of the City's trucks, despite having 3,000+ gallon capacity, can only haul 2,100 gallons at a time. The City trucks with 4,000-gallon capacity can only legally carry 3,000 gallons. In spring months (April, May, June), weight restrictions are tightened even further to 75 percent of allowable load.

Figure 9: Active Haul Truck

The trucks that have not been replaced need to be replaced with new trucks because of parts scarcity, and because operating the trucks at partial capacity is inefficient. The fleet could be replaced with a fleet of newer models, with longer configurations, which would allow for greater total vehicle loads. Weight restrictions are based on length of vehicle and number of axles, so longer trucks with more axles can carry more weight.

The City keeps track of all insurance claims from water and sewer related truck incidents (Table 1). One reason the City has identified the need to transition away from water and sewer haul trucks is the number of truck incidents and the impacts it has on the City's insurance claims and rates premiums.

Table 1: 2012 - 2018 Water and Sewer Truck Reportable Incidents

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
Truck struck vehicle when entering/leaving customer premises	0	2	1	0	2	1	4	0	0	1	3	0	
Truck struck building or damaged property	2	0	0	1	1	6	1	3	0	1	0	1	
Overflowed tank while delivering water	1	2	2	0	1	3	0	5	0	0	0	0	
Pumped sewage into house	0	1	0	1	0	0	0	0	0	0	0	0	
Truck rollover	0	0	0	0	1	0	0	0	0	0	0	0	
Missed scheduled sewer pick-up	0	0	0	0	0	0	0	1	0	0	0	0	**Total Incidents**
Stuck in driveway/property	0	0	0	0	0	0	0	0	0	0	0	0	
Monthly Totals	**3**	**5**	**3**	**2**	**5**	**10**	**5**	**9**	**0**	**2**	**3**	**1**	**48**

The cost to operate the hauled water and sewer system accounts for insurance payments. Table 2 shows the total value of claims of water and sewer truck incidents made in the last three years. The value of these claims is passed on to the City in their insurance premiums. Reduction in the size of the hauled fleet will reduce claims and premiums.

Table 2: 2014 - 2018 Cost of Incident Claims

Insurance Year	Insurance Claims Total Payout ($)
2014-2015	$84,343
2015-2016	$33,841
2016-2017	$270,871
2017-2018	$11,000

2.4.3 Bethel Heights Project Area

The City of Bethel serves approximately 300 customers in Bethel Heights by piped water and sewer. If all vacant lots were occupied this would rise to approximately 310 residences. Approximately 25 additional properties in Bethel Heights (3 on Atsaq Street and the cluster between Manignaq and Ptarmigan) are not connected to the piped water and sewer and are served by the truck-haul system.

Sewage from Bethel Heights flows generally southeast from the Martina Oscar subdivision through the neighborhood advancing through the AVCP West and AVCP East lift stations and flowing by gravity through 8-inch insulated arctic pipe to the ASHA Lift Station. The ASHA station was built in 1975 and is located near the AC Quickstop store along Akakeek Street. From there, the sewage is pumped to the Main Lift Station, adjacent to the BHWTP, where it ties into the force main and is pumped to the sewage lagoon. All other piped wastewater in Bethel is pumped through the Main Lift Station to the lagoon. The existing sewer main is approximately 35 years old.

The City-owned lift stations are shown in Figure 10.

The Main Lift Station has three variable speed pumps with a peak capacity of 2,130 GPM with all three operating at high speed. With only one operating at full speed, the pump flow-rate drops to 1,475 GPM. The influent trunk line is an insulated 8-inch diameter Schedule 40 steel pipe, and the discharge trunk line is an insulated 10-inch HDPE pipe.

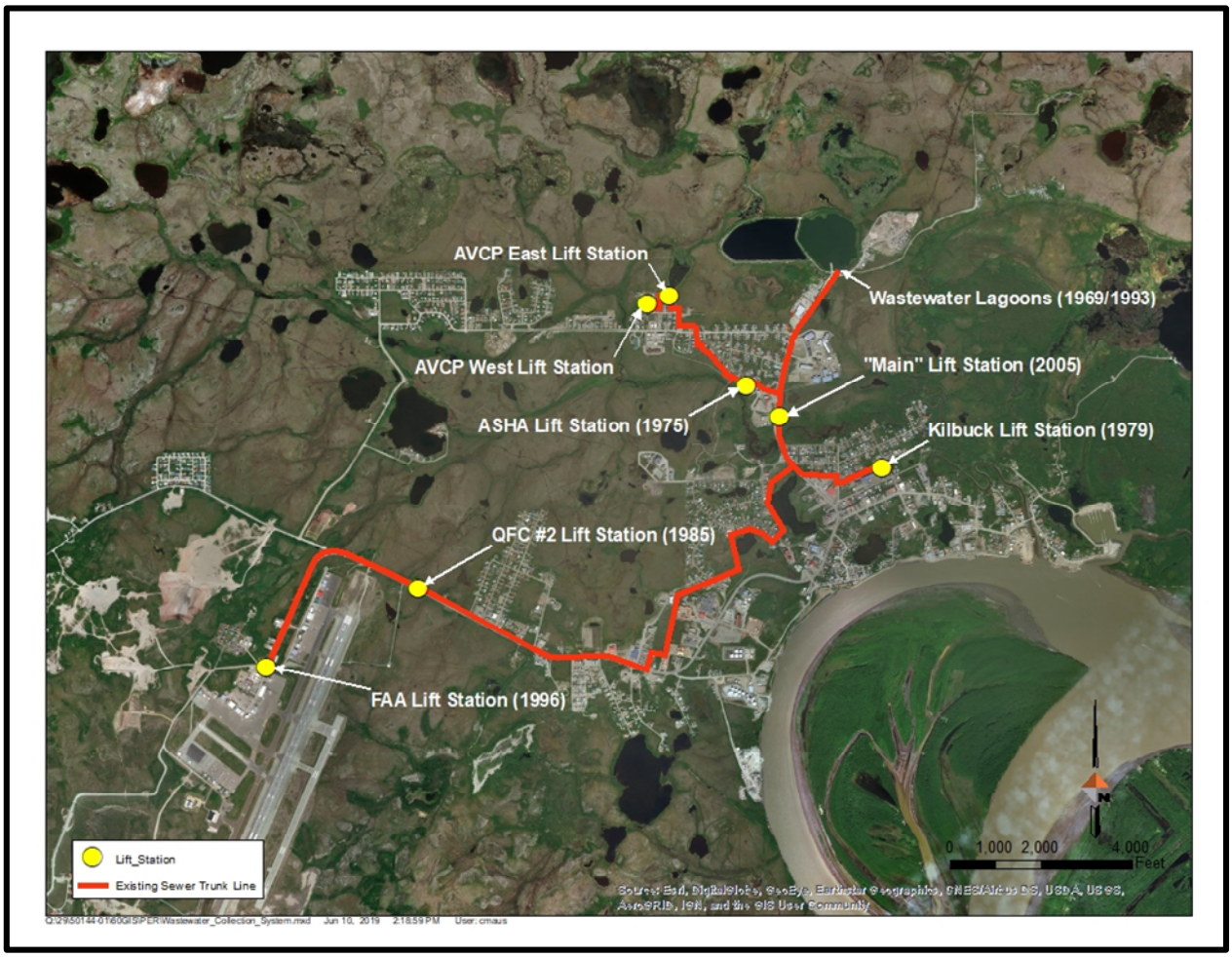


Figure 10: Existing Sewer Trunk Line

Throughout much of the community and the project area, water and sewer mains run together. Figure 11 shows an example of this.

Figure 11: Stacked Water and Sewer Main

2.5 System Operations and Maintenance

Operations and maintenance of public water and sewer systems is the responsibility of the City of Bethel Department of Public Works (DPW). The DPW manages a fleet of equipment, including work trucks, water and wastewater haul trucks, dump trucks, excavators, tractors, loaders, generators, and tools.

Key advantages of a piped system over hauled is that Operations & Maintenance (O&M) costs are lower and sanitation conditions are better. The disadvantage of a piped system is the increased potential for pipe freezing, and the higher initial capital and replacement costs.

Heavy loads transported by water and sewer haul trucks damage the roads in Bethel. A piped system would decrease use of haul trucks, which would decrease future road repair needs.

The 2013 utility rate study for the City of Bethel (CH2MHill 2013) identified a path to make the whole utility financially solvent. The path is in its second year of implementation. The City has implemented a subscription fee for water and sewer funds, but the reserve is not sufficient to cover capital improvements. These must be funded through loan and grant opportunities.

According to the 2013 utility rate study, current sewer system revenues are approximately $2.5 million annually. Hauled sewer service revenue accounts for approximately 61 percent of this total, even though hauled sewer services only account for approximately 30 percent of total wastewater volume.

In years when the water and sewer utility exceeded the budget, the City dipped into the City general fund. The proposed utility rate structure increase has potential to build up reserves for future emergency repairs, if properly accounted for in a repairs and replacement (R&R) account.

The life of water and sewer infrastructure in Bethel, and other arctic and sub-arctic communities, is short. The anticipated life of various water and sewer components is shown in Table 3.

Table 3: Anticipated Life Expectancy of Various Water and Sewer Components

Components	Useful Life (Years)
Storage tanks	40
Water distribution lines	40
Sewage collection lines	30
Lift station (not pumps)	30
Wells	30
Buildings	30
Service connections	15
Trucks	15
Meters	10
Pumps	10
Paint (exterior)	10
Valves	10
Backhoes (occasional use)	10
Tracked vehicles	5
Pumps and Controls	5
Compressors	5

2.6 Growth

2.6.1 Projected Growth

According to the Alaska Department of Labor and Workforce Development (DLWD) 2012 report, “Alaska Population Projections 2012 to 2042,” the Bethel Census Area, as of 2012, had a total population of 17,600. This report projects the population of the Bethel Census Area to be 19,246 by 2222 and 22,200 by 2032.

The City is growing disproportionately to the rest of the census area. For this PER, the City of Bethel is assumed to be growing at 1.1 percent, which is in accordance with the Water Loops A, B, C, & Lagoon PER prepared by LCG in 2013, and is fairly consistent with DLWD projections. This yields the population projection shown in Table 4.

Table 4: Projected Population for Planning Period

Year	Projected Population
2015	(Actual) 6,241
2025	6,962
2035	7,767

2.6.2 Estimate of New Customers

The 2013 City of Bethel Water and Sewer Cost Allocation and Rate Study (CH2MHill 2013) assumed that new customers, both commercial and residential, would grow at an annual rate of one percent. The City currently has approximately 1,600 water and sewer customers. Approximately 70 percent of these customers are on the hauled systems. This percentage does not correspond proportionally to the volume of hauled wastewater, because most of the major wastewater producers in town are within the 30 percent that receive piped sewer collection. The City is pushing to transition to a piped network throughout the community but given that most new developments/subdivisions are occurring far from the piped networks, transitioning to a piped network is cost restrictive. In high density areas, located near the existing piped network, transitioning is less cost restrictive. Table 5 projects the growth in hauled customers.

Table 5: Projected Hauled Services for all of Bethel

Year	Total Projected Hauled Services
2015	(Actual) 1,125
2025	1,242
2035	1,372

Approximately half of Bethel's hauled customers have their wastewater collected and brought to the sewage lagoon. The other half has sewage hauled to the lift station near the airport (QFC#2) which saves significant time and expense for operating the haul trucks. This project impacts the management of wastewater from approximately 350 services. The delineation between hauled and piped sewer services, in this area and throughout Bethel, is shown in Figure 12.

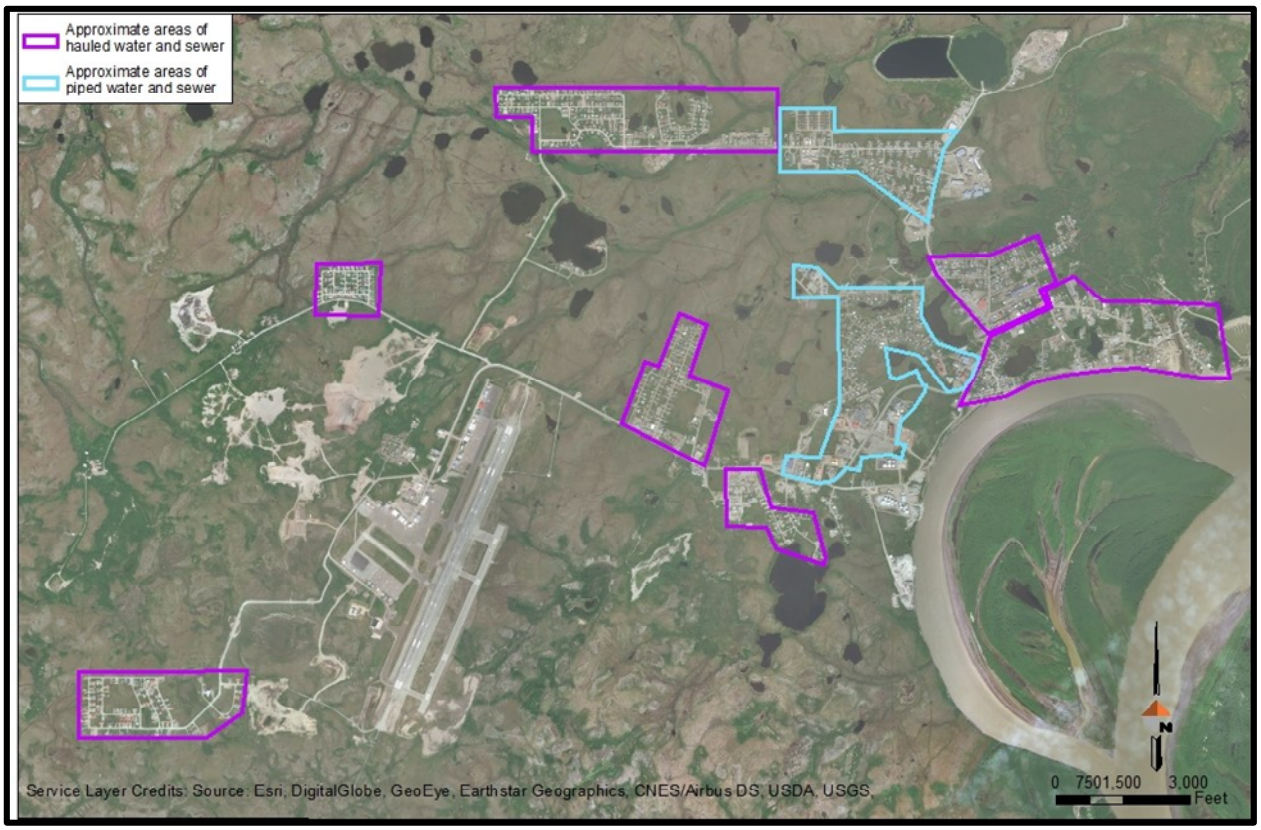


Figure 12: Extent of Sewage Haul Service Areas

3.0 NEED FOR PROJECT

There are multiple factors contributing to the project need, which include water supply quality and quantity driven human health issues, sanitation (removal and handling of human waste), aging infrastructure, and future improvements for community growth.

3.1 Health, Sanitation, Security, and Safety

Improving public health is a primary reason to improve and extend the existing piped water system. Increased access to clean domestic water is directly connected to improving individual and community sanitary conditions and public health and reducing the likeliness and severity of human disease events (Hennessy & Bressler 2016). There are approximately 335 residences, business, and lots in the BH neighborhood, 25 of which currently utilize hauled water and sewer services. This system requires above ground storage of sewage at the residences for prolonged periods of time, which creates the risk of cross contamination and spillage.

Additionally, the truck-haul system introduces inherent dangers due to the increased potential for vehicular accidents and increased traffic. The trucks often exceed weight limitations and can have access issues in arctic road conditions. The City has multiple accidents each year with truck drivers backing haul trucks to private property. The storage tanks are often hard to find and back-up to, which can be challenging for new haul drivers. The City is continually replacing and seeking new drivers as these positions are low paid and have high turnover rates. In April 2019, the City reported 6 out of 18 driver positions were vacant. The City has recently considered reducing water deliveries for hauled residents by up to half of the ordered quantity to be able to make deliveries to all hauled residents. The stretching of staff and equipment to meet the water demand of the hauled system users creates more opportunities for human error, increases employee burnout, and equipment breakdown.

Fire hydrants are another safety concern in Bethel Heights. The existing cam-lock fittings for fire hoses are widely defunct and the City replaces at least six valves per year. Installing new fire department connections, expanding the hydrant coverage area, and ensuring the fire flow is adequate for fire response are important elements of this project for City officials and residents.

3.1.1 System Age

A secondary motive to improve and extend the existing water and sewer system is the age of the system and increasing risk of major failures and unforeseen repair costs. The typical useful life of above-ground arctic-pipe systems is 40 years. With construction of the original segments of the piped system in 1977, with additions completed over the 40+ years of operation, the age of some parts of the system have exceeded the expected useful life. The age of the system has resulted in tangibly reduced reliability and performance, comparatively high and increasing costs of O&M, and an overall reduction in the safety of the system.

Specific issues with the piped sewer system as a result of its age include settlement and shifting of pipe supports and the sagging of pipes creating low points and inconsistent grades for gravity sewer flow. Reductions in the gravity flow velocity due to low points from sagging pipes (Figure 13) can cause sedimentation and pipe constrictions to occur, and also cause stagnant water susceptible to freezing. Reports of pipe freeze-ups and other repairs such as clogged sewer or no water for the ASHA-managed residences indicate a general decrease in reliability of the water and wastewater pipe networks and widely varying maintenance and repair costs from year to year.

Figure 13: Sagging Water and Sewer Pipes

As described in Section 2.4, the galvanized lining on the interior, and occasionally the exterior, of the pipes is in various stages of deterioration, or in some cases non-existent, making some pipes highly susceptible to corrosion (Figure 14, 15, and 16). The corrosion was studied and documented by the City and its consultants CRW and NTL over a three-year period from 2005-2008 while they were testing multiple corrosion inhibitors. The typical iron and manganese levels in the storage tank, post treatment, are low with iron at <0.10 mg/L and manganese at <0.050 mg/L. The elevated iron and manganese found in the distribution system as a result of the pipe corrosion were documented at 7.8 to 8.5 mg/L and 0.12 to 0.15 mg/L, respectively. Iron levels have not been consistently evaluated and documented since the study.

In April of 2019, a segment of each Loop A and Loop B water main was opened for examination. In both instances the pipe appeared to retain some galvanized lining, and the inspectors observed minimal corrosion visible to the naked eye. In the locations where Loop A and Loop B mains were visually examined, each contained a significant amount of iron-oxide sludge deposition which was easily removed from the pipe wall by hand. The specific source of the iron deposits remains unknown but suggests significant corrosion within the distribution system.

Figure 14: Iron Oxide Deposit Accumulation

Figure 15: External Pipe Corrosion Near AVCP West Lift Station

Water samples were collected from the Loop A and Loop B water mains during the examination and submitted to SGS analytical lab in Anchorage. A basic metals analysis was completed for Copper, Iron, Lead, Manganese, and Zinc. The results are included in Table 6 and indicate low levels of iron, manganese and zinc. These sample results represent a single snapshot in time and indicate the water quality was stable at the time of the examination. The CRW/NTL corrosion study (2008) documented elevated iron and manganese concentrations, especially during construction or other disturbance of the pipes.

Table 6: Loop A & B Water Main Metals Analysis

Parameter	Loop A Result	Loop B Result	EPA Action Limit	Units
Copper	0.0176	0.0064	1.3	mg/L
Iron	0.444	0.336	0.3	mg/L
Lead	0.0131	0.0078	.015	mg/L
Manganese	0.161	0.174	0.05	mg/L
Zinc	0.0868	0.0391	5.0	mg/L

Figure 16: Loop A Water Main Pipe Interior

3.1.2 Recurring Incidents and Repairs

According to the City staff, both the water and sewer pipes are prone to freezing during the winter due to the lack of heat trace, sagging pipe sections, and long pipe runs in some areas. Work order logs show 97 calls in the past two years, all during winter months. At least 49 of the 97 work orders were for instances of frozen pipes. Upgrades to the pipe network including heat trace would benefit both the potable water and sewer systems and alleviate the incidence of service line and water main freeze ups. Table 7 illustrates the frequency and nature of reported incidents for just the ASHA housing units.

Table 7: ASHA Housing Water System Incidents

Priority	Reported Incident Type	2016* Incidents	2017 Incidents	2018 Incidents	2019* Incidents
Wastewater Collection System					
Emergency	Frozen Pipes		6	4	1
Emergency	Other	1	1	2	
Routine	Frozen Pipes				2
Routine	Other	1	1	1	
Potable Water System					
Emergency	Frozen Pipes	2	10	13	
Emergency	Other	1	2	3	
Routine	Frozen Pipes	1		3	
Routine	Other		2	14	4
Non-Categorized					
Emergency	Frozen Pipes		2		
Emergency	Other	3	7		
Routine	Frozen Pipes		1	2	
Routine	Other			9	

Incident Type "Other" Includes: Check Water, Check Pipes, No Water, Toilet Not Flushing, Clogged Sewer Line, Sewer Backup

**Incomplete Reporting Year*

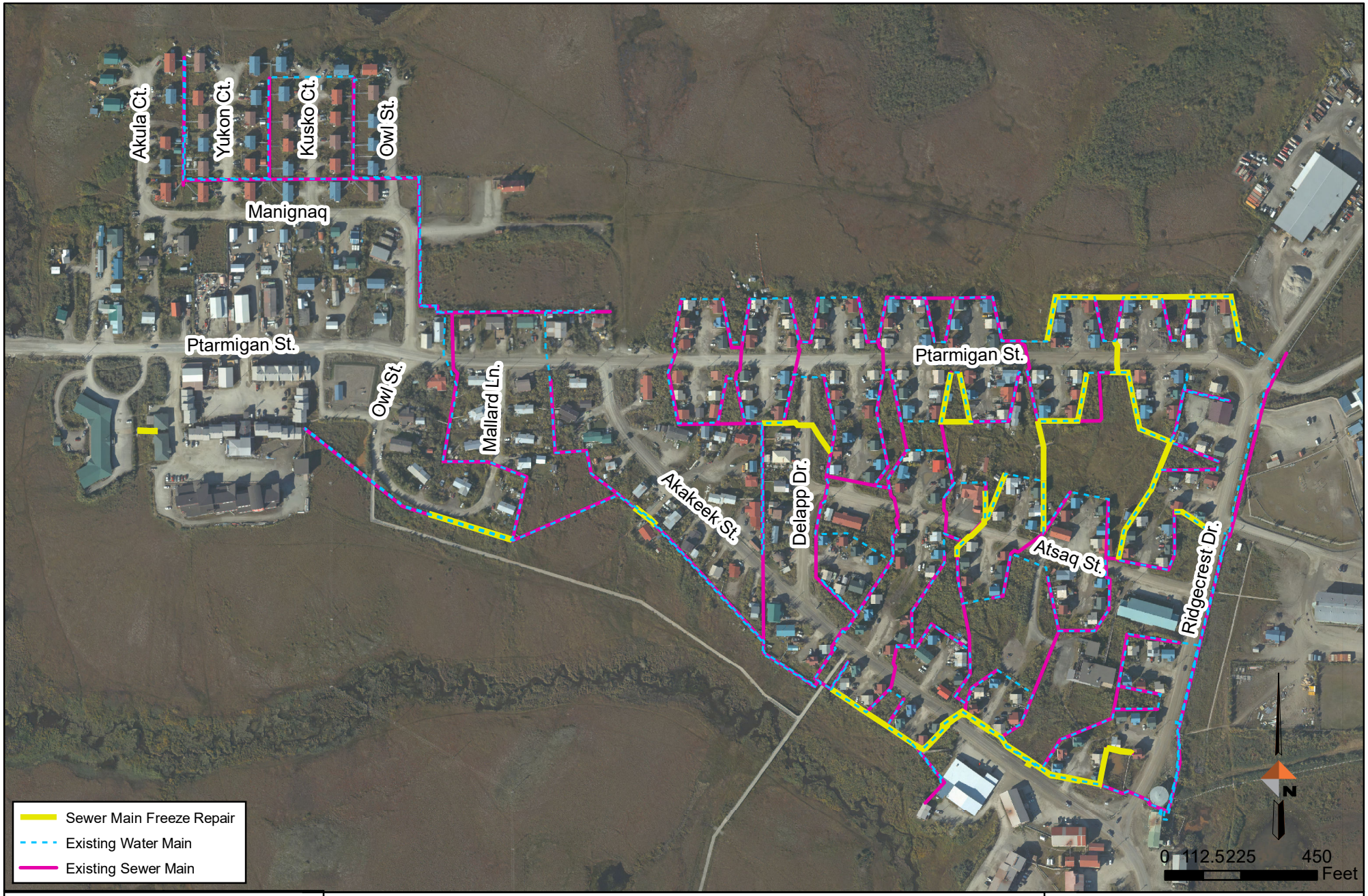
Figure 17 displays the areas of the pipe network outlined by the City which recurrently freeze or experience other issues. The ASHA incidents in Table 7 are not reflected in the figure as there is no address data or associated spatial documentation to accompany the data.

3.2 Regulatory Compliance Concerns

The need for the water pipe replacement is underscored by iron and manganese levels measured well above the State of Alaska's secondary contaminant levels in the past, and numerous complaints from residents regarding the color and taste of the water. More recently, during the summer of 2019, water in the CSWTP circulation loop exceeded federal lead and copper concentration standards. Water leaving the CSWTP was well within the limits; however, lead solder and copper fixtures in service connections leached the metals into the circulating water loop. Elevated metals concentrations correlate with construction and other disturbances to the distribution system, and likely occur in the BHWTP water loops as well.

The need for the sewer project is not specifically related to a regulatory compliance issue, although sewage spills must be reported as noncompliance to the Alaska Department of Environmental Conservation (ADEC).

As previously discussed, the haul trucks can only be partially filled because of weight restrictions levied by the State of Alaska Bridge Law.



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Area of Recurring Pipe Freezing
Bethel Heights Water & Sewer Improvements
Bethel, Alaska

PROJECT	1529.50144.01
DATE	Jun 11, 2019

Figure 17

Q:\29\50144-01\60GIS\PER\Pipe Freeze Areas.mxd Jun 11, 2019 2:27:08 PM User: cmaus

4.0 ALTERNATIVES CONSIDERED

Several project alternatives are described to identify a proposed solution that will best meet the purpose and need of the project. This section specifically provides a description of each alternative, anticipated environmental impacts, land requirements, general advantages and disadvantages, construction challenges, and the estimated capital and O&M costs for each. The alternatives considered include a no-action plan; various pipe rehabilitation options using "repair-in-place," such as Cured-In-Place Pipe (CIPP) to extend the useful life of the existing pipes; replacing and reconfiguring the pipe loops; construction of an additional loop; spot repair of high-risk areas; and full system replacement.

4.1 Alternative 1: No-Build

4.1.1 Description

In the no-action alternative, the City would continue to use the existing piped water and sewer system in Bethel Heights and provide hauled service to the residents and businesses not currently served by pipes. It is assumed that the piped system would operate as-is until the cost of O&M surpassed the cost of reverting and operating the entire Bethel Heights subdivision on hauled service. It is difficult to predict the remaining useful life of the piped system in its current state and project the widely varying yearly O&M costs to determine a break-even point.

The City would continue to dispatch crews to thaw frozen pipes, to repair leaking pipe appurtenances and replace system components such as hydrants, valves, and services on an as-needed or emergency basis. The City would continue to replace water and sewer trucks every fifteen years and continue to deliver water and sewer as they currently do. This alternative would result in minimal change to operations and practice for the near-term future; however, since it would not address the issue of pipe settlement or the pipe corrosion and coating degradation, water and sewer O&M costs would continue to increase, and water quality would likely continue to decline.

4.1.2 Environmental Impacts

The no-build alternative results in minimal or no direct environmental impacts. The alternative could result in increased sewage backups for residents, potential sewage spills as pipe settlement and sagging continue along with degradation of the pipe and joint integrity. The City's haul trucks would continue to have wear impacts on DOT&PF and City roads, resulting in continued high frequency roadway maintenance. The eventual reversion to hauled water service could require construction of new access roadways around or behind homes as the current home connections on the piped system are typically located at the back of the structure. New access roads in these areas would potentially impact permafrost.

4.1.3 Land Requirements

The No-Build alternative does not immediately have specific land requirements, as no construction is incidental to this option. The City's haul trucks would continue to be stored at the DPW shop. In anticipation of when the pipes wear out beyond repair and would be replaced with the haul system, it is presumed that sufficient space exists within each lot to locate water and sewer holding tanks. Access for haul trucks could present new land requirements depending on

siting of the insulated tanks. If construction of new access roads or alleys were required based on tank siting, the haul system would require new permanent easements.

4.1.4 Advantages and Disadvantages

The advantage of the No-Build alternative is a low initial capital cost. The cost of purchasing new haul trucks as an alternative to other system upgrades, when considered a capital cost, is comparatively minimal. The recurring annual cost to maintain the existing pipes for the current 310 piped services and to replace trucks on a 15-year useful life schedule for the 25 hauled services remains nearly one third of the theoretical cost of operating all 335 services on a hauled system.

The primary disadvantage is that the alternative does not directly meet the identified needs.

Further disadvantage is the recurrence of unplanned O&M costs for repairs to the degraded gravity sewer system. City staff, and Alaska Housing Finance Corporation maintenance representatives frequently respond to frozen pipes, blocked sewer lines, and other emergent incidents. Water and sewer main failure and the subsequent impact on residents is a serious risk. DPW staff estimate that the operational and maintenance challenges will become overwhelming within ten years, and a reversion back to hauled water and sewer in this area may be considered.

Prospective future reversion to a hauled water system and increasing the O&M costs is inconsistent with the objectives of the sanitation goals identified in the two previous master plans and those currently held by the City.

The State of Alaska has noted, as part of an ongoing statewide rural sanitation study for sustainable solutions, that some haul service homeowners will tend to self-limit their water use and may not realize many of the health benefits associated with household running water and sanitary sewage. Converting to a haul system throughout the Bethel Heights service area would also increase truck traffic within Bethel Heights, which would raise annual road maintenance costs. In addition, fire protection capability within Bethel Heights would be reduced if the piped water loops were replaced with a truck-haul system. These changes would tend to reduce public safety in general. Homeowner fire insurance rates may also be affected as a result of removing existing fire hydrants from the Bethel Heights service area.

Projects that reduce the number of truck-haul accounts and add to the piped water accounts are consistent with both short and long-term planning goals to upgrade the existing piped infrastructure, improve level of service and reduce annual O&M costs. For the reasons stated above, the No-Build alternative does not meet the goals of this project and is therefore not recommended.

4.1.5 Construction Challenges

There are no immediate construction challenges with this alternative. Ongoing challenges involving construction include major maintenance, repairs, or replacement of pipe segments, and service connections due to leaks and freeze ups. Excavating frozen ground to access water and sewer mains at road crossings is labor, time, and energy-intensive. Working on the pipe system in the winter months exposes the maintenance staff to undue cold-related hazards.

4.1.6 Cost Estimate

The no-build alternative cost estimate includes the capital expenditures needed to proceed with the existing system, and the fixed and variable operations and maintenance costs of running both hauled and piped systems for the 335 services. The cost of reverting the piped portion to a hauled system is not considered in this report.

The capital costs associated with this alternative are the costs to purchase two new water haul trucks. The recent Bethel Avenues Neighborhood Water & Sewer Improvement PER indicated the City is in the process of replacing up to five sewage haul trucks, leaving only water trucks to be replaced in the immediate future.

Salvage value of the piped water system would be minimal to non-existent as the pipes are largely corroded and not useful for their intended purpose.

Assuming a 25-year design life, two new water trucks would be procured, and two replacement trucks again at year 15. The trucks at the end of their 15-year useful life would each have an estimated $42,000 salvage value. Total capital costs are shown in Table 8.

Table 8: Capital Costs of Alternative 1

Phase	Present Value of Capital Cost	Water	Sewer
Single Phase Build Out	$ 736,000	NA	NA

The O&M costs are to continually operate and maintain the existing gravity sewer system and piped water system, as well as hauled water and sewer service to 25 users.

These costs are shown in Table 9: O&M Costs of Alternative 1. An interest rate of 1.5% was used based on an average of the 20 (1.5%) and 30 (1.5%) year discount rates published by the White House Office of Management and Budget Circular A-94.

Table 9: O&M Costs of Alternative 1

O&M Item	Total Annual Cost	Present Value of O&M Cost
Hauled Water	$ 144,359	$ 2,991,069
Hauled Sewer	$ 149,036	$ 3,087,975
Piped Water	$ 888,680	$ 18,413,106
Piped Sewer	$ 323,156	$ 6,695,675
Repairs (lump sum)	$ 70,000	$ 1,450,373
	Present Value of O&M Costs	**$ 32,639,000**

4.2 Alternative 2: Repair-In-Place

4.2.1 Description

An alternative to pipe replacement is repair-in-place or “trenchless” technology, such as swagelining or CIPP with the addition of heat trace. Swagelining involves pulling lengths of HDPE liner pipe through a reduction die, inserting the liner pipe into the host pipe, and swelling the liner to conform to the host pipe. This results in no annular space between the old and new pipe and a minor reduction in the internal pipe diameter. Sections of HDPE are assembled into the required length with thermal butt fusion, thereby avoiding mechanical couplers.

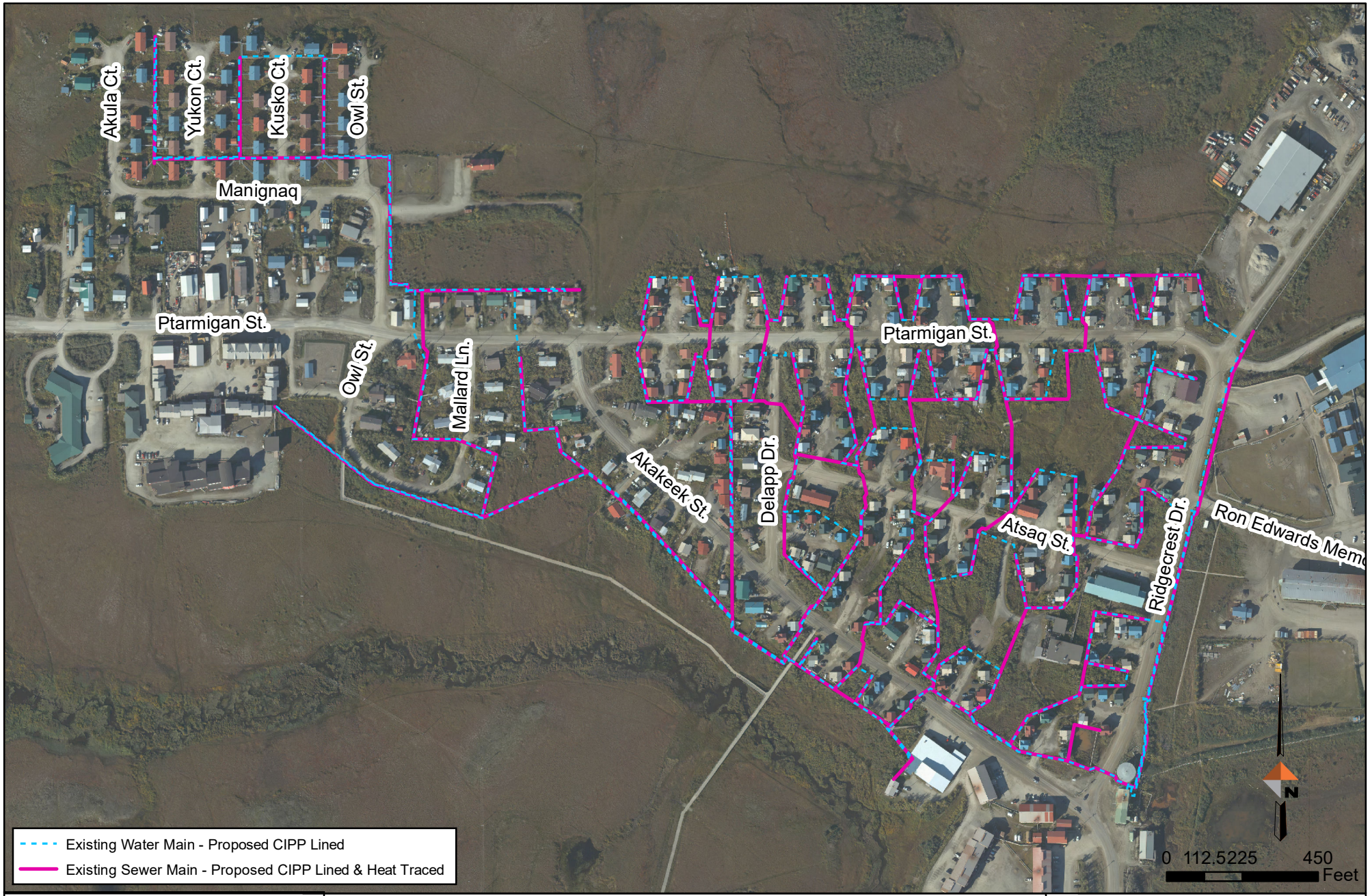
CIPP is another option, in which a fabric tube saturated with a thermosetting-polymer is inserted into the existing pipe, often with air pressure. Hot air, water, or steam is then blown into the pipe, curing the polymer and bonding the liner to the old pipe and creating a structural pipe core. Thermally-cured liner materials include resin and epoxy and are suitable for both sewer and potable water pipelines.

Swagelining and CIPP require cleaning the existing pipe to prepare for the new liner. The liner must be tapped at lateral and service connections or pipeline termination points, which for any buried sections of pipe would require excavation. Both methods result in strong, durable, smooth liners that can significantly extend the useful life of the pipe.

Electrical element heat trace for prevention of pipeline freezing can be inserted into existing pipes with a sewer jetter, using water pressure or other means. The teflon-coated heat trace is pulled or pushed through the pipe and lays along the pipe wall. The smooth coating is NSF-approved for potable water and suitable for use in both sewer and potable water lines. The heat trace can be installed in lengths up to 750 feet, and the joints can be on the inside or the outside of the pipe. Direct contact between the heat trace and the process fluid results in more efficient heat transfer than heat trace on the exterior of pipes, although installing the wire inside the carrier pipe would cause a slightly higher operating pressure of the pipeline due to friction losses. If CIPP were used, the heat trace could get installed in the existing carrier pipe before the liner and effectively be laminated into the pipe during the liner installation.

The existing steel pipes are supported every 20 feet. New swagelining and CIPP materials provide some structural support but are subject to long-term strain. To prevent further inconsistency in slope and sagging of wastewater pipes causing zones of stagnant water, additional piles and supports should be installed in critical areas to reduce the unsupported pipe spans. Numerous sections of existing pipe would need to be elevated or lowered to reestablish consistent gradient.

This alternative assumes CIPP lining of the entire pipe network in the Bethel Heights service area and includes 28,000 LF of sewer main, and 30,500 LF of water main (Figure 18). This systematic rehabilitation could extend the useful life of the water mains by up to 40 years, and the sewer mains by up to 30 years. Valves, hydrants, cleanouts, and other appurtenances would require replacement at various intervals to match the useful life of the rehabilitated pipe. Replacement of these appurtenances on a system-wide basis at the time of pipe rehabilitation is included in the alternative. Pit orifices would also be removed and replaced for the existing 310 services.



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Alternative 2 - Repair In-Place
Bethel Heights Water & Sewer Improvements
Bethel, Alaska

PROJECT	1529.50144.01
DATE	May 07, 2019

Figure 18

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4.2.2 Environmental Impacts

Floodplains: Prior to project construction or ground disturbing activities within naturally vegetated areas, authorization for fill in wetlands would be obtained. The City of Bethel currently administers a General Permit, issued by the United States Army Corps of Engineers per Section 404 of the Clean Water Act, that authorizes work in wetlands. This project is anticipated to qualify for this general permit.

Wetlands: The proposed action consists of modifying existing pilings and installing new pilings within the 100-year floodplain. The exact elevation of the project area is unknown, therefore consultation with the City of Bethel will determine if a floodplain permit is required and if the bottom of the structures will be built above 17 feet amsl.

Biological Resources: Although this project would not bisect or fragment wildlife habitat, the proposed action could disturb up to one acre of previously disturbed lands. Disturbed areas would be stabilized to prevent the introduction and spread of invasive species. Removal of shrubs and trees would occur outside of the USFWS migratory bird window (May 5 to July 25).

Historic and Cultural Properties: DOWL's finding and recommendation is that there would be no affects to buried historic properties within the APE due to minimal subsurface impacts, and the lack of previously recorded sites within the APE. No adverse effects to historic properties are anticipated from the project.

4.2.3 Land Requirements

This alternative utilizes the existing pipes, pilings, and easements. The above-grade arctic pipes are placed on driven pile foundations or on timber supports, currently spaced 20 feet apart. A new driven pile or timber support will be required every 10 feet to support the lined arctic water and sewer pipes. The actual ground penetrations for each pile are less than 1 square foot. The total ground disturbance to place the pipe on the ground is minimal. To construct the pipe networks, an area approximately 10 to 15 feet wide is required (which is why easements tend to measure 10 to 15 feet wide). The proposed alternative as described above would result in a total of 58,500 linear feet of lined water and sewer pipe. The majority of the water and sewer mains follow the same path with the sewer located beneath the water.

4.2.4 Advantages and Disadvantages

Alternative 2 provides the City with an option that renews existing infrastructure and addresses issues of freezing and excessive head pressure in the water pipes. Lining the old steel pipes with smooth-walled HDPE or CIPP will increase flow velocities which reduces the freeze potential; however, the liner would slightly reduce the pipe internal diameter which would increase the required system pressure in the water mains and increase the clog potential in the sewer mains. The net gain in efficiency is predicted to be negligible.

A significant advantage is this alternative uses the existing pipe network and reduces the amount of pipe materials needed to extend system's life and achieve the purpose and need.

This alternative does not reduce the existing footprint and significant space requirements in each parcel and does not increase capacity for water delivery and sewer collection for future pipe extensions to the Uiviq and Tundra Ridge Subdivisions. It also does not serve the 25 additional residences or commercial properties in the Martina Oscar subdivision.

The use of the existing sewer pipeline continues to rely on a gravity sewer system where frost heave and settlement causes changes in pipe grade over time.

Alternative 2 relies on the existing insulation, which is up to 40 years old and has likely lost some of its insulation value.

Trenchless technologies require specialized equipment and materials, which would need to deploy from outside of Bethel.

The existing 4” sewer connection lines are smaller than the recommended 6” diameter lines. Lining the existing pipes would reduce the diameter to around 3.5 inches, which could result in more clogging.

Water leakage at the pit orifice connections will be reduced with a corresponding reduction in the cost of heating, treating and pumping of the water. Maintenance callouts for these loops will also be reduced.

4.2.5 Construction Challenges

Work will be in easements and along the City roads. There may be some areas where equipment access to the existing above-ground pipes and pile supports may be limited by existing structures. Many of the easements have significant encroachments (e.g. homes, sheds, old vehicle). While it is technically the responsibility of the homeowner to keep easements open, this has not been standard practice in Bethel. Many residents may not have money available to relocate items in easements.

Pile drilling would most likely occur in the spring, when the ground is still cold, to avoid excessive ponding of snowmelt and to limit tracked vehicle impact to the existing ground surface.

Bypass pipes would be needed during the project to maintain water and sewer service to the affected households. According to the manufacturer and installation contractor located in Anchorage, the required timeframe for installation of CIPP lining of the sewer mains is 50 weeks, and thus would need to be spread over two summer periods. Installation of CIPP lining in the water mains could be accomplished in 20 weeks and therefore could take place in one summer period, therefore the overall project would be spread over two construction seasons to account for the sewer main lining.

4.2.6 Sustainability Considerations

Adding heat to the water at the water treatment plant is a significant expense for the City. New pump controls and heat trace will increase efficiency and capacity for heat addition although not without cost.

Hauling water and sewage by truck to the 25 services not reached by the piped system in this alternative is less energy efficient than piped service due to the diesel fuel consumption.

Alternative 2 reduces construction waste by utilizing existing pipes rather than removing and scrapping the pipes. It is unlikely the disassembly, packaging and shipping to a recycling facility would occur due to the required barging of the materials and associated costs.

4.2.7 Cost Estimate

The Repair-In-Place alternative cost estimate includes the capital expenditures needed to install new pilings and the lining through the length of the distribution system, and the fixed and variable operation and maintenance costs of running both hauled and piped systems in the neighborhood.

The capital costs associated with Alternative 2 (Table 10) include CIPP lining of the existing 6-inch sewer main, 4-inch sewer service lines, and the existing 6-inch water main loops, replacement of all pit-orifices, hydrants, miscellaneous valves and appurtenances, and rehabilitation of the existing water service lines.

Table 10: Capital Costs of Alternative 2

Phase	Present Value of Capital Cost	Water	Sewer
Single Phase Build Out	$ 33,512,000	$ 14,143,000	$ 19,369,000

The determination of O&M costs (Table 11) for this alternative are based on the following assumptions:

- The costs to produce or remove water and sewer (both piped and hauled) per 1,000 gallons remain the same as developed in the CH2MHill Rate Study and presented in the Bethel Avenues Neighborhood Water and Sewer Improvements PER.
- Each residence will be responsible for paying the electrical cost for the heat trace installed in the service lines.
- The electrical costs to operate the heat trace installed in the sewer and water mains will be included in the water system operating costs.
- Heat trace will be installed in 4,400 LF of sewer main problem areas defined by the City.

Table 11: O&M Costs of Alternative 2

O&M Item	Total Annual Cost	Present Value of O&M Cost
Hauled Water	$ 144,359	$ 2,991,069
Hauled Sewer	$ 149,036	$ 3,087,975
Piped Water (Yr. 1-2)	$ 888,680	$ 1,743,293
Piped Water (Yr. 3-25)	$ 960,348	$ 18,564,351
Piped Sewer (Yr. 1-2)	$ 323,156	$ 633,925
Piped Sewer (Yr. 3-25)	$ 349,217	$ 6,750,673
Electrical Cost (Yr.1)	$ 49,507	$ 48,872
Electrical Cost (Yr. 2-25)	$ 99,014	$ 1,983,299
Repairs (lump sum)	$ 8,000	$ 165,757
	Present Value of O&M Costs	**$ 35,970,000**

4.3 Alternative 3: Construct Loop C, Extend Sewer, and Perform Spot Repair

4.3.1 Description

This alternative includes the construction of the previously studied Loop C extension *(LCG, 2013)* which brings piped water and sewer to the approximately twenty-five additional properties within Bethel Heights currently served by truck-haul service. These properties are located on Akula Court, Manignaq, and Ptarmigan Street. Construction of Loop C water main as described in the LCG report would split the existing Loop A just south of the junction of Akakeek Street and Delapp Drive near the boardwalk and extend separate source and return lines to the BHWTP. This extension would create the independent Loop C, reduce the length of the existing Loop A by 9,300 LF, and keep the existing Loop B, allowing all three loops to operate in a lower and more acceptable pressure range. This improvement would result in increased fire flow performance of the system. From the prior studies and hydraulic modeling done as part of the LCG PER it was recommended to install HDPE pipe in the new Loop C water main construction to contribute to a reduction in friction head losses and contribute to an overall reduction in operating cost of the circulation pumps.

Spot repair of the existing sewer main problem areas would focus on reducing the causes of frequent pipe freeze up. The freeze problem is common in the sewer service lines and mains and appears to be correlated with areas of settled pipe supports and sagging pipes which no longer maintain a positive drainage grade. The suggested repairs include replacement of the sewer main and service line segments and installation of additional pile supports to prevent future low spots in the pipe. Based on problem areas indicated by the City, an estimated 35 sewer service lines, and 3,600 LF of sewer main would be replaced. Combined water and sewer service lines would be used in this alternative to reduce the amount of arctic pipe materials, heat trace footage, and to reduce the amount of pipe space required at each residence. Containing both water and sewer lines in a single insulated pipe with the heat trace element would contribute to energy savings during the freezing months. Figure 19 and Figure 13 highlight the areas of the pipe network which the City has documented to need frequent maintenance and attention due to freeze-ups in winter months.

Localized issues with the water main and service lines include leaks, corrosion, and occasional joint breaks due to settling supports. Repairs would include replacement of specific pipe segments, deteriorated hydrants, isolation valves, and pit orifices. The water main repair areas are estimated to be 1,300 LF.

It is recommended to perform a system wide condition assessment separate from this PER to obtain quantities and critical locations for spot repair or replacement through a more scientific approach.

The Loop C water main extension from the BHWTP would include 1,300 LF of new HDPE core arctic pipe (outgoing), and 1,300 LF of return pipeline. The core “carrier” pipe size would be increased to 8-inch, or 10-inch to meet the City’s desired fire flow criteria. Currently the 6-inch galvanized steel pipeline does not allow for standard fire flow of 1,500 GPM. This is due in part to small diameter hydrants the restrictive 6-inch pipeline diameter, and the angular topology of the pipeline. In the looped system during fire flow, water is delivered to the hydrant through both the outgoing and return pipeline, thus each individual pipeline does not need to carry the full fire

flow capacity. A disadvantage of HDPE is an equivalent internal pipe diameter to steel, DIP, or PVC, requires increase in one or more nominal pipe diameters.

Construction of a third circulation pump terminal and piping within the BHWTP would be required to serve a new independent Loop C. Updates to the current process piping and valving within the plant would be required to accommodate independent loop operation and to achieve the desired fire flow. The Martina Oscar subdivision extension of Loop C would include 2,100 LF of new 8-inch or 10-inch HDPE arctic pipe water main and 2,100 LF of 10-inch HDPE arctic pipe gravity sewer main.

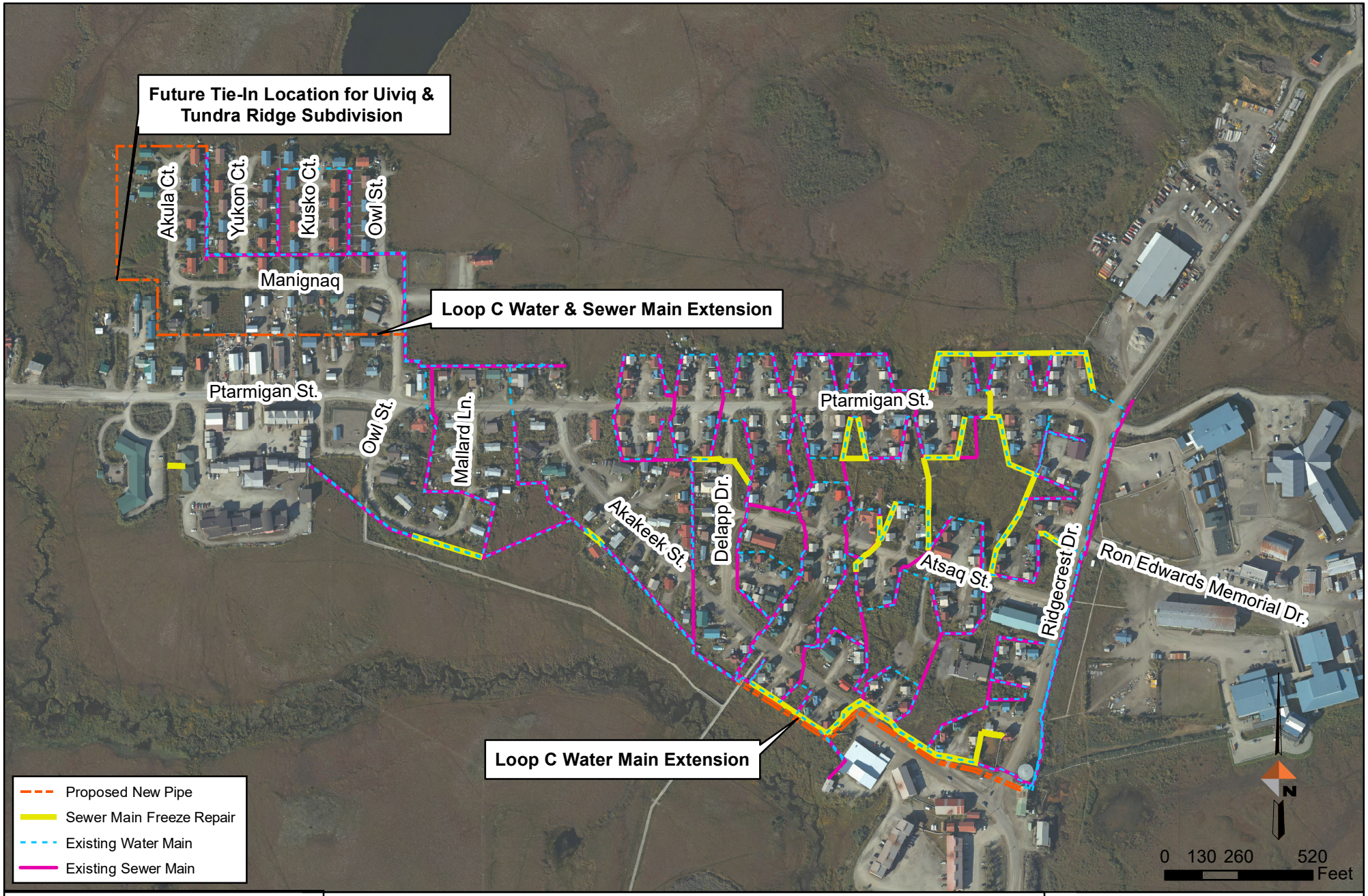
Two approaches for the implementation of this alternative are presented which compare construction completed in a single phase or completed in three distinct phases. In the single phased approach, construction would be completed in one mobilization and over a single summer season.

In the multi-phased approach, the implementation of the improvements would be spread over 3 or more years and be treated as independent projects with definitive end points where the operation of the implemented phase would not depend on the completion of a later phase. The order of construction of Phase 2 and 3 as described could be switched depending on the severity of the need for spot repairs.

Phase 1: Construction of the Loop C trunk line from the BHWTP, install Loop C circulation terminal in the BHWTP, and split Loop A into Loop C,

Phase 2: Construct Loop C extension in the Martina Oscar subdivision; construct 25 services,

Phase 3: Perform spot repair on the identified critical areas.



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Alternative 3 - Construct Loop C, Extend Sewer & Perform Spot Repair
Bethel Heights Water & Sewer Improvements
Bethel, Alaska

PROJECT	1529.50144.01
DATE	May 07, 2019

Figure 19

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4.3.2 Environmental Impacts

The environmental impacts of Alternative 3 are very similar to those of Alternative 2. Although this project would not bisect or fragment wildlife habitat, the proposed action would disturb approximately 1,000 LF (0.35 acres) of previously undisturbed land with the construction of new pipeline near the Martina Oscar subdivision. The action would disturb approximately 6,000 LF (2.1 acres) of lands previously disturbed or currently occupied by pipeline, roadways, or residential lots. The disturbed area estimate assumes a 15-foot construction easement. The disturbed areas which are undeveloped would be stabilized to prevent the introduction and spread of invasive species. Removal of shrubs and trees would occur outside of the USFWS migratory bird window (May 5 to July 25).

Historic and Cultural Properties: DOWL's finding and recommendation is that there will be no affect to buried historic properties within the APE due to minimal subsurface impacts, and the lack of previously recorded sites within the APE. No adverse effects to historic properties are anticipated from the project.

4.3.3 Land Requirements

The rehabilitation spot repair work could utilize the existing pilings and easements. The above-grade arctic pipes are placed on driven pile foundations or on timber supports, currently spaced 20 feet apart. This alternative includes driven piles to be added in critical areas spaced every 10 feet to support the new arctic water and sewer pipes. The actual ground penetrations for each pile are less than 1 square foot. The total ground disturbance to place the pipe on the ground is minimal. To construct the pipe networks, an area approximately 10 to 15 feet wide is required. The water and sewer pipes typically share pile supports and overall route. The proposed alternative would result in 2,100 LF of new water and sewer main route, and 1,250 LF of new service line route for a total of 3,350 LF with piles spaced every 10 feet (1.2 acres). The remaining 4,900 LF of new pipe would share the existing pipe route and pile supports, thus not require new land.

4.3.4 Advantages and Disadvantages

The spot repair work and extension of water main from the BHWTP could utilize the existing pilings and easements as described in the previous section. This minimal ground disturbance is a distinct advantage. The land required for the existing water and sewer tanks adjacent to each residence or business still on hauled service would be occupied by the above ground service connections. Residents with tanks could elect to keep their water and sewer tanks for back-up although City Code requires other water sources to be isolated to prevent cross contamination.

Approximately 46 utility easements were identified (LCG 2013) as necessary to provide suitable legal access for the pipe extension to the Martina Oscar Subdivision and Akula Street. This number has not been verified for the purposes of the PER. The City will coordinate with the respective landowners to obtain signed easements where necessary although it is likely the existing permanent utility easements would suffice. If the selected route for the pipes deviates from the existing pipe placement, acquisition of additional easements would be necessary. Construction of the Loop C extension near the BHWTP could be completed within the existing pipeline easements.

Maintaining piped service to the current 310 services and adding up to 25 additional residences to the piped water system meets the objectives of maintaining or improving individual hygiene, community health, and making costs and services more equitable among users.

A specific advantage of splitting Loop A into two loops includes allowing the operating pressure of Loop A to be reduced to normal industry standards of 30-80 psi, down from the estimated required 110 psi (LCG 2013). This reduction in pressure could result in fewer leaks in the pipe joints, the individual pit orifices, as well as reduce the wear and tear on household appliances and fixtures.

By adding twenty-five piped services, the fire hydrant coverage would be increased, improving the safety of the neighborhood and potentially reducing individual home insurance rates.

Reducing the number of properties served by truck-haul would result in fewer heavy vehicle trips on the roads and subsequently reduce the dirt road wear and tear and O&M costs borne by the DPW.

Disadvantages of this alternative include the temporary nature of the fix and shorter-term solution for the system as a whole. The majority of the existing pipes in this alternative would not be replaced and the underlying water quality issue due to the internal pipe corrosion would not be wholly addressed. As the system continues to age, the City will be required to continue to address the failing components in a piece-wise manner.

4.3.5 Construction Challenges

Pipes will be placed in easements and along the City roads. Many of the easements have significant encroachments (e.g. homes, sheds, old vehicles). While it is technically the responsibility of the homeowner to keep easements open, this has not been standard practice in Bethel. Many residents may not have the means available to relocate encroachments in easements.

Another construction challenge will be to transition each truck-haul residence over to the new City water and sewer mains. Each residence has a unique plumbing system, and it may not be feasible to pre-engineer each connection. Many of the connections will have to be field engineered with a certified plumber and a project representative from the design team.

4.3.6 Sustainability Considerations (Energy Use)

While the reduction in operational pressure of each loop will contribute to minor energy savings, adding a third circulation pump will negate the energy savings. The installation of heat trace in the problem areas would contribute to an increased electrical usage.

4.3.7 Cost Estimate

Assuming a single phased approach to the implementation of this alternative, it is estimated that construction could be completed over a single summer season. This cost estimate includes removing problem sections of existing pipe, installing new Arctic water and sewer mains, constructing additional steel pilings, installing submersible heat trace, and driveway and street crossings. The present value of capital cost of construction as a single phase is presented in Table 12**.**

Table 12: Capital Costs of Alternative 3

Phase	Present Value of Capital Cost	Water	Sewer
Single Phase Build Out	$ 10,142,000	$ 5,098,000	$ 5,044,000

The City would continue to haul water and sewer to the neighborhood as the project is built out.

The O&M costs for this alternative consist of providing piped water and sewer to the current and new residents and commercial users added to the project area for the 25-year life of the project. New costs include the operation of a third circulation pump to serve Loop C, and the operation of heat trace in the spot repair areas and in the new Loop C pipes (Table 13: O&M Costs of Alternative 3).

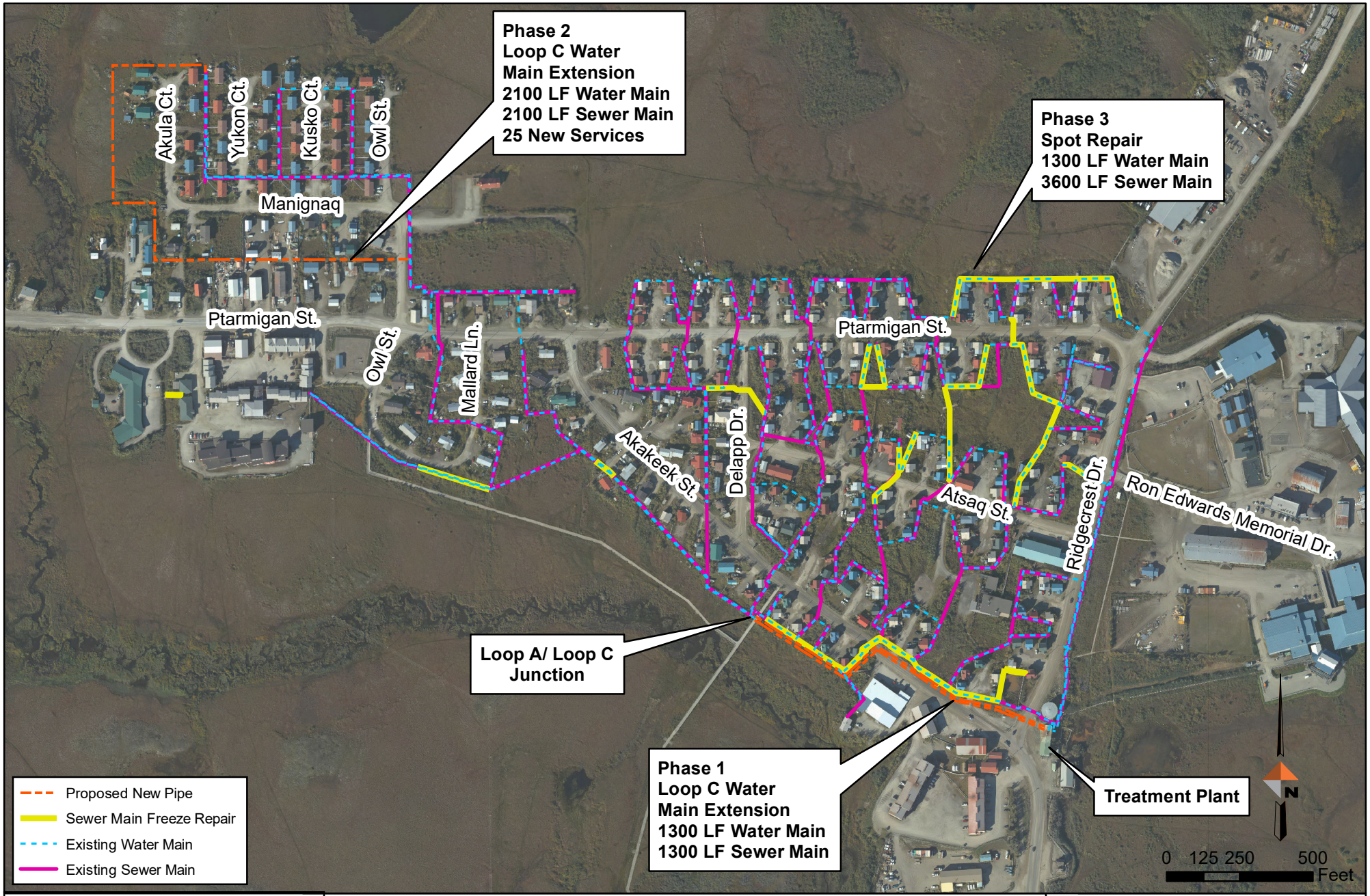
Table 13: O&M Costs of Alternative 3

O&M Item	Total Annual Cost	Present Value of O&M Cost
Piped Water	$ 960,348	$ 19,898,034
Piped Sewer	$ 349,217	$ 7,235,649
Electrical Cost	$ 34,214	$ 708,909
Repairs (lump sum)	$ 70,000	$ 1,450,373
	Present Value of O&M Costs	**$ 29,293,000**

4.4 Alternative 3A: Phased Approach

This sub-alternative of the Alternative 3 previously described presents the work in three distinct phases that could be constructed over multiple years, either individually or in multiples as larger blocks if the funding becomes available (Figure 20). Phase 1 and 2 represent the work proposed in previous years as Loop C construction. Phase 3 represents the work proposed to address the identified problem areas in Alternative 6 – Spot Repair.

The most significant advantage to this phased approach is it provides a lower immediate capital cost burden to the City and increases the chances for full or partial RD grant or loan funding.



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Alternative 3A - Phased Approach
Bethel Heights Water & Sewer Improvements
Bethel, Alaska

PROJECT	1529.50144.01
DATE	May 07, 2019

Figure 20

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This cost estimate includes removing problem sections of existing pipe, installing new Arctic water and sewer mains, constructing additional steel pilings, installing submersible heat trace, and driveway and street crossings. The capital cost of construction is the present value and is presented in Table 14.

Table 14: Capital Costs of Alternative 3A (Phased Approach)

Phase	Present Value of Capital Cost	Water	Sewer
1	$ 1,702,000	$ 1,702,000	$ -
2	$ 4,375,000	$ 2,230,000	$ 2,145,000
3	$ 4,927,000	$ 1,839,000	$ 3,088,000
Total	$ 11,004,000	$ 5,771,000	$ 5,233,000

The O&M costs include provision of hauled water during the years of construction, in addition to providing piped water and sewer to the current and new residents and commercial users added to the project area for the 25-year life of the project. New costs include the operation of a third circulation pump to serve Loop C, and the operation of heat trace in the spot repair areas and in the new Loop C pipes (Table 15).

Table 15: O&M Costs of Alternative 3A (Phased Approach)

O&M Item	Total Annual Cost	Present Value of O&M Cost
Hauled Water	$ 29,663	$ 29,225
Hauled Sewer	$ 30,624	$ 30,171
Piped Water (Yr. 1)	$ 888,680	$ 875,547
Piped Water (Yr. 2-25)	$ 960,348	$ 18,564,351
Piped Sewer (Yr. 1)	$ 323,156	$ 318,381
Piped Sewer (Yr. 2-25)	$ 349,217	$ 6,750,673
Electrical Cost (Yr.1-2)	$ 6,480	$ 12,674
Electrical Cost (Yr. 3-25)	$ 34,188	$ 660,883
Repairs (Yr. 1 Lump Sum)	$ 70,000	$ 136,912
Repairs (Yr. 2 Lump Sum)	$ 18,000	$ 347,956
Present Value of O&M Costs		**$ 27,727,000**

4.5 Alternative 4: Full System Replacement (Mains and Services)

4.5.1 Description

This alternative considers full replacement of the existing piped water and sewer infrastructure in the project area as a single phased project and includes demolition and replacement of both the existing water and sewer mains, services, and appurtenances as well as construction of the Loop C extension for the 25 services on hauled-water in the Martina Oscar subdivision. The capital cost of this total-replacement is the highest of the other alternatives but would provide an opportunity to improve the design of the system and optimize for minimum O&M costs, plan for an expanded system to serve the Uiviq and Tundra Ridge subdivision, reduce the space requirements of the pipe network by combining water and sewer service lines into single service line pipes, and eliminate the patchwork of varying age components and segments of the system.

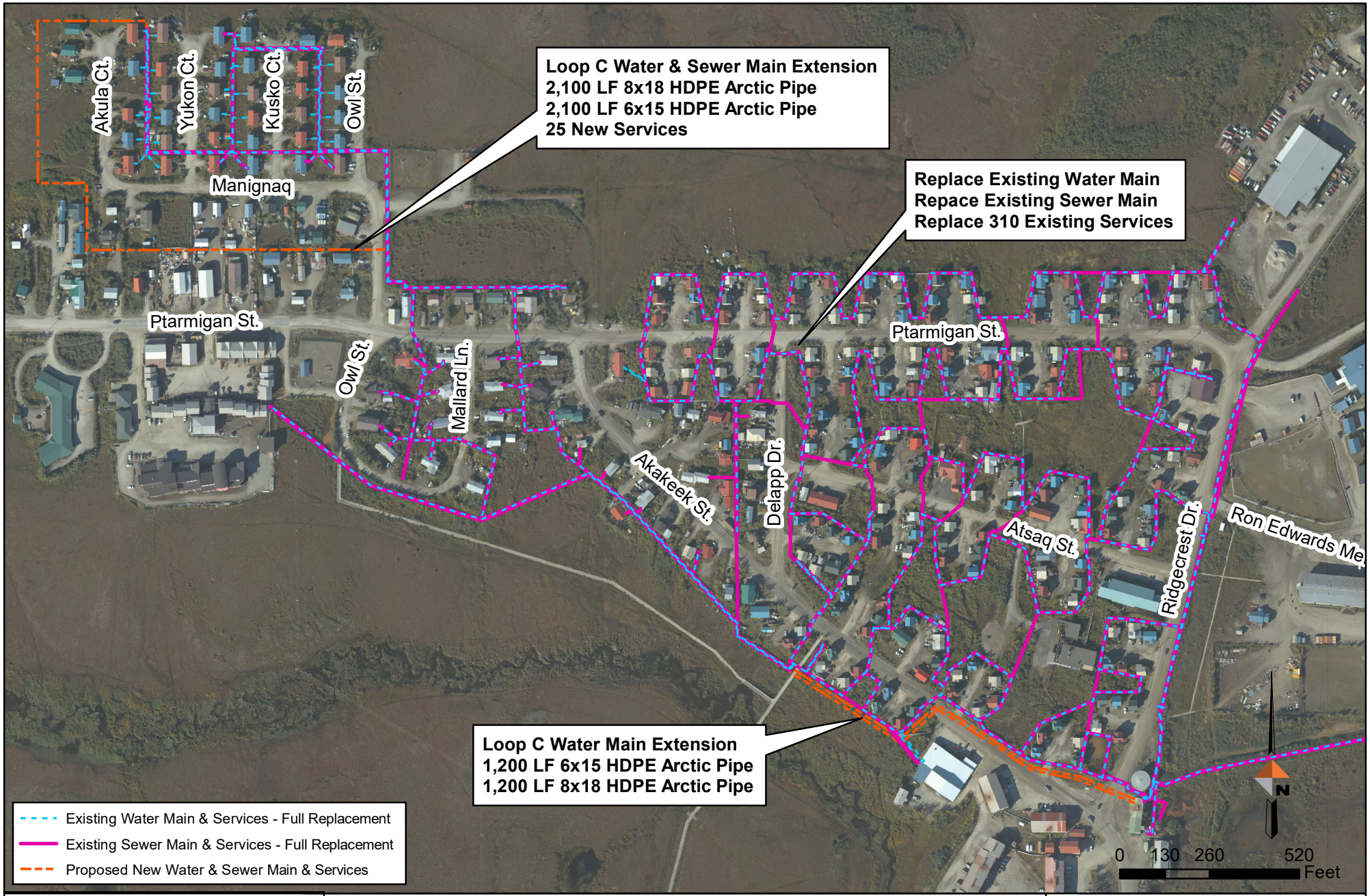
The alignment of the pipes would be similar to the existing pipe network to minimize the need for new easement acquisition but would be routed to optimize hydraulic performance, reduce the space requirements, road crossings, and susceptibility to freezing. Figure 21 displays the proposed work including Loop C extension near the BHWTP and the Martina Oscar subdivision.

4.5.2 Environmental Impacts

The environmental impacts of Alternative 4 would be similar to Alternative 3 with the additional footage of pipeline and surface area impacted during construction resulting from the removal and replacement of all the pipeline throughout the Bethel Heights subdivision. The existing infrastructure removed from service would likely remain in Bethel in some form of stockpile or material yard and require space on the order of multiple acres. Given Bethel's location and access by river or air only, it is unlikely the materials would be shipped for recycle due to the cost of disassembly, organization and preparation for barging to a recycling facility.

4.5.3 Land Requirements

The requirements for Alternative 4 would include the additional estimated 46 easements needed to extend the new Loop C water and sewer line to the Martina Oscar subdivision. Temporary construction easements in critical locations throughout the existing pipe system may be needed to perform the demolition and new construction in an efficient manner. New easements would be obtained for any deviations from the existing pipe routes identified during the design phase.



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Alternative 4 - Full System Replacement & Construct Loop C
Bethel Heights Water & Sewer Improvements
Bethel, Alaska

PROJECT	1529.50144.01
DATE	May 07, 2019

Figure 21

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4.5.4 Advantages & Disadvantages

Advantages of full replacement include:

- Opportunity for system performance optimization and planned capacity for expansion to the additional neighborhoods to the west,
- A system built to updated design standards with higher efficiency components,
- Greater resiliency to natural hazards such as flooding and permafrost related ground movement,
- Would reduce or eliminate the freeze up of the sewer mains and subsequently the number of service line backups.

Disadvantages of full replacement include:

- Very high capital cost,
- Multi-year construction disturbance.

4.5.5 Construction Challenges

Challenges include maintaining water and sewer service to residents and businesses during the demolition and buildout of the new system over a multi-year period.

4.5.6 Sustainability Considerations

Full replacement of the existing system would involve removing the current arctic pipe infrastructure and installing all new pipeline, supports, services, and other system components. Various components may not yet have reached the end of their useful life and might be replaced pre-maturely. This bears an environmental cost; however, it is impossible to predict an exact useful life and assess the condition of each individual component separately within the system. Operation of a new and size-optimized pipeline could result in an increased energy efficiency of the circulation pumps and minimal need for use of electrical heat trace.

4.5.7 Cost Estimate

This cost estimate includes all new heat-traced, insulated pipe, supports, hydrants, street and driveway crossings, and services, and removal of the existing pipes.

Table 16: Capital Costs of Alternative 4

Phase	Present Value of Capital Cost	Water	Sewer
Single Phase Build Out	$ 52,029,000	$ 24,784,000	$ 27,245,000

The operations and maintenance costs of Alternative 4 include hauling water and sewer until all homes are connected to the new pipe network, and then operating and maintaining the new pipes and glycol heating systems (Table 17).

Table 17: O&M Costs of Alternative 4

O&M Item	Total Annual Cost	Present Value of O&M Cost
Hauled Water (Yr. 1-2)	$ 144,359	$ 282,350
Hauled Sewer (Yr. 1-2)	$ 149,036	$ 291,498
Piped Water (Yr. 1-2)	$ 888,680	$ 1,738,155
Piped Water (Yr. 3-25)	$ 960,348	$ 18,564,351
Piped Sewer (Yr. 1-2)	$ 323,156	$ 632,056
Piped Sewer (Yr. 3-25)	$ 349,217	$ 6,750,673
Electrical Cost (Yr. 2-25)	$ 3,600	$ 74,591
Boiler Cost	$ 120,000	$ 2,486,353
Repairs (lump sum)	$ 2,500	$ 51,799
Present Value of O&M Costs		**$ 30,872,000**

4.6 Alternative 5: Full Replacement of Water & Sewer Mains Only

4.6.1 Description

This alternative considers full replacement of the existing piped water and sewer mains in the project area as a single phased project and includes the construction of the Loop C extension. This alternative does not include replacement of the existing 310 services. This alternative would represent the same environmental impacts, land requirements, and sustainability considerations described under Alternative 4.

4.6.2 Advantages & Disadvantages

Advantages of water and sewer main only replacement include:

- Provides piped water and sewer to 25 additional services currently using the hauled water system,
- Opportunity for system performance optimization and planned capacity for expansion to the additional neighborhoods to the west,
- A system built to updated design standards with higher efficiency components,
- Greater resiliency to natural hazards such as flooding and permafrost related ground movement,
- Would reduce or eliminate the freeze up of the sewer mains and subsequently the number of service line backups,
- Lower capital cost than Alternative 4.

Disadvantages of main only replacement include:

- Does not solve the underlying issue of service line freeze ups,
- Relying on the existing service line tie-in locations limits the opportunities for optimizing the hydraulics and layout of the system,
- Very high capital cost.

4.6.3 Cost Estimate

This cost estimate includes replacing all of the water and sewer mains, removing old pipe, constructing additional steel pilings, constructing the extension of Loop C, installing new hydrants, installing a glycol circulations system, adding a circulation pump, and driveway and street crossings. The capital cost of construction is the present value and is presented in Table 18.

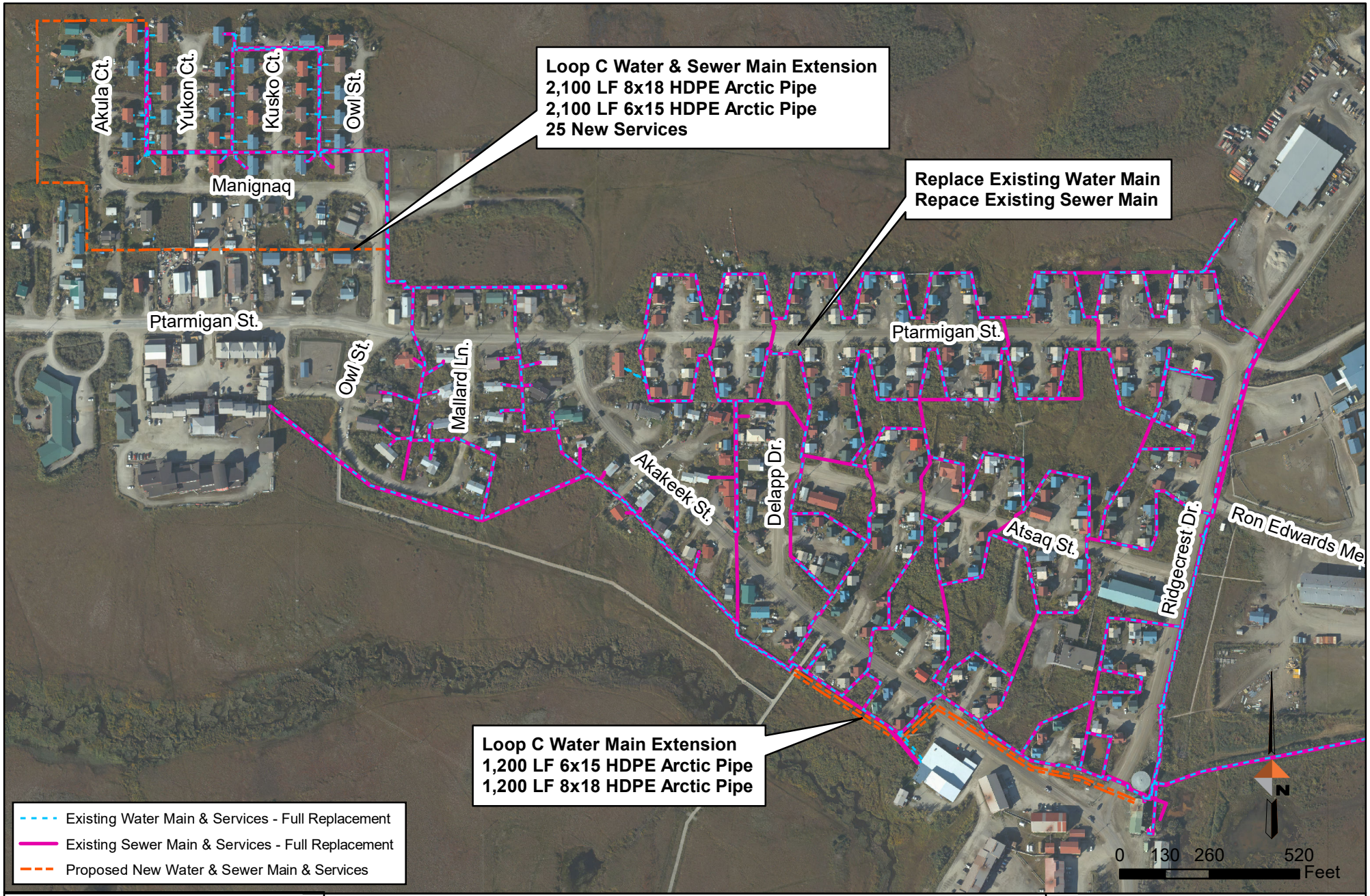
Table 18: Capital Costs of Alternative 5

Phase	Present Value of Capital Cost	Water	Sewer
Single Phase Build Out	$ 43,481,000	$ 22,702,000	$ 20,779,000

The O&M costs of this alternative include hauling water and sewer during construction until homes are reconnected to the new mains, and then operating and maintaining the piped water and sewer and the glycol circulating heat system (Table 19).

Table 19: O&M Costs of Alternative 5

O&M Item	Total Annual Cost	Present Value of O&M Cost
Hauled Water (Yr. 1-2)	$ 144,359	$ 282,350
Hauled Sewer (Yr. 1-2)	$ 149,036	$ 291,498
Piped Water (Yr. 1-2)	$ 888,680	$ 1,738,155
Piped Water (Yr. 3-25)	$ 960,348	$ 18,564,351
Piped Sewer (Yr. 1-2)	$ 323,156	$ 632,056
Piped Sewer (Yr. 3-25)	$ 349,217	$ 6,750,673
Electrical Cost (Yr. 1)	$ 3,600	$ 74,591
Boiler Costs	$ 120,000	$ 2,486,353
Repairs (lump sum)	$ 2,500	$ 51,799
Present Value of O&M Costs		**$ 30,872,000**



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Alternative 5 - Replace Water & Sewer Main & Construct Loop C
Bethel Heights Water & Sewer Improvements
Bethel, Alaska

PROJECT	1529.50144.01
DATE	May 07, 2019

Figure 22

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4.7 Alternative 6: Selective Spot Repair of Problem Areas

4.7.1 Description

This alternative focuses on the repair portion of Alternative 3 and focuses on reducing the causes of frequent pipe freeze up. The freeze problem is common in the sewer service lines and mains and appears to be correlated with areas of settled pipe supports and sagging pipes which no longer maintain a positive drainage grade. The suggested repairs include replacement of the sewer main and service line segments and installation of additional pile supports to prevent future low spots in the pipe. Based on problem areas indicated by the City, an estimated 35 sewer service lines, and 4,400 LF of sewer main would be replaced. Combined water and sewer service lines would be used in this alternative to reduce the amount of arctic pipe materials, heat trace footage, and to reduce the amount of pipe space required at each residence. Containing both water and sewer lines in a single insulated pipe with the heat trace element would contribute to energy savings during the freezing months.

Localized issues with the water main and service lines include leaks, corrosion, and occasional freeze up. Repairs would include replacement of specific pipe segments, deteriorated hydrants, isolation valves, and pit orifices. Figure 19 and Figure 13 highlight the areas of the pipe network which the City has documented to need frequent maintenance and attention due to freeze-ups in winter months.

Road and driveway crossings identified as shifted, heaved or impacting the water mains or service lines in the project area would be replaced. Figure 23 presents the eleven City provided problem areas of greatest need of repair.

This alternative would utilize either CIPP lining, or replacement of the water and sewer mains and services to repair the isolated sections that are in the poorest condition. The City has provided a general map of the areas of pipeline which recurrently freeze, leak or are subject to other forms of repair. Included with this alternative would be the replacement of valves, hydrants and other appurtenances where located within the segment of pipe to be replaced. Existing piles and pipe supports would be rehabilitated where necessary, and additional piles and supports would be added to reduce the rehabilitated or new pipe spans to 10-feet.

The environmental impacts and land requirements of this alternative would be minimal as the existing pipeline alignments would be utilized. With the addition of driven or augured piles, there would be some ground disturbance in the selected areas similar to that described in Alternative 3. Impacts to floodplains, wetlands, biological and archeological resources would be negligible. The results of the work would be similar to maintenance the City routinely performs.

4.7.2 Advantages and Disadvantages

Advantages of Spot Repair:

- The lowest capital cost of all the “build” alternatives,
- The repairs considered would provide a short-term solution to the freezing pipe issues identified in the problem areas.

Disadvantages of Spot Repair:

- Does not provide piped water and sewer to the 25 services in the Martina Oscar subdivision. High operational costs of hauled service would remain,
- No expansion of capacity for future connection of the Tundra Ridge and Uiviq subdivisions,
- More problem areas would be likely to develop in the near-term future. The City would continue to rely on the corroded 40-year old pipe system and be required to make ongoing repairs for leaking and freezing pipes not addressed in the repair areas.

4.7.3 Construction Challenges

This option would require identification of the greatest problem areas and access points along the pipe into which to insert the new liner or to replace the pipe. This would present disruption in water and sewer service.

4.7.4 Sustainability Considerations

Adding heat to the water at the water treatment plant is a significant expense for the City. New pump controls and heat trace will increase efficiency and capacity for heat addition by only increasing the heating of problem freeze areas. The deteriorating existing pipes are wasting a lot of water from leaks and a lot of personnel time to address leaks and frozen sections.

Hauling water and sewage by truck is less efficient than piped service because it costs more and uses more resources in trucks. Piping water is a more energy efficient way of providing the same service. Alternative 6 reduces construction waste by utilizing existing pipes rather than scrapping the pipes.

4.7.5 Cost Estimate

This cost estimate includes removing problem sections of existing pipe, installing new Arctic water and sewer mains, constructing additional steel pilings, installing submersible heat trace, and driveway and street crossings. The capital cost of construction is the present value and is presented in Table 20.

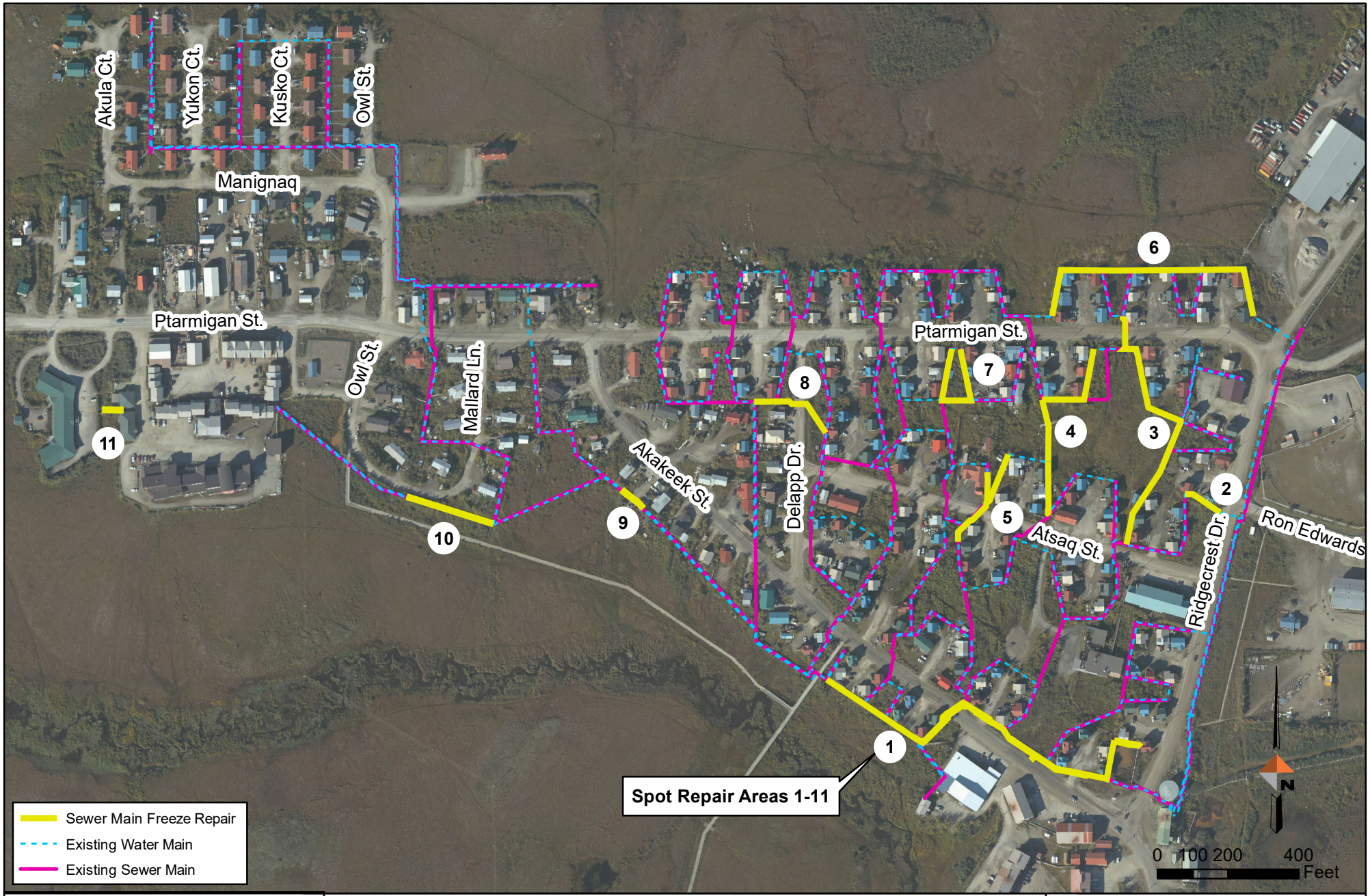
Table 20: Capital Costs of Alternative 6

Phase	Present Value of Capital Cost	Water	Sewer
Single Phase Build Out	$ 4,928,000	$ 1,838,000	$ 3,090,000

The O&M costs of this alternative include piping water and sewer for the life of the pipes, and electrically heating the water loops (Table 21).

Table 21: O&M Costs of Alternative 6

O&M Item	Total Annual Cost	Present Value of O&M Cost
Hauled Water	$ 144,359	$ 2,991,069
Hauled Sewer	$ 149,036	$ 3,087,975
Piped Water	$ 888,680	$ 18,413,106
Piped Sewer	$ 323,156	$ 6,695,675
Electrical Cost	$ 27,734	$ 574,646
Repairs (lump sum)	$ 70,000	$ 1,450,373
	Present Value of O&M Costs	**$ 33,213,000**



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Alternative 6 - Spot Repair of Problem Areas
Bethel Heights Water & Sewer Improvements
Bethel, Alaska

PROJECT	1529.50144.01
DATE	May 07, 2019

Figure 23

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4.8 Other Piped Water and Sewer Alternatives Considered

1. Clean the water mains by some means of physical removal of the accumulated iron oxide sludge/scale. This could include pigging the pipe, brush cleaning, high pressure jetting, and flushing. This would theoretically reduce the iron levels in the water for the near-term future but would not address the source of the corrosion. This option would not address the issues created by sagging and heaving pipes, and ultimately would not provide piped water to the 25 hauled customers or create additional capacity for future development. The cost of a systematic cleaning of the water mains by physical means provides little long-term benefit.

2. Utilize trenchless (repair-in-place) technology for the sewer lines and replace water mains with new pipe. This would be considered where the installation of the potable water liner is not feasible due to construction challenges such as the pit orifice removal/replacement and compatibility with the liner.

3. Full pipe replacement paralleling/stacked on existing pipes to minimize impact to users during construction.

4. Full reroute and build-out of both water and sewer: greater impact on land and residents.

5. Installing lift stations for clusters of homes and converting the gravity sewer system to pressure sewer. The City has historically preferred to avoid this because it can become complicated and un-equitable holding any one customer accountable for a clog or problem.

6. Installing individual lift stations at each residence and converting portions or all of the gravity sewer to pressure sewer. The City has historically preferred to avoid this because it is expensive and requires the homeowner perform regular maintenance.

These alternatives were eliminated based on the following considerations:

- Alternative does not provide piped water and sewer to the 25 hauled customers in the neighborhood.
- Alternative in itself does not provide a long-term solution to the issues driving the project.
- The City's preference to centralize wastewater lift stations.

Ultimately, the preferred alternative was selected because it:

- Lowers the operating pressure of existing Loop A.
- Addresses the problem areas of the existing system with highest incident occurrence.
- Serves the residents and businesses in the Martina Oscar subdivision not yet connected to piped water and sewer thereby meeting in-part the objectives of the Bethel Public Works Committee.
- Creates future add-on capacity for the Tundra Ridge and Uiviq subdivisions to connect to the piped water and sewer system.

- Lowest capital cost of the alternatives which serve the Martina Oscar subdivision.
- Has the least impact to existing users during construction of the “build” alternatives.
- Makes cost and services more equitable among users.
- Provides the City with an incremental solution that has a higher likelihood of funding.

Constructing piped water and sewer to the areas west of Bethel Heights, including Tundra Ridge Subdivision, is possible with the construction of the preferred alternative. Generally, reducing the size of the truck haul system and taking strategic steps to convert hauled water users to piped water users is a City priority. Making improvements to the water system that stand alone is also very important to the City when implemented in a phased approach.

4.9 Cost Summary of Alternatives

Table 22: Summary of Alternative Life Cycle Costs

Bethel Heights Water & Sewer Alternatives									
	Alt. 1	Alt. 2	Alt. 3	Alt. 3A Phase 1	Alt. 3A Phase 2	Alt. 3A Phase 3	Alt. 4	Alt. 5	Alt. 6
	No Build	Repair In-Place	Construct Loop C, Perform Spot Repair - Single Phase	Construct Loop C Water Treatment Plant Extension	Construct Martina Oscar Loop C Extension	Perform Spot Repair	Full System Replacement with Loop C Extension	Water & Sewer Main Replacement with Loop C Extension	Perform Spot Repair
[1]Present Value of Capital Costs-Total	$ 736,000	$ 33,512,000	$ 10,142,000	$ 1,702,000	$ 4,375,000	$ 4,927,000	$ 52,029,000	$ 43,481,000	$ 4,928,000
[2]Annual O&M Cost (Year 1)	$ 1,575,232	$ 1,513,232	$ 1,413,780	$ 1,342,123	$ 1,368,233	$ 1,368,233	$ 1,507,732	$ 1,507,732	$ 1,309,571
[3]Annual O&M Cost (Year 2)	$ 1,575,232	$ 1,513,232	$ 1,413,780	$ 1,368,233	$ 1,368,233	$ 1,368,233	$ 1,507,732	$ 1,507,732	$ 1,309,571
[4]Annual O&M Cost (Year 3-25)	$ 1,575,232	$ 1,367,072	$ 1,413,780	$ 1,368,233	$ 1,368,233	$ 1,368,323	$ 1,315,665	$ 1,312,065	$ 1,309,571
[5]15-Year Salvage/Book Value Total	$ 84,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
[6]Present Worth of Salvage Value	$ 264,891	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
[7]Annual O&M Present Worth	$ 32,639,000	$ 35,970,000	$ 29,293,000	$ 1,390,235	$ 26,336,538	$ 26,336,538	$ 30,872,000	$ 30,872,000	$33,213,000
[8]Total Cost Net Present Worth	$ 33,375,000	$ 69,482,000	$ 39,435,000	$ 38,731,000	$ 38,731,000	$ 38,731,000	$ 82,901,000	$ 74,353,000	$38,141,000

[1]For Alt 1, the Present Value Capital cost consists of the purchase of two trucks in year 1, and 2 trucks in year 15.

[2,3,4]Represents the operating cost of the alternative during multi-year construction.
[5]Represents the salvage value estimated for two trucks retired at year 15 and two trucks salvaged 10 years into useful life. Based on straight line depreciation and $42,000 value at end of useful life.

[6]Present worth of salvage value.
[7]Present Value of Annual O&M = Fixed Cost Ordinary Annuity.
[8]Net Present Value = Capital Cost + Uniform Series Present Worth of O&M – Single Payment Present Worth of Salvage Value.

4.10 Alternative Selection

4.10.1 Design Criteria

The selected alternative must be designed for the following criteria. The criteria for the alternatives including Loop C construction and the additional 25 services are in Table 23.

Table 23: Design Criteria

	Without Loop C[1]	With Loop C[2]	Loop C Upsized[3]
General			
Design Period	25 years	25 years	25 years
Parcels/Services	310	335	716
Population Per Parcel	3	3	3
Design Population	1132	1223	2613
[4]Real Interest Rate	3.55%	3.55%	3.55%
Environmental Conditions			
Mean Temperature	29.1°F	29.1°F	29.1°F
Design High Temperature	90°F	90°F	90°F
Design Low Temperature	-48°F	-48°F	-48°F
Mean Annual Precipitation	16 inches	16 inches	16 inches
Days per Year Reaching 32° F or Lower	240	240	240
Mean Annual Snowfall	55 inches	55 inches	55 inches
Ground Snow Load	40 PSF	40 PSF	40 PSF
Basic Wind Speed	120 mph	120 mph	120 mph
Water Demand & Wastewater Production			
Water Usage Per Capita System (gallons)	100	100	100
Design Daily Water Demand (gallons)	130,123	140,616	300,541
Peak Factor	1.6	1.6	1.6
Peak Hourly Demand (gallons)	8,675	9,374	20,036
Design Daily Wastewater Generation (gallons)	130,123	140,616	300,541
Peak Hourly Wastewater Generation (gallons)	8,675	9,374	20,036

[1]Design Criteria for Bethel Heights Existing Piped System
[2]Design Criteria for Bethel Heights Including Martina Oscar Subdivision Loop C Addition

[3]Design Criteria for Bethel Heights Including Uiviq & Tundra Ridge Subdivisions (Future Build-Out, Not used in analysis)

[4]United States Office of Management and Budget, A-94, Average of 20-year & 30-year Rates

4.10.2 Non-Monetary Considerations

The City of Bethel's Water and Sewer Master Plan (CRW 2005) prioritized the provision of piped water and sewer to all areas of the community. Piped water and sewer have the following non-monetary advantages:

- Users on the piped system use more water, which has been linked to better health,
- Fire hydrant coverage improves the safety of the neighborhood and has the potential to reduce insurance premiums for homeowners and the City,
- Elimination of water and sewer truck incidents in the neighborhood,
- Reduces the burden on the Utilities Department to maintain and fill water and sewer truck driver positions, and reduces strain on current drivers and mechanics,
- Minimizes road wear.

5.0 PROPOSED PROJECT (RECOMMENDED ALTERNATIVE)

5.1 Recommended Alternative Description

5.1.1 Project Schedule

The existing piped water and sewer pipe network in Bethel Heights is aging and at or beyond its intended anticipated useful life. Portions of the sewer main and services experience frequent freezing and interruption of service, backups, and the City is responsible for the repairs. The potable water pipes have been documented to be corroding for up to 15 years, and users experience high levels of iron and manganese during system upsets, starts and stops, flushing, or other maintenance activities. Nevertheless, the system currently functions with rare ADEC violations for water quality, and the severity of the corrosion and transport of iron in the potable water main has appeared to have subsided during normal operations in correlation with fewer customer complaints and water samples collected in April 2019. The City continues to make repairs to both the sewer mains and services, as well as the water mains and services. The estimated remaining useful life of the piped system is varied. After considering the information gathered during the previous LCG 2013 report, the 2005-2008 Corrosion Study (CRW), and the writing of this PER, it is recommended to proceed with Alternative 3A Phased Approach. The 25-year lifecycle cost of implementing the phased approach is approximately $52,080,000. This cost is $1.8M greater than single phase construction, however, single phase construction presents an unfavorable capital cost for a single funding cycle and is unlikely to receive approval.

In addition to the selected alternative, it is recommended that the City perform a conditions assessment of the Bethel Heights Public Water System. Isolated areas of severe corrosion in the water mains likely exist based on visual observations made during the writing of this PER. Areas of corrosion, pipe jacking, joint breaks, and freeze ups in the sewer main should be identified. A system-wide inventory of the assets and their condition should be taken to better implement the recommended Alternative 3A Phase 3 (spot repair of problem areas).

Conditions assessment, topographic survey, public involvement, geotechnical investigations, design, permitting, and easement acquisition will take approximately 18 months. The driven piles (driven to a depth of approximately 20 feet) on which the arctic water and sewer mains are installed could be installed during the winter months, and water and sewer main installation

could occur in summer months. At the time of this PER development, assuming funding becomes available, construction is forecast to be able to commence late in 2020 and would progress through the following three summer construction periods. It is anticipated substantial completion of Phase 1 could be reached by the end of 2021, Phase 2 in 2022, and Phase 3 in 2023.

This PER should be used to solicit funds from the USDA RD Fiscal Year 2020 (FY20) allocations for Phase 1 of Alternative 3. Updates to costs and scope for Phase 2 and 3 could be made following award of funding for FY20, and FY21 respectively in order to ensure completion of the three-phase approach and best realize the incremental improvements and cost efficiencies of converting more hauled users to the piped system.

5.1.2 Permit Requirements

Final permit requirements will be included in the Environmental Report for this project. It is currently anticipated that permits will be minimal for the proposed action, because the proposed action takes place mainly in previously disturbed areas.

Once engineering documents are developed, ADEC will require an Engineering Plan Set review prior to granting an approval to construct and operate the piped water and sewer systems. This is a standard permit for the City's engineering firm to obtain. The project area would have many water and sewer separation violations, but ADEC will grant waivers because all the water and sewer mains are above ground, and leaks are easy to identify.

5.2 Project Cost Estimate for the Recommended Alternative

Table 24: Recommended Alternative Water and Sewer Cost Estimate

Capital Costs, Alternative 3, Phase 1						
Construct Loop C Water Treatment Plant Extension						
Item Description	**Quantity**	**Unit**	**Unit Price**	**Total Cost**	**Water**	**Sewer**
Install New 6x15 HDPE Arctic Water Main	1,300	LF	$ 225	$ 293,000	$ 293,000	$ -
Install 8x18 HDPE Arctic Water Main	1,300	LF	$ 250	$ 325,000	$ 325,000	$ -
Steel Piles & Pipe Supports	65	EA	$ 3,000	$ 195,000	$ 195,000	$ -
Loop C Circulation Pump and Appurtenances	1	EA	$ 200,000	$ 200,000	$ 200,000	$ -
Cased Street Crossing	2	EA	$ 10,000	$ 20,000	$ 20,000	$ -
Hydrants, Furnish & Install New	3	EA	$ 10,000	$ 30,000	$ 30,000	$ -
Loop C Junction Valves and Fittings	1	LS	$ 30,000	$ 30,000	$ 30,000	$ -
Sub-total of Construction Costs				**$ 1,093,000**	**$ 1,093,000**	**$ -**
Mobilization/Demobilization (7.5% of Subtotal)				$ 82,000	$ 82,000	**$ -**
Taxes, Bonds, Insurance (5% of Subtotal)				$ 55,000	$ 55,000	**$ -**
Traffic Control and Public Relations (3% of Subtotal)				$ 33,000	$ 33,000	**$ -**
Construction Surveying (3% of Subtotal)				$ 33,000	$ 33,000	**$ -**
Preparation of SWPPP				$ 20,000	$ 20,000	**$ -**
Subtotal				**$ 1,316,000**	**$ 1,316,000**	**$ -**
Design (7.2%)				$ 95,000	$ 95,000	**$ -**
Construction Administration (2%)				$ 27,000	$ 27,000	**$ -**
Contingency (20%)				$ 264,000	$ 264,000	**$ -**
Total				**$ 1,702,000**	**$ 1,702,000**	**$ -**
Phase 1 Capital Cost Present Value				**$ 1,702,000**	**$ 1,702,000**	**$ -**

Capital Costs, Alternative 3, Phase 2

Construct Martina Oscar Loop C Extension

Item Description	Quantity	Unit	Unit Price	Total Cost	Water	Sewer
Install New 8x18 HDPE Arctic Water Main	2100	LF	$ 250	$ 525,000	$ 525,000	$ -
Install 8x18 Arctic Gravity Sewer Main	2100	LF	$ 250	$ 525,000	$ -	$ 525,000
Water & Sewer Services, Construct New (dual)	25	EA	$ 20,000	$ 500,000	$ 250,000	$ 250,000
Steel Piles & Pipe Supports	310	EA	$ 3,000	$ 930,000	$ 465,000	$ 465,000
Submersible Heat Trace System	1,250	LF	$ 12	$ 15,000	$ -	$ 15,000
Electrical Service & Controls	25	EA	$ 1,200	$ 30,000	$ -	$ 30,000
Cased Driveway Crossing	3	EA	$ 7,000	$ 21,000	$ 10,500	$ 10,500
Cased Street Crossing, New	1	EA	$ 10,000	$ 10,000	$ 5,000	$ 5,000
Easement Obstruction Clearance	10	EA	$ 5,000	$ 50,000	$ 25,000	$ 25,000
Temporary Water & Sewer Service	25	EA	$ 6,000	$ 150,000	$ 75,000	$ 75,000
Hydrants, Furnish & Install New	10	EA	$ 10,000	$ 100,000	$ 100,000	$ -
Sub-total of Construction Costs				**$ 2,856,000**	**$ 1,455,500**	**$ 1,400,500**
Mobilization/Demobilization (7.5% of Subtotal)				$ 214,200	$ 109,163	$ 105,038
Taxes, Bonds, Insurance (5% of Subtotal)				$ 142,800	$ 72,775	$ 70,025
Traffic Control and Public Relations (3% of Subtotal)				$ 85,680	$ 43,665	$ 42,015
Construction Surveying (3% of Subtotal)				$ 85,680	$ 43,665	$ 42,015
Preparation of SWPPP				$ 20,000	$ 10,000	$ 10,000
Subtotal				**$ 3,404,360**	**$ 1,734,768**	**$ 1,669,593**
Design (6.5%)				$ 221,283	$ 112,760	$ 108,524
Construction Administration (2%)				$ 68,087	$ 34,695	$ 33,392
Contingency (20%)				$ 680,872	$ 346,954	$ 333,919
Total				**$ 4,375,000**	**$ 2,230,000**	**$ 2,145,000**
Phase 2 Capital Cost Present Value				**$ 4,375,000**	**$ 2,230,000**	**$ 2,145,000**

Capital Costs, Alternative 3, Phase 3

Perform Spot Repair

Item Description	Quantity	Unit	Unit Price	Total Cost	Water	Sewer
Remove & Replace Existing Water & Sewer Service Connection	35	EA	$ 25,000	$ 875,000	$ 437,500	$ 437,500
Remove Arctic Water Main	1,300	LF	$ 50	$ 65,000	$ 65,000	$ -
Remove Arctic Gravity Sewer Main	3,600	LF	$ 50	$ 180,000	$ -	$ 180,000
Install New 6x15 HDPE Arctic Water Main	1,300	LF	$ 225	$ 293,000	$ 293,000	$ -
Install New 8x18 HDPE Arctic Gravity Sewer Main	3,600	LF	$ 250	$ 900,000	$ -	$ 900,000
Steel Piles & Pipe Supports	180	EA	$ 3,000	$ 540,000	$ 270,000	$ 270,000
Submersible Heat Trace System	5,350	LF	$ 12	$ 65,000	$ -	$ 65,000
Electrical Service & Controls	40	EA	$ 1,200	$ 48,000	$ -	$ 48,000
Cased Street Crossing, Remove & Replace	7	EA	$ 10,000	$ 70,000	$ 35,000	$ 35,000
Cased Driveway Crossing	7	EA	$ 4,000	$ 28,000	$ 14,000	$ 14,000
Temporary Water & Sewer Service	35	EA	$ 6,000	$ 210,000	$ 105,000	$ 105,000
			Sub-total of Construction Costs	**$ 3,274,000**	**$ 1,219,500**	**$ 2,054,500**
			Mobilization/Demobilization (7.5% of Subtotal)	$ 245,550	$ 91,463	$ 154,088
			Taxes, Bonds, Insurance (5% of Subtotal)	$ 163,700	$ 60,975	$ 102,725
			Traffic Control and Public Relations (1% of Subtotal)	$ 32,740	$ 12,195	$ 20,545
			Construction Surveying (3% of Subtotal)	$ 98,220	$ 36,585	$ 61,635
			Preparation of SWPPP	$ 20,000	$ 10,000	$ 10,000
			Subtotal	**$ 3,834,210**	**$ 1,430,718**	**$ 2,403,493**
			Design (6.5%)	$ 249,224	$ 92,997	$ 156,227
			Construction Administration (2%)	$ 76,684	$ 28,614	$ 48,070
			Contingency (20%)	$ 766,842	$ 286,144	$ 480,699
			Total	**$ 4,927,000**	**$ 1,839,000**	**$ 3,088,000**
			Phase 3 Capital Cost Present Value	**$ 4,927,000**	**$ 1,839,000**	**$ 3,088,000**

5.3 Annual Operation Budget

5.3.1 Income

Residents of Bethel Heights on the haul system will see a decrease in their water and sewer bills as they transition to piped service. The average size of the residential water and sewer tanks in the haul system is approximately 1,000 gallons, which are filled and emptied an average of once per week. According to the 2018 haul utility rate schedule, a haul service consumer located in either Zone 1 or Zone 2 with those tank sizes and refill/empty frequency will pay $221.38 per month for water haul service and $165.91 for sewer haul service, which results in a total expenditure of $387.29 per month.

Transitioning to a piped system will result in less water and sewer revenue for the City but would result in a calculated O&M cost reduction of $267,724.

In 2017 the City passed an ordinance that modified the utility rate code 13.16.070 to allow the City Council to raise all utility rates 3% per year, until the water and sewer systems operate profitably. For the purposes of this PER, we assume the City will continue to raise rates by 3% for the planning period. Table 25 shows the projected revenue.

Table 25: Anticipated Water and Sewer Revenue from Bethel Heights

Alternative 3A Phased Approach		
Service	Monthly Cost	Projected Yearly Revenue
Piped Water	$ 176.11	$ 707,962
Piped Sewer	$ 49.86	$ 200,437
	Total	$ 908,399

5.3.2 Debt Repayments

The City is considering taking on new debt for development of the Bethel Avenues Piped Water and Sewer project. At the time of this report the City has not yet committed to the project. The City needs to be able to service its potential Avenues Project and any existing debt while/if taking on additional debt for the Bethel Heights project.

5.3.3 Short Lived Assets

The City must continue to plan for R&R of all water and sewer short lived assets. The City needs to continually contribute to an R&R account to plan for these eventualities. Table 26 and Table 27 list all short-lived assets that need to be planned.

Table 26: Water Short Lived Assets

Asset	Type/Size	Replacement Cost	Total Number	Total Value	Annual Reserve
5 Year Replacements					
Water Department Computers	Generic	$2,500	2	$5,000	$1,000
Copiers, Printers	Generic	$3,000	2	$6,000	$1,200
City Sub Computer and Monitoring		$3,600	1	$3,600	$720
Bethel Heights Computer and Monitoring		$2,500	1	$2,500	$500
Lab Equipment	Hach	$6,300	2	$12,600	$2,520
		5 Year Replace Budget		**$29,700**	**$5,940**
10 Year Replacements					
City Sub Circulation Pumps	5hp	$4,000	4	$16,000	$1,600
City Sub Pressure Pumps	7.5hp	$4,000	4	$16,000	$1,600
Bethel Heights Circulation Pumps	5hp	$4,000	4	$16,000	$1,600
Bethel Heights Pressure Pumps	7.5hp	$4,000	4	$16,000	$1,600
High Demand Fire Pumps	125hp	$70,000	2	$140,000	$14,000
Water Department Truck	Ford	$25,000	1	$25,000	$2,500
Water System Meter		$3,000	60	$180,000	$18,000
Air Release Valves		$2,500	120	$300,000	$30,000
		10 Year Replace Budget		**$709,000**	**$70,900**
15 Year Replacements					
Water Haul Trucks	Kenworth	$200,000	9	$1,800,000	$126,000
Glycol Heat Exchangers		$25,000	2	$50,000	$3,500
Bethel Heights Boilers	250,000BTU	$140,000	2	$280,000	$19,600
City Sub Boilers	250,000BTU	$140,000	2	$280,000	$19,600
Water System Controls	Municipal	$100,000	2	$200,000	$14,000
Well Submersible Pumps	40hp	$40,000	3	$120,000	$8,400
Hydrants	Mueller	$8,000	80	$640,000	$44,800
		15 Year Replace Budget		**$3,370,000**	**$235,900**
		Annual Contribution to R&R Account			**$312,740**

Table 27: Sewer Short Lived Assets

Asset	Type/Size	Replacement Cost	Total Number	Total Value	Annual Reserve
5 Year Replacements					
Lift Station Submersible Pumps	2hp	$2,500	78	$195,000	$39,000
Lift Station Submersible Pumps	3hp	$3,000	6	$18,000	$3,600
Lift Station Submersible Pumps	4hp	$3,600	4	$14,400	$2,880
Lift Station Submersible Pumps	8.5hp	$60,000	3	$180,000	$36,000
Lift Station Submersible Pumps	5hp	$9,000	3	$27,000	$5,400
Lift Station Submersible Pumps	14hp	$75,000	3	$225,000	$45,000
Lagoon Pump	5 MGD	$75,000	1	$75,000	$15,000
Public Works Computers		$2,000	2	$4,000	$800
Public Works Copiers, Printers		$1,000	1	$1,000	$200
		Total 5 Year Replacement Budget		**$739,400**	**$147,880**
10 Year Replacements					
Lift Station Submersible Controls	Residential	$800	78	$62,400	$6,240
Lift Station Submersible Pumps	2hp	$2,500	78	$195,000	$19,500
Sewer Line Truck	Ford	$25,000	1	$25,000	$2,500
Glycol loop heat pumps	Various	$10,000	6	$60,000	$6,000
		Total 10 Year Replacement Budget		**$342,400**	**$34,240**
15 Year Replacements					
Sewage Haul Trucks	Kenworth	$200,000	9	$1,800,000	$126,000
Lift Station Rails, Valves	Municipal	$15,000	8	$120,000	$8,400
Lagoon Divider	Curtain	$250,000	2	$500,000	$35,000
Lagoon Motor Boat	Generic	$10,000	1	$10,000	$700
Lift station Controls	Municipal	$60,000	8	$480,000	$33,600
		Total 15 Year Replacement Budget		**$2,910,000**	**$203,700**
		Total Contribution to R&R Account			**$385,820**

6.0 CONCLUSION

The preferred approach is to implement phased improvements to the existing piped network in the following order:

Phase 1: Construction of the Loop C trunk line from the BHWTP, install Loop C circulation terminal in the WTP, and split Loop A into Loop C,

Phase 2: Construct Loop C water extension in the Martina Oscar subdivision, construct 25 water and sewer services, and extend gravity sewer main to serve the additional residences,

Phase 3: Perform spot repair on the identified problem areas.

This recommended approach is in line with the City's long-term priorities and provide resiliency for the aging system without replacing the entire system.

As a separate, stand-alone recommendation, DOWL also recommends the City solicit funding for a physical conditions assessment of the piped water and sewer network in Bethel Heights. This assessment is recommended to be completed in conjunction with implementation of Phase 1 or 2 of Alternative 3A. This assessment would provide the City with an intimate knowledge of the asset conditions and afford a more surgical approach to spot repairs of Phase 3.

7.0 REFERENCES

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APPENDICES

APPENDIX 1: ALTERNATIVES MEMO

DRAFT MEMORANDUM

TO:	Peter Williams, City of Bethel Katie Winter, Village Safe Water
FROM:	Chase Nelson, P.E., DOWL
DATE:	March 25th, 2018
SUBJECT:	Bethel Heights Draft PER/EA Water and Sewer Main Preliminary Alternatives

The purpose and need of this project is to improve the existing piped water and sewer system in the Bethel Heights (BH) neighborhood and to provide piped service to the residents and businesses currently on hauled water and sewer in the Martina Oscar subdivision. The piped water and sewer system in the Bethel Heights Piped Water Supply (BHPWS) is at or near the end of its useful life, and growing portions of the system have degraded to the point the City is considering systematic rehabilitation and improvement options. Preliminary alternatives have been prepared for multiple water and sewer improvements to address the purpose and need. We have also considered how these alternatives would impact one of the City's long-term priorities; to bring more of the community onto the piped network. Special attention has been placed on the alternative's build-out potential to provide piped service to unconnected residents and businesses in neighboring Tundra Ridge and Uiviq subdivisions.

Preliminary analysis on five action alternatives and one no-action alternative have been performed. The narrative descriptions provided are followed by figures and conceptual level cost estimates. The alternatives presented are as follows:

Alternative 1 – No Action
Alternative 2 – Repair-In-Place
Alternative 3 – Construct Loop C, Extend Sewer, and Perform Spot Repair
Alternative 4 – Full System Replacement with Loop C Extension
Alternative 5 – Water and Sewer Main Replacement with Loop C Extension
Alternative 6 – Perform Spot Repair

Alternative 1 – No Action

In the no-action alternative, the City would continue to use the existing piped water and sewer system in Bethel Heights and provide hauled service to the residents and businesses not currently served by water and sewer pipes. It is assumed that the piped system would be operated as-is until the cost of O&M surpassed the cost of reverting and operating the entire BH subdivision on hauled service.

The City would continue to dispatch crews to thaw frozen pipes, to repair leaking pipe and replace system components such as hydrants, valves, and services on an as-needed or emergency basis. The City would continue to replace water and sewer haul trucks every fifteen years and continue to deliver water and sewer as they currently do. This alternative would result in minimal change to operations and practice for the near-term future. However, it would not address the issue of pipe settlement, pipe corrosion and coating degradation, high O&M costs of the neighborhood, and declining water quality. Capital costs associated with the no-build option include the purchase of two new water haul trucks to continue hauled service to Martina Oscar Subdivision.

Advantages of Alternative 1:

- Lowest capital cost of alternatives considered.

Disadvantages of Alternative 1:

- Risk of water main failure and impact to residents on entire loop (all or nothing nature of the looped system),
- Risk of sewer main failure and impact to upstream residents,
- Ongoing high operational costs of truck haul service to unconnected residents,
- Ongoing and increasing maintenance cost of 40+ year old piped system with frequent breakdowns, freezing pipe, and leak related issues.

Alternative 2 – Repair-In-Place

This alternative considers Cured-In-Place Pipe (CIPP) lining of the entire BHPWS pipe network and includes lining 28,000 LF of 6-inch sewer main, approximately 310 sewer service lines, and 30,500 LF of 6-inch water main and replacement of 310 water service connections. Electrical heat trace would be installed in the service lines and problem areas of the water/sewer mains. Heat trace wire could either be submerged in the pipe flow or laminated into the pipe lining during rehabilitation. This systematic rehabilitation could extend the useful life of the water mains by up to 40 years, and the sewer mains by up to 30 years depending on the condition of the insulation. Valves, hydrants, cleanouts, and other appurtenances would require replacement at various intervals to match the useful life of the rehabilitated pipe. Replacement of these appurtenances on a system-wide basis at the time of pipe rehabilitation is included in the alternative. Although this alternative is very costly up front, it would reduce the O&M cost to the City for the useful life of the piped system.

Advantages of Alternative 2:

- Re-uses existing pipe system and minimizes material waste,
- Reliably extends the useful life of existing system,
- Would result in improved water quality.

Disadvantages of Alternative 2:

- Does not serve the unconnected users in Martina Oscar subdivision or provide additional capacity for Tundra Ridge and Uiviq subdivisions future connection,
- Slightly reduces the pipe capacity by decreasing the internal diameter.
- Third highest capital cost of alternatives considered,
- Multiple-year construction timeframe,
- Costly and disruptive temporary water service and bypass sewer operations.

Alternative 3 – Construct Loop C Water Main, Extend Sewer, and Perform Spot Repair

This alternative considers construction of the previously studied Loop C extension (Larsen Consulting Group, 2012) which brings piped water and sewer to the approximately twenty-five additional properties within Bethel Heights currently served by truck-haul service, referred to as the Martina Oscar subdivision. These properties are located on Akula Court, Manignaq, and Ptarmigan Street. Construction of Loop C water main as described in the LCG report would split the existing Loop A just south of the junction of Akakeek Street and Delapp Drive near the boardwalk and extend separate source and return lines to the Bethel Heights Water Treatment Plant (BHWTP). This extension would reduce the length of the existing 20,700 linear feet (LF) Loop A by 9,300 LF, and create an independent Loop C, allowing all three loops to operate in a

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lower and more efficient pressure range. From the prior studies and hydraulic modeling done as part of the LCG PER it was recommended to install HDPE pipe in the new Loop C water main construction to contribute to a reduction in friction head losses and contribute to an overall reduction in operating cost of the circulation pumps.

Spot repair performed on the existing problem areas would focus on reducing the causes of frequent pipe freeze ups, leaks, and settling pipe supports. The freeze problem is common in the sewer service lines and mains and appears to be correlated with areas of settled pipe supports and sagging pipes which no longer maintain a consistently positive drainage grade. The suggested repairs include replacement of the sewer main and service line segments and installation of additional pile supports to prevent future low spots in the pipe. Electrical heat trace would be installed in the service lines and water/sewer mains either submerged in the carrier pipes or built into the new pipe insulation during manufacture. Problem areas indicated by the City include an estimated 35 sewer service lines, and 4,400 LF of sewer main which would be replaced. Combined water and sewer service lines would be used in this alternative to reduce the amount of arctic pipe materials, heat trace footage, and to reduce the amount of pipe space required at each residence.

Advantages of Alternative 3:

- Converts up to 25 hauled services to the piped network,
- Reduces O&M cost by eliminating hauled services in subdivision,
- Lowest capital cost of the alternatives which serve the Martina Oscar subdivision,
- Would include future capacity to connect Tundra Ridge and Uiviq subdivisions,
- Potentially constructed in a single construction season,
- Reduces high operating pressure of Loop A,
- Enhances flow balance between the circulation loops,
- Improves resiliency by breaking the project area into three independent water main loops.

Disadvantages of Alternative 3:

- Does not address the non-repair area pipes and services,
- Creates a patchwork of varying age system components,
- Disruptive temporary water service and bypass sewer operations.

Alternative 4 – Full System Replacement with Loop C Extension

This alternative considers full replacement of the existing piped water and sewer infrastructure in the project area as a single phased project over multiple construction seasons and includes demolition and replacement of both the existing water and sewer mains, services, and appurtenances as well as construction of the Loop C extension for the 25 services on hauled-water in the Martina Oscar subdivision. Electrical heat trace would be installed in the service lines and new water/sewer mains outfitted with glycol heated circulation lines. Replacing the existing steel pipe with HDPE arctic pipe would require installing additional pipe supports to provide 10 feet spacing to prevent pipe sagging as recommended by the manufacturer. The capital cost of this total-replacement is the highest of the alternatives but would provide an opportunity to improve the system design, reduce O&M costs, and provide build out potential to serve the Uiviq and Tundra Ridge subdivisions. It would also reduce the space requirements of the pipe network by combining water and sewer service lines into a single arctic pipe and eliminate the patchwork of varying age components and segments of the system.

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Advantages of Alternative 4:

- System-wide replacement resulting in lowest O&M cost of the alternatives,
- Would result in improved water quality and reliability for residents,
- Would result in fewer pipe freeze ups, leaks, and O&M effort,
- Enhances flow balance between the circulation loops,
- Improves resiliency by breaking the project area into three independent water main loops.

Disadvantages of Alternative 4:

- Highest capital cost of alternatives,
- Multiple-year construction timeframe,
- Very disruptive and costly temporary water service and bypass sewer operations,
- Decommissions the existing pipe network which may have useful life remaining.

Alternative 5 – Water and Sewer Main Replacement with Loop C Extension

This alternative considers full replacement of the existing piped water and sewer mains in the project area as a single phased project and construction of Loop C extension. This alternative does not consider replacement of the existing service lines. Otherwise, this alternative would represent the same work on the water and sewer mains and appurtenances, including additional pipe supports, environmental Impacts, land requirements, and sustainability considerations as Alterative 4.

Advantages of Alternative 5:

- Nearly a system-wide replacement resulting in lowered O&M cost,
- Would result in improved water quality and reliability for residents,
- Would result in fewer pipe freeze ups, leaks, and O&M effort,
- Enhances flow balance between the circulation loops,
- Improves resiliency by breaking the project area into three independent water main loops.

Disadvantages of Alternative 5:

- Second highest capital cost of alternatives,
- Multiple-year construction timeframe,
- Very disruptive and costly temporary water service and bypass sewer operations,
- Does not directly address service line freeze up issues,
- Decommissions the existing pipe network which may have useful life remaining.

Alternative 6 – Perform Spot Repair

This alternative focuses on the repair portion of Alternative 3 and focuses on reducing the causes of frequent pipe freeze up. The freeze problem is common in the sewer service lines and mains and appears to be correlated with areas of settled pipe supports and sagging pipes which no longer maintain a positive drainage grade. The suggested repairs include replacement of the sewer main and service line segments and installation additional pile supports to prevent future low spots in the pipe. Based on problem areas indicated by the City, an estimated 35 sewer service lines, and 4,400 LF of sewer main would be replaced. Electrical heat trace would be installed in the service lines and water/sewer mains either submerged in the carrier pipe or built into the new pipe insulation during the pipe manufacture. Combined water and sewer

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service lines would be used in this alternative to reduce the amount of arctic pipe materials, heat trace footage, and to reduce the amount of pipe space required at each residence. Containing both water and sewer lines in a single insulated pipe with the heat trace element would contribute to energy savings during the freezing months.

Advantages of Alternative 6:

- Lowest capital cost of all the “build” alternatives,
- Addresses the immediate water/sewer main and service line freeze up issue,
- Minimizes the temporary water service effort.

Disadvantages of Alternative 6:

- Does not provide piped water and sewer to the 25 services in the Martina Oscar subdivision, high O&M costs remain,
- Does not expand the system capacity for future connection of Tundra Ridge and Uiviq subdivisions,
- Highest O&M cost of all the “build” alternatives.

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APPENDIX 2: COST ESTIMATE CALCULATIONS

Project: City of Bethel Heights Neighborhood Water and Sewer Improvements

Alternatives Analysis

Factors Used In Calculation

Life Cycle	1	2	22	23	24	25
Interest Rate[1]	1.30%	1.30%	1.50%	1.50%	1.50%	1.50%
Hauled Services	25	25	25	25	25	25
Piped Services	310					

[1]Real Interest Rate, OMB Circular A-94 Appendix C, 3-Year=1.3%, 5-Year=1.3%, 10-Year=1.4%, 20-Year=1.5%, 30-Year=1.5%

Capital Costs for Truck Purchase, Alternative 1

Alternative 1: No-Build

Item	Quantity	Unit Type	Unit Price	Total Cost	Present Value
New Water/Sewer Haul Truck	2	EA[1]	$ 250,000	$ 500,000	$ 500,000
New Water/Sewer Haul Truck	2	EA[2]	$ 250,000	$ 500,000	$ 411,935
			Total Capital Costs	$ 1,000,000	
			Salvage Value @ Year 15		$ 84,000
			PW Salvage @ Year 15		$ 69,205
			Salvage Value @ Year 25		$ 222,666
			PW Salvage @ Year 25		$ 195,686
			PW Total Salvage Value		$ 264,891
			Present Value of Capital Cost		$ 736,000

[1]Two trucks procured at year 1

[2]Two replacement trucks procured at year 15

O&M Costs, Alternative 1

Alternative 1: No Build

Item	Quantity	Type	Unit Price	Total Annual Cost	USPW[4]
Hauled Water Costs[1]	2,326,875	Gallons	$ 62.04	$ 144,359	$ 2,991,069
Hauled Sewer Costs[1]	2,326,875	Gallons	$ 64.05	$ 149,036	$ 3,087,975
Piped Water Costs[2]	33,945,000	Gallons	$ 26.18	$ 888,680	$ 18,413,106
Piped Sewer Costs[2]	33,945,000	Gallons	$ 9.52	$ 323,156	$ 6,695,675
Piped Water & Sewer System Repairs[3]	1	EA	$ 70,000.00	$ 70,000	$ 1,450,373
			Total Annual O&M Cost	$1,575,232	
			Total Present Value of O&M Costs		$ 32,639,000
			Alternative 1 Net Present Value		**$ 33,375,000**

[1]Assumes 85 gallons per person per day for Hauled System, 3 people per service, 365 days per year

[2]Assuming 100 gallons per person per day for Piped System, 3 people per service

[3]Total annual repair project costs from City Budget Records for FY2017, 2018, 2019 ($210,000 for FY2019 spread over 3 years)

[4]Uniform Series Present Worth

Capital Costs, Alternative 2						
Alternative 2: Repair-In-Place						
Item	Quantity	Unit	Unit Price*	Total Cost*	Water	Sewer
Existing 8" Sewer Main - CIPP Lining	28,000	LF	$ 233	$ 6,524,000		$ 6,524,000
Existing 4" Sewer Service Line - CIPP Lining	310	EA	$ 11,650	$ 3,612,000		$ 3,612,000
Existing 6" Water Main - CIPP Lining	31,200	LF	$ 190	$ 5,928,000	$ 5,928,000	
Pit Orifice Pair, Remove & Replace	310	EA	$ 500	$ 155,000	$ 155,000	
Hydrant, Remove & Replace	38	EA	$ 10,000	$ 380,000	$ 380,000	
Valves and Appurtenances, Remove & Replace	1	LS	$ 100,000	$ 100,000	$ 100,000	
HDPE Service Line Rehabilitation	310	EA	$ 1,800	$ 558,000	$ 558,000	
Submersible Heat Trace System	19,100	LF	$ 12	$ 230,000		$ 230,000
Electrical Services & Controls	316	EA	$ 1,200	$ 380,000		$ 380,000
Steel Piles & Pipe Supports	1,020	EA	$ 3,000	$ 3,060,000	$ 1,530,000	$ 1,530,000
Cased Street Crossing, Remove & Replace	26	EA	$ 14,000	$ 364,000	$ 182,000	$ 182,000
Easement Obstruction Clearance	10	EA	$ 5,000	$ 50,000	$ 25,000	$ 25,000
Temporary Water and Sewer Service	310	EA	$ 6,000	$ 1,860,000	$ 930,000	$ 930,000
			Sub-total of Construction Costs	**$ 23,201,000**	**9,788,000**	**13,413,000**
			Mobilization/Demobilization (7.5% of Subtotal)	$ 1,741,000	$ 735,000	$ 1,006,000
			Taxes, Bonds, Insurance (5% of Subtotal)	$ 1,161,000	$ 490,000	$ 671,000
			Traffic Control and Public Relations (0.5% of Subtotal)	$ 117,000	$ 49,000	$ 68,000
			Construction Surveying (0.5% of Subtotal)	$ 117,000	$ 49,000	$ 68,000
			Preparation of SWPPP	$ 50,000	$ 25,000	$ 25,000
			Subtotal	**$ 26,387,000**	**$ 11,136,000**	**$ 15,251,000**
			Design (5%)	$ 1,319,350	$ 556,800	$ 762,550
			Construction Administration (2%)	$ 527,740	$ 222,720	$ 305,020
			Contingency (20%)	$ 5,277,400	$ 2,227,200	$ 3,050,200
			Total	**$ 33,512,000**	**$ 14,143,000**	**$ 19,369,000**
			Total Present Value of Capital Costs	**$ 33,512,000**	**$ 14,143,000**	**$ 19,369,000**

*Unit price based on American Iron and Steel requirements that all iron and steel products used in the project to be produced in the United States.

O&M Costs, Alternative 2					
Alternative 2: Repair-In-Place					
Item	Quantity	Type	Unit Price*	Total Annual Cost	USPW
Hauled Water Costs[1]	2,326,875	Gallons	$ 62.04	$ 144,359	$ 2,991,069
Hauled Sewer Costs[1]	2,326,875	Gallons	$ 64.05	$ 149,036	$ 3,087,975
Piped Water Costs (Year 1 and 2)[2]	33,945,000	Gallons	$ 26.18	$ 888,680	$ 1,743,293
Piped Water Cost (Year 3-25)[2]	36,682,500	Gallons	$ 26.18	$ 960,348	$ 18,564,351
Piped Sewer Costs (Year 1 and 2)[2]	33,945,000	Gallons	$ 9.52	$ 323,156	$ 633,925
Piped Sewer Costs (Year 3-25)[2]	36,682,500	Gallons	$ 9.52	$ 349,217	$ 6,750,673
Heat Trace Electrical Costs (Year 1)[3]	9,550	LF	$ 5.18	$ 49,507	$ 48,872
Heat Trace Electrical Costs (Year 2-25)[3]	19,100	LF	$ 5.18	$ 99,014	$ 1,983,299
Piped Water System Repairs[4]	1	Repair Per Year	$ 8,000.00	$ 8,000	$ 165,757
			Annual O&M Cost Years 1-2	$ 1,513,232	
			Annual O&M Cost Year 3-25	$ 1,367,072	
			Total Present Value of O&M Costs		$ 35,970,000
			Alternative 2 Net Present Value		**$ 69,482,000**

[1]Assumes 85 gallons per person per day for Hauled System, 3 people per service, 365 days per year

[2]Assuming 100 gallons per person per day for Piped System, 3 people per service

[3]Electrical unit price based on 5 watt/ft heat trace, $0.18/kWh, 240 days of use per year

[4]Total annual repair project costs for minor repairs for life of CIPP system

Capital Costs, Alternative 3, Single-Phase Approach

Construct Loop C Water & Sewer, Perform Spot Repair

Item Description	Quantity	Unit	Unit Price*	Total Cost*	Water	Sewer
Remove & Replace Existing Water & Sewer Service Connection	35	EA	$ 25,000	$ 875,000	$ 437,500	$ 437,500
Water & Sewer Dual Services Lines, Construct New	25	EA	$ 20,000	$ 500,000	$ 250,000	$ 250,000
Remove Existing Water Main	1,300	LF	$ 50	$ 65,000	$ 65,000	
Remove Existing Gravity Sewer Main	3,600	LF	$ 50	$ 180,000		$ 180,000
Install New 6x15 HDPE Arctic Water Main	2,600	LF	$ 225	$ 585,000	$ 585,000	
Install New 8x18 HDPE Arctic Water Main	3,400	LF	$ 250	$ 850,000	$ 850,000	
Install New 8x18 Arctic Gravity Sewer Main	5,700	LF	$ 250	$ 1,425,000		$ 1,425,000
Steel Piles & Pipe Supports	555	EA	$ 3,000	$ 1,665,000	$ 832,500	$ 832,500
Submersible Heat Trace System	6,600	LF	$ 12	$ 80,000		$ 80,000
Electical Service & Controls	65	EA	$ 1,200	$ 78,000		$ 78,000
Cased Street Crossing	7	EA	$ 10,000	$ 70,000	$ 35,000	$ 35,000
Cased Driveway Crossing	7	EA	$ 4,000	$ 28,000	$ 14,000	$ 14,000
Hydrants, Furnish & Install New	10	EA	$ 10,000	$ 100,000	$ 100,000	
Easement Obstruction Clearance	10	EA	$ 5,000	$ 50,000	$ 25,000	$ 25,000
Loop C Circulation Pump and Appurtenances	1	EA	$ 200,000	$ 200,000	$ 200,000	
Temporary Water & Sewer Service	35	EA	$ 6,000	$ 210,000	$ 105,000	$ 105,000
			Sub-total of Construction Costs	**$ 6,961,000**	**$ 3,499,000**	**$ 3,462,000**
			Mobilization/Demobilization (7.5% of Subtotal)	$ 522,075	$ 262,425	$ 259,650
			Taxes, Bonds, Insurance (5% of Subtotal)	$ 348,050	$ 174,950	$ 173,100
			Traffic Control and Public Relations (0.5% of Subtotal)	$ 34,805	$ 17,495	$ 17,310
			Construction Surveying (1% of Subtotal)	$ 69,610	$ 34,990	$ 34,620
			Preparation of SWPPP	$ 50,000	$ 25,000	$ 25,000
			Subtotal	**$ 7,985,540**	**$ 4,013,860**	**$ 3,971,680**
			Design (5%)	$ 399,277	$ 200,693	$ 198,584
			Construction Administration (2%)	$ 159,711	$ 80,277	$ 79,434
			Contingency (20%)	$ 1,597,108	$ 802,772	$ 794,336
			Total	**$ 10,142,000**	**$ 5,098,000**	**$ 5,044,000**
			Phase 1 Capital Cost Present Value	**$ 10,142,000**	**$ 5,098,000**	**$ 5,044,000**

*Unit price based on American Iron and Steel requirements that all iron and steel products used in the project to be produced in the United States.

O&M Costs, Alternative 3, Single-Phase Approach

Construct Loop C Water & Sewer, Perform Spot Repair

Item	Quantity	Type	Unit Price	Total Annual Cost	USPW
Piped Water Costs[1]	36,682,500	Gallons	$ 26.18	$ 960,348	$ 19,898,034
Piped Sewer Costs[1]	36,682,500	Gallons	$ 9.52	$ 349,217	$ 7,235,649
Heat Trace Electrical Costs[5]	6,600	LF	$ 5.18	$ 34,214	$ 708,909
Piped Water & Sewer System Repairs[3]	1	EA	$ 70,000.00	$ 70,000	$ 1,450,373
			Total Annual O&M Cost	$1,413,780	
				Total Present Value of O&M Costs	$ 29,293,000
				Alternative 3 Net Present Value	**$ 39,435,000**

[1]Assuming 115 gallons per person per day, 3.65 people per service

[2]Electrical unit price based on 5 watt/ft heat trace, $0.18/kWh, 240 days of use per year

[3]Total annual repair project costs from City Budget Records for FY2017, 2018, 2019

Capital Costs, Alternative 3A, Phase 1						
Construct Loop C Water Treatment Plant Extension						
Item Description	**Quantity**	**Unit**	**Unit Price***	**Total Cost***	**Water**	**Sewer**
Install New 6x15 HDPE Arctic Water Main	1,300	LF	$ 225	$ 293,000	$ 293,000	$ -
Install 8x18 HDPE Arctic Water Main	1,300	LF	$ 250	$ 325,000	$ 325,000	$ -
Steel Piles & Pipe Supports	65	EA	$ 3,000	$ 195,000	$ 195,000	$ -
Loop C Circulation Pump and Appurtenances	1	EA	$ 200,000	$ 200,000	$ 200,000	$ -
Cased Street Crossing	2	EA	$ 10,000	$ 20,000	$ 20,000	$ -
Hydrants, Furnish & Install New	3	EA	$ 10,000	$ 30,000	$ 30,000	$ -
Loop C Junction Valves and Fittings	1	LS	$ 30,000	$ 30,000	$ 30,000	$ -
			Sub-total of Construction Costs	**$ 1,093,000**	**$ 1,093,000**	**$ -**
			Mobilization/Demobilization (7.5% of Subtotal)	$ 82,000	$ 82,000	$ -
			Taxes, Bonds, Insurance (5% of Subtotal)	$ 55,000	$ 55,000	$ -
			Traffic Control and Public Relations (3% of Subtotal)	$ 33,000	$ 33,000	$ -
			Construction Surveying (3% of Subtotal)	$ 33,000	$ 33,000	$ -
			Preparation of SWPPP	$ 20,000	$ 20,000	$ -
			Subtotal	**$ 1,316,000**	**$ 1,316,000**	**$ -**
			Design (7.2%)	$ 95,000	$ 95,000	$ -
			Construction Administration (2%)	$ 27,000	$ 27,000	$ -
			Contingency (20%)	$ 264,000	$ 264,000	$ -
			Total	**$ 1,702,000**	**$ 1,702,000**	**$ -**
			Phase 1 Capital Cost Present Value	**$ 1,702,000**	**$ 1,702,000**	**$ -**

*Unit price based on American Iron and Steel requirements that all iron and steel products used in the project to be produced in the United States.

Capital Costs, Alternative 3A, Phase 2						
Construct Martina Oscar Loop C Extension						
Item Description	**Quantity**	**Unit**	**Unit Price***	**Total Cost***	**Water**	**Sewer**
Install New 8x18 HDPE Arctic Water Main	2100	LF	$ 250	$ 525,000	$ 525,000	$ -
Install 8x18 Arctic Gravity Sewer Main	2100	LF	$ 250	$ 525,000	$ -	$ 525,000
Water & Sewer Services, Construct New (dual)	25	EA	$ 20,000	$ 500,000	$ 250,000	$ 250,000
Steel Piles & Pipe Supports	310	EA	$ 3,000	$ 930,000	$ 465,000	$ 465,000
Submersible Heat Trace System	1,250	LF	$ 12	$ 15,000	$ -	$ 15,000
Electical Service & Controls	25	EA	$ 1,200	$ 30,000	$ -	$ 30,000
Cased Driveway Crossing	3	EA	$ 7,000	$ 21,000	$ 10,500	$ 10,500
Cased Street Crossing, New	1	EA	$ 10,000	$ 10,000	$ 5,000	$ 5,000
Easement Obstruction Clearance	10	EA	$ 5,000	$ 50,000	$ 25,000	$ 25,000
Temporary Water & Sewer Service	25	EA	$ 6,000	$ 150,000	$ 75,000	$ 75,000
Hydrants, Furnish & Install New	10	EA	$ 10,000	$ 100,000	$ 100,000	$ -
			Sub-total of Construction Costs	**$ 2,856,000**	**$ 1,455,500**	**$ 1,400,500**
			Mobilization/Demobilization (7.5% of Subtotal)	$ 214,200	$ 109,163	$ 105,038
			Taxes, Bonds, Insurance (5% of Subtotal)	$ 142,800	$ 72,775	$ 70,025
			Traffic Control and Public Relations (3% of Subtotal)	$ 85,680	$ 43,665	$ 42,015
			Construction Surveying (3% of Subtotal)	$ 85,680	$ 43,665	$ 42,015
			Preparation of SWPPP	$ 20,000	$ 10,000	$ 10,000
			Subtotal	**$ 3,404,360**	**$ 1,734,768**	**$ 1,669,593**
			Design (6.5%)	$ 221,283	$ 112,760	$ 108,524
			Construction Administration (2%)	$ 68,087	$ 34,695	$ 33,392
			Contingency (20%)	$ 680,872	$ 346,954	$ 333,919
			Total	**$ 4,375,000**	**$ 2,230,000**	**$ 2,145,000**
			Phase 2 Capital Cost Present Value	**$ 4,375,000**	**$ 2,230,000**	**$ 2,145,000**

*Unit price based on American Iron and Steel requirements that all iron and steel products used in the project to be produced in the United States.

Capital Costs, Alternative 3A, Phase 3						
Perform Spot Repair						
Item Description	**Quantity**	**Unit**	**Unit Price***	**Total Cost***	**Water**	**Sewer**
Remove & Replace Existing Water & Sewer Service Connection	35	EA	$ 25,000	$ 875,000	$ 437,500	$ 437,500
Remove Arctic Water Main	1,300	LF	$ 50	$ 65,000	$ 65,000	$ -
Remove Arctic Gravity Sewer Main	3,600	LF	$ 50	$ 180,000	$ -	$ 180,000
Install New 6x15 HDPE Arctic Water Main	1,300	LF	$ 225	$ 293,000	$ 293,000	$ -
Install New 8x18 HDPE Arctic Gravity Sewer Main	3,600	LF	$ 250	$ 900,000	$ -	$ 900,000
Steel Piles & Pipe Supports	180	EA	$ 3,000	$ 540,000	$ 270,000	$ 270,000
Submersible Heat Trace System	5,350	LF	$ 12	$ 65,000	$ -	$ 65,000
Electical Service & Controls	40	EA	$ 1,200	$ 48,000	$ -	$ 48,000
Cased Street Crossing, Remove & Replace	7	EA	$ 10,000	$ 70,000	$ 35,000	$ 35,000
Cased Driveway Crossing	7	EA	$ 4,000	$ 28,000	$ 14,000	$ 14,000
Temporary Water & Sewer Service	35	EA	$ 6,000	$ 210,000	$ 105,000	$ 105,000
			Sub-total of Construction Costs	**$ 3,274,000**	**$ 1,219,500**	**$ 2,054,500**
			Mobilization/Demobilization (7.5% of Subtotal)	$ 245,550	$ 91,463	$ 154,088
			Taxes, Bonds, Insurance (5% of Subtotal)	$ 163,700	$ 60,975	$ 102,725
			Traffic Control and Public Relations (1% of Subtotal)	$ 32,740	$ 12,195	$ 20,545
			Construction Surveying (3% of Subtotal)	$ 98,220	$ 36,585	$ 61,635
			Preparation of SWPPP	$ 20,000	$ 10,000	$ 10,000
			Subtotal	**$ 3,834,210**	**$ 1,430,718**	**$ 2,403,493**
			Design (6.5%)	$ 249,224	$ 92,997	$ 156,227
			Construction Administration (2%)	$ 76,684	$ 28,614	$ 48,070
			Contingency (20%)	$ 766,842	$ 286,144	$ 480,699
			Total	**$ 4,927,000**	**$ 1,839,000**	**$ 3,088,000**
			Phase 3 Capital Cost Present Value	**$ 4,927,000**	**$ 1,839,000**	**$ 3,088,000**

*Unit price based on American Iron and Steel requirements that all iron and steel products used in the project to be produced in the United States.

O&M Costs, Alternative 3A - Phased Approach					
Construct Loop C and Perform Spot Repair					
Item	**Quantity**	**Type**	**Unit Price**	**Total Annual Cost**	**USPW**
Hauled Water Cost (Year 1)[1,3]	478,125	Gallons	$ 62.04	$ 29,663	$ 29,225
Hauled Sewer Cost (Year 1)[1,3]	478,125	Gallons	$ 64.05	$ 30,624	$ 30,171
Piped Water Costs (Year 1)[2]	33,945,000	Gallons	$ 26.18	$ 888,680	$ 875,547
Piped Sewer Costs (Year 1)[2]	33,945,000	Gallons	$ 9.52	$ 323,156	$ 318,381
Piped Water Costs (Year 2-25)[2]	36,682,500	Gallons	$ 26.18	$ 960,348	$ 18,564,351
Piped Sewer Cost (Year 2-25)[2]	36,682,500	Gallons	$ 9.52	$ 349,217	$ 6,750,673
Heat Trace Electrical Costs (Year 1-2)[4]	1,250	LF	$ 5.18	$ 6,480	$ 12,674
Heat Trace Electrical Costs (Year 3-25)[4]	6,600	LF	$ 5.18	$ 34,188	$ 660,883
Piped Water & Sewer System Repairs (Year 1-2)[5]	1	EA	$ 70,000.00	$ 70,000	$ 136,912
Piped Water & Sewer System Repairs (Year 3-25)[6]	1	EA	$ 18,000.00	$ 18,000	$ 347,956
			Total Annual O&M Cost Year 1	$1,342,123	
			Total Annual O&M Cost Year 2-25	$1,368,233	
			Total Present Value of Year 1 O&M Costs		**$ 1,390,235**
			Total Present Value of Year 2-25 O&M Costs		**$ 26,336,538**
			Phase 1-3 Net Present Value		**$ 38,731,000**

[1]Assuming 85 gallons per person per day, 3 people per service

[2]Assuming 100 gallons per person per day, 3 people per service

[3]Estimated Fraction of Total Truck Haul System Cost for 25 BH Services

[4]Unit price based on 5 watt/ft heat trace, $0.18/kWh, 240 days per year

[5]Total annual repair project costs from City Budget Records for FY2017, 2018, 2019

[6]Total estimated repair costs based on fraction of existing system replaced

Capital Costs, Alternative 4

Full System Replacement with Loop C Extension

Item	Quantity	Unit	Unit Price*	Total Cost*	Water	Sewer
Remove Existing Arctic Water Main	20,700	LF	$ 50	$ 1,035,000	$ 1,035,000	
Remove Existing Arctic Water Service Lines	310	EA	$ 2,000	$ 620,000	$ 620,000	
Remove Existing Arctic Gravity Sewer Main	28,000	LF	$ 50	$ 1,400,000		$ 1,400,000
Remove Existing Arctic Gravity Sewer Service Lines	310	EA	$ 2,000	$ 620,000		$ 620,000
Install New 6x15 HDPE Arctic Water Main	12,700	LF	$ 225	$ 2,858,000	$ 2,858,000	
Install New 8x18 HDPE Arctic Water Main	13,000	LF	$ 250	$ 3,250,000	$ 3,250,000	
Install New 8x18 Arctic Gravity Sewer Main	30,100	LF	$ 250	$ 7,525,000		$ 7,525,000
Water & Sewer Services, Construct New (dual)	335	EA	$ 20,000	$ 6,700,000	$ 3,350,000	$ 3,350,000
Valves and Appurtenances, Remove & Replace	1	LS	$ 100,000	$ 100,000	$ 50,000	$ 50,000
Steel Piles & Pipe Supports	1,770	EA	$ 3,000	$ 5,310,000	$ 2,655,000	$ 2,655,000
Rehabilitate Existing Steel Piles & Pipe Supports	1,560	EA	$ 1,200	$ 1,872,000	$ 936,000	$ 936,000
Submersible Heat Trace System	16,750	LF	$ 12	$ 201,000		$ 201,000
Electrical Service & Controls	335	EA	$ 1,200	$ 402,000		$ 402,000
Glycol Boiler System Improvements	1	LS	$ 50,000	$ 50,000	$ 25,000	$ 25,000
Glycol Circulation Line	55,800	LF	$ 18	$ 1,005,000	$ 502,500	$ 502,500
Cased Street Crossing, Remove & Replace	26	EA	$ 14,000	$ 364,000	$ 182,000	$ 182,000
Cased Driveway Crossing	10	EA	$ 7,000	$ 70,000	$ 35,000	$ 35,000
Hydrants, Furnish & Install New	48	EA	$ 10,000	$ 480,000	$ 480,000	
Easement Obstruction Clearance	25	EA	$ 5,000	$ 125,000	$ 62,500	$ 62,500
Loop C Circulation Pump and Appurtenances	1	LS	$ 200,000	$ 200,000	$ 200,000	
Temporary Water & Sewer Service	310	EA	$ 6,000	$ 1,860,000	$ 930,000	$ 930,000
			Sub-total of Construction Costs	**$ 36,047,000**	**$ 17,171,000**	**$ 18,876,000**
			Mobilization/Demobilization (7.5% of Subtotal)	$ 2,704,000	$ 1,288,000	$ 1,416,000
			Taxes, Bonds, Insurance (5% of Subtotal)	$ 1,803,000	$ 859,000	$ 944,000
			Traffic Control and Public Relations (0.5% of Subtotal)	$ 181,000	$ 86,000	$ 95,000
			Construction Surveying (0.5% of Subtotal)	$ 181,000	$ 86,000	$ 95,000
			Preparation of SWPPP	$ 50,000	$ 25,000	$ 25,000
			Subtotal	**$ 40,966,000**	**$ 19,515,000**	**$ 21,451,000**
			Design (5%)	$ 2,049,000	$ 976,000	$ 1,073,000
			Construction Administration (2%)	$ 819,320	$ 390,300	$ 429,020
			Contingency (20%)	$ 8,194,000	$ 3,903,000	$ 4,291,000
			Total	**$ 52,029,000**	**$ 24,784,000**	**$ 27,245,000**
			Capital Cost Present Value	**$ 52,029,000**	**$ 24,784,000**	**$ 27,245,000**

*Unit price based on American Iron and Steel requirements that all iron and steel products used in the project to be produced in the United States.

O&M Costs, Alternative 4

Full System Replacement with Loop C Extension

Item	Quantity	Type	Unit Price	Total Cost	USPW
Hauled Water Costs (Year 1 and 2)[1]	2,326,875	Gallons	$ 62.04	$ 144,359	$ 282,350
Hauled Sewer Costs (Year 1 and 2)[1]	2,326,875	Gallons	$ 64.05	$ 149,036	$ 291,498
Piped Water Costs (Year 1 and 2)[2]	33,945,000	Gallons	$ 26.18	$ 888,680	$ 1,738,155
Piped Water Cost (Year 3-25)[2]	36,682,500	Gallons	$ 26.18	$ 960,348	$ 18,564,351
Piped Sewer Costs (Year 1 and 2)[2]	33,945,000	Gallons	$ 9.52	$ 323,156	$ 632,056
Piped Sewer Costs (Year 3-25)[2]	36,682,500	Gallons	$ 9.52	$ 349,217	$ 6,750,673
Glycol Circulation Electrical Cost[3]	3	EA	$ 1,200.00	$ 3,600	$ 74,591
Glycol Boiler Cost[4]	2	EA	$ 60,000.00	$ 120,000	$ 2,486,353
Piped Water System Repairs[5]	1	Repair Per Year	$ 2,500.00	$ 2,500	$ 51,799
			Annual O&M Cost Years 1-2	$ 1,507,732	
			Annual O&M Cost Year 3-25	$ 1,315,665	
			Total Present Value of O&M Costs		**$ 30,872,000**
			Alternative 4 Net Present Value		**$ 82,901,000**

[1]Assuming 85 gallons per person per day, 3 people per service

[2]Assuming 100 gallons per person per day, 3 people per service

[3]Assumes 3 1.5-HP pumps operating 240 days per year

[4]Based on City budget

[5]Total annual repair project costs estimated

*Unit price based on American Iron and Steel requirements that all iron and steel products used in the project to be produced in the United States.

Capital Costs, Alternative 5						
Water & Sewer Main Replacement with Loop C Extension						
Item	**Quantity**	**Unit**	**Unit Price***	**Total Cost***	**Water**	**Sewer**
Remove Existing Arctic Water Main	20,700	LF	$ 50	$ 1,035,000	$ 1,035,000	
Pit Orifice Pair, Remove & Replace	310	EA	$ 600	$ 186,000	$ 186,000	
Remove Existing Arctic Gravity Sewer Main	28,000	LF	$ 50	$ 1,400,000		$ 1,400,000
Install New 6x15 HDPE Arctic Water Main	22,700	LF	$ 225	$ 5,108,000	$ 5,108,000	
Install New 8x18 HDPE Arctic Water Main	13,000	LF	$ 250	$ 3,250,000	$ 3,250,000	
Install New 6x15 Arctic Gravity Sewer Main	30,100	LF	$ 250	$ 7,525,000		$ 7,525,000
Valves and Appurtenances, Remove & Replace	1	LS	$ 100,000	$ 100,000	$ 50,000	$ 50,000
Steel Piles & Pipe Supports	1,770	EA	$ 3,000	$ 5,310,000	$ 2,655,000	$ 2,655,000
Rehabilitate Existing Steel Piles & Pipe Supports	1,560	EA	$ 1,200	$ 1,872,000	$ 936,000	$ 936,000
Glycol Boiler System Improvements	1	LS	$ 50,000	$ 50,000	$ 25,000	$ 25,000
Glycol Circulation Line	65,800	LF	$ 18	$ 1,185,000	$ 592,500	$ 592,500
Cased Street Crossing, Remove & Replace	26	EA	$ 14,000	$ 364,000	$ 182,000	$ 182,000
Cased Driveway Crossing	10	EA	$ 7,000	$ 70,000	$ 35,000	$ 35,000
Hydrants, Furnish & Install New	48	EA	$ 10,000	$ 480,000	$ 480,000	
Easement Obstruction Clearance	25	EA	$ 5,000	$ 125,000	$ 62,500	$ 62,500
Loop C Circulation Pump and Appurtenances	1	LS	$ 200,000	$ 200,000	$ 200,000	
Temporary Water & Sewer Service	310	EA	$ 6,000	$ 1,860,000	$ 930,000	$ 930,000
			Sub-total of Construction Costs	**$ 30,120,000**	**$ 15,727,000**	**$ 14,393,000**
			Mobilization/Demobilization (7.5% of Subtotal)	$ 2,259,000	$ 1,179,525	$ 1,079,475
			Taxes, Bonds, Insurance (5% of Subtotal)	$ 1,506,000	$ 786,350	$ 719,650
			Traffic Control and Public Relations (0.5% of Subtotal)	$ 151,000	$ 79,000	$ 72,000
			Construction Surveying (0.5% of Subtotal)	$ 151,000	$ 79,000	$ 72,000
			Preparation of SWPPP	$ 50,000	$ 25,000	$ 25,000
			Subtotal	**$ 34,237,000**	**$ 17,875,875**	**$ 16,361,125**
			Design (5%)	$ 1,711,850	$ 893,794	$ 818,056
			Construction Administration (2%)	$ 684,740	$ 357,518	$ 327,223
			Contingency (20%)	$ 6,847,400	$ 3,575,175	$ 3,272,225
			Total	**$ 43,481,000**	**$ 22,702,000**	**$ 20,779,000**
			Capital Cost Present Value	**$ 43,481,000**	**$ 22,702,000**	**$ 20,779,000**

*Unit price based on American Iron and Steel requirements that all iron and steel products used in the project to be produced in the United States.

O&M Costs, Alternative 5					
Full System Replacement with Loop C Extension					
Item	**Quantity**	**Type**	**Unit Price**	**Total Cost**	**USPW**
Hauled Water Costs (Year 1 and 2)[1]	2,326,875	Gallons	$ 62.04	$ 144,359	$ 282,350
Hauled Sewer Costs (Year 1 and 2)[1]	2,326,875	Gallons	$ 64.05	$ 149,036	$ 291,498
Piped Water Costs (Year 1 and 2)[2]	33,945,000	Gallons	$ 26.18	$ 888,680	$ 1,738,155
Piped Water Cost (Year 3-25)[2]	36,682,500	Gallons	$ 26.18	$ 960,348	$ 18,564,351
Piped Sewer Costs (Year 1 and 2)[2]	33,945,000	Gallons	$ 9.52	$ 323,156	$ 632,056
Piped Sewer Costs (Year 3-25)[2]	36,682,500	Gallons	$ 9.52	$ 349,217	$ 6,750,673
Glycol Circulation Electrical Cost[3]	3	EA	$ 1,200.00	$ 3,600	$ 74,591
Glycol Boiler Cost[4]	2	EA	$ 60,000.00	$ 120,000	$ 2,486,353
Piped Water System Repairs[5]	1	Repair Per Year	$ 2,500.00	$ 2,500	$ 51,799
			Annual O&M Cost Years 1-2	$ 1,507,732	
			Annual O&M Cost Year 3-25	$ 1,312,065	
			Total Present Value of O&M Costs		**$ 30,872,000**
			Alternative 5 Net Present Value		**$ 74,353,000**

[1]Assuming 85 gallons per person per day, 3 people per service

[2]Assuming 100 gallons per person per day, 3 people per service

[3]Assumes 3 1.5-HP pumps operating 240 days per year

[4]Based on City budget

[5]Total annual repair project costs estimated

*Unit price based on American Iron and Steel requirements that all iron and steel products used in the project to be produced in the United States.

Alternative 6, Capital Costs

Perform Spot Repair

Item Description	Quantity	Unit	Unit Price*	Total Cost*	Water	Sewer
Remove & Replace Existing Water & Sewer Service Connectior	35	EA	$ 25,000	$ 875,000	$ 437,500	$ 437,500
Remove Arctic Water Main	1,300	LF	$ 50	$ 65,000	$ 65,000	
Remove Arctic Gravity Sewer Main	3,600	LF	$ 50	$ 180,000		$ 180,000
Install New 6x15 HDPE Arctic Water Main	1,300	LF	$ 225	$ 293,000	$ 293,000	
Install New 8x18 HDPE Arctic Gravity Sewer Main	3,600	LF	$ 250	$ 900,000		$ 900,000
Steel Piles & Pipe Supports	180	EA	$ 3,000	$ 540,000	$ 270,000	$ 270,000
Submersible Heat Trace System	5,350	LF	$ 12	$ 65,000		$ 65,000
Electrical Service & Controls	40	EA	$ 1,200	$ 48,000		$ 48,000
Cased Street Crossing, Remove & Replace	7	EA	$ 10,000	$ 70,000	$ 35,000	$ 35,000
Cased Driveway Crossing	7	EA	$ 4,000	$ 28,000	$ 14,000	$ 14,000
Temporary Water & Sewer Service	35	EA	$ 6,000	$ 210,000	$ 105,000	$ 105,000
			Sub-total of Construction Costs	**$ 3,274,000**	**$ 1,219,500**	**$ 2,054,500**
			Mobilization/Demobilization (7.5% of Subtotal)	$ 245,550	$ 91,463	$ 154,088
			Taxes, Bonds, Insurance (5% of Subtotal)	$ 163,700	$ 60,975	$ 102,725
			Traffic Control and Public Relations (1% of Subtotal)	$ 32,740	$ 12,195	$ 20,545
			Construction Surveying (3% of Subtotal)	$ 98,220	$ 36,585	$ 61,635
			Preparation of SWPPP	$ 20,000	$ 10,000	$ 10,000
			Subtotal	**$ 3,834,210**	**$ 1,430,718**	**$ 2,403,493**
			Design (6.5%)	$ 250,000	$ 93,000	$ 157,000
			Construction Administration (2%)	$ 76,684	$ 28,614	$ 48,070
			Contingency (20%)	$ 766,842	$ 286,144	$ 480,699
			Total	**$ 4,928,000**	**$ 1,838,000**	**$ 3,090,000**
			Capital Cost Present Value	**$ 4,928,000**	**$ 1,838,000**	**$ 3,090,000**

O&M Costs, Alternative 6

Spot Repair of Problem Areas

Item	Quantity	Type	Unit Price	Total Cost	USPW
Hauled Water Costs[1]	2,326,875	Gallons	$ 62.04	$ 144,359	$ 2,991,069
Hauled Sewer Costs[1]	2,326,875	Gallons	$ 64.05	$ 149,036	$ 3,087,975
Piped Water Costs[2]	33,945,000	Gallons	$ 26.18	$ 888,680	$ 18,413,106
Piped Sewer Costs[2]	33,945,000	Gallons	$ 9.52	$ 323,156	$ 6,695,675
Heat Trace Electrical Costs[3]	5,350	LF	$ 5.18	$ 27,734	$ 574,646
Piped Water & Sewer System Repairs[4]	1	EA	$ 70,000.00	$ 70,000	$ 1,450,373
			Total Annual O&M Cost	$1,309,571	
			Total Present Value of O&M Costs		**$ 33,213,000**
			Alternative 6 Net Present Value		**$ 38,141,000**

[1]Assumes 85 gallons per person per day for Hauled System, 3 people per service, 365 days per year

[2]Assuming 100 gallons per person per day for Piped System, 3 people per service

[3]Unit price based on 5 watt/ft heat trace, $0.18/kWh, 240 days per year

[4]Total annual repair project costs from City Budget Records for FY2017, 2018, 2019 ($210,000 for FY2019 spread over 3 years)

*Unit price based on American Iron and Steel requirements that all iron and steel products used in the project to be produced in the United States.