Technical Memorandum

To:	Jay Poulin, P.E. HEB Engineers
CC:	Roger Dionne, P.E., New Hampshire Department of Administrative Services Seth Prescott, Thomas Mansfield, Nathaniel Camille, New Hampshire Department of Natural and Cultural Resources
From:	David Mercier, P.E, Thaddeus Webb, Underwood Engineers
Date:	January 26, 2018
Subject:	Mount Washington Sewer Interceptor Pipeline Feasibility Study

In accordance with our contract with HEB Engineers, Underwood Engineers is providing the following Technical Memorandum on the feasibility of a sewer interceptor pipeline from the summit of Mount Washington to the base of the Cog Railway. The sewer interceptor is proposed to be an option to eliminate treatment and disposal at the summit.

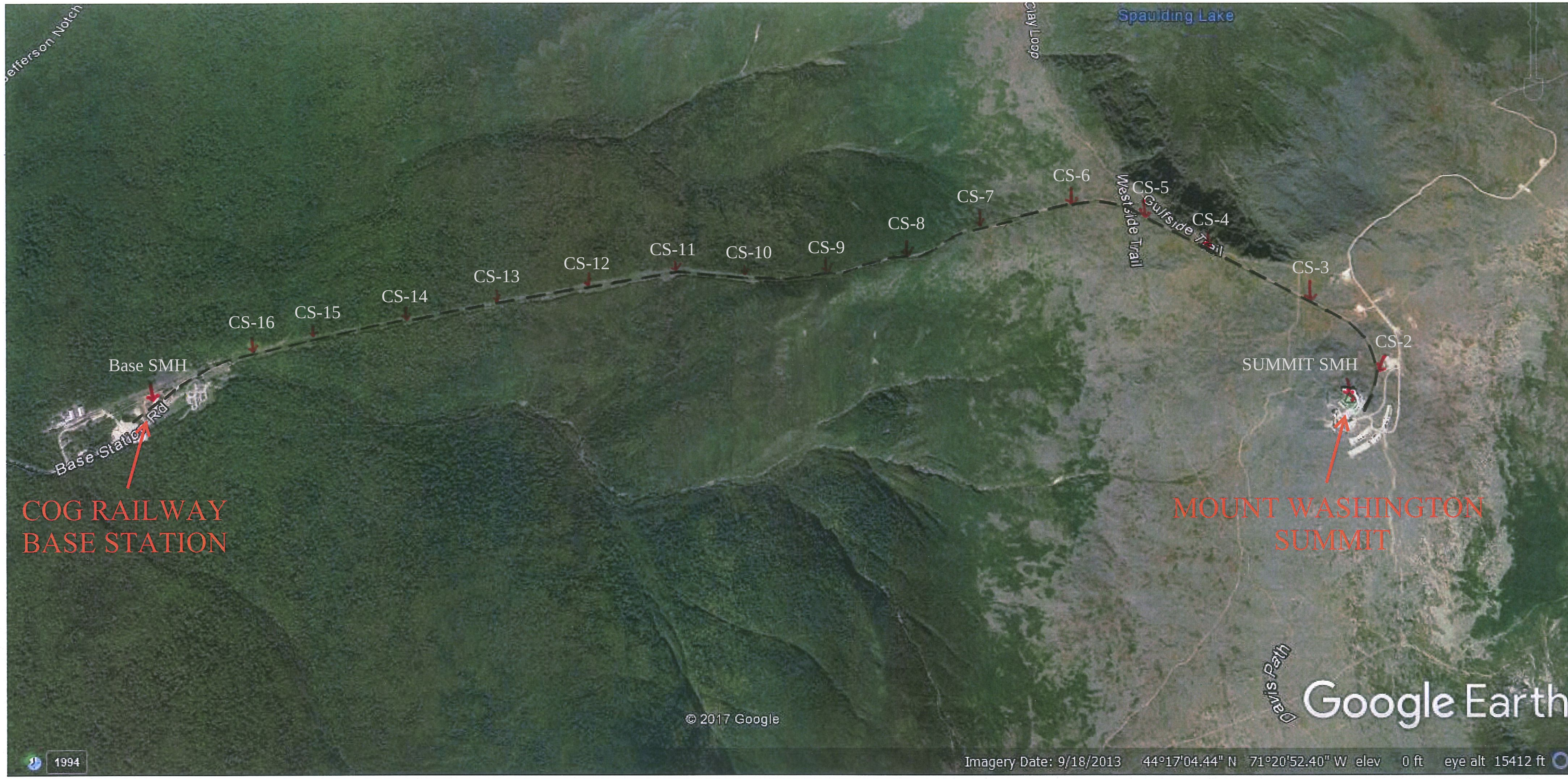
Background

The wastewater system on the summit of Mount Washington is owned and operated by the New Hampshire Department of Natural and Cultural Resources (NHDNCR). It serves a small year-round resident population and a large tourist population during summer months. The existing system on the summit of Mount Washington does not reliably meet the permit limits for groundwater disposal under Groundwater Discharge Permit #199007007. Additionally, current permitted capacity is 5,000 gpd and NHDNCR anticipates requiring additional capacity up to a total of 7,500 gpd. The NHDNCR is therefore evaluating alternatives to improve the wastewater system. A sewer interceptor pipeline has been proposed to transport wastewater nearly 3 miles (15,100') from the Mount Washington summit (Elevation 6,260') to the base of the Cog Railway (Elevation 2,660') for septic tank treatment and subsurface disposal. Access to the ROW is assumed to be obtained in exchange for allocation of a portion of the interceptor excess capacity to the ROW owner. The objective of this study is to evaluate the feasibility of constructing and operating the proposed pipeline.

Similar Projects

The proposed pipeline (Figure 1) has several unique features which may complicate design and construction including the following:

- The route selected for the pipeline follows a steep grade that averages 25% slope.
- Anticipated shallow depth to bedrock and deep frost penetration are assumed to make burial of the pipeline below the frostline impractical. Additional means of protecting the pipeline from freezing conditions are assumed to be required.



NOTE: ALL PROPOSED LOCATIONS ARE APPROXIMATE.

LEGEND

- - - PROPOSED PIPELINE ROUTE

CS-6 CROSS SECTION LOCATION CORRESPONDING TO ELVATION AND DISTANCE LISTED IN TABLE 2.

DATE 12/7/17	UNDERWOOD engineers	PIPELINE WORKPLAN SEWER FEASIBILITY STUDY MOUNT WASHINGTON SARGENT'S PURCHASE, NEW HAMPSHIRE	FIG. 1
PROJECT 2233	25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733		

At least two similar pipelines have been constructed at ski resorts in New England. Both projects have shorter length of run and are at lower elevation. The identified projects are described as follows:

- Jay Peak Ski Resort, Vermont – According to conversations with Urecon, an insulated pipe manufacturer, and review of the site with Google Earth, a 6,000' pipeline was constructed from the Sky Haus (Elevation ~3,800') to the base of the mountain (Elevation ~2,000) for treatment and subsurface disposal. The pipeline operates year-round and is reported to function acceptably. It has the following features:
    - On grade construction.
    - Two (2) inches urethane foam insulation.
    - Average slope = 30%.
    - At least one low point (dip) in construction.
    - At least one energy dissipation structure.

- Cannon Mountain Ski Resort, New Hampshire – the Summit Lodge is served by a sewer pipeline. Based on construction plans (New Hampshire Department of Administrative Services, 2008) provided by NHDNCR and features measured with the Google Earth tool, it is estimated to be approximately 7,000' long and have an average slope of 28%. The construction plans included the following features:
    - A three (3) inch uninsulated HDPE sewer pipe laid on grade.
    - Anchored every 20' OC.
    - Thrust blocking at all pipe bends.

  The Cannon Mountain sewer pipeline has been reported to work satisfactorily during spring, summer and fall. Ice buildup and freezing of the effluent in the line have been observed during winter operation and significant operational effort is required to operate the pipeline during cold weather. Given the more extreme temperature and wind conditions of the proposed project, experience with the Canon Mountain pipeline indicates that uninsulated above grade construction is not appropriate for a Mount Washington sewer interceptor used during winter.

Shallow Bury Seasonal Operation

Winter operation of shallow bury and at grade pipeline has been successfully demonstrated in New England and other northern climates, however, typical applications have a shorter length of run and higher flowrate. Design considerations to avoid problems due to pipeline freezing include the following:

- Insulation of the pipe and all components with at least two (2) inches of urethane foam or similar such as the Urecon pipe system (Appendix 1).
- Careful installation to ensure the sewer continuously slopes to the base of the mountain with no local low points. If energy dissipation structures are required for velocity reduction

or to eliminate hydraulic jumps the cost for designing and constructing for winter operation is expected to increase significantly because these structures may be susceptible to freezing.

- Dosed operation of the pipeline during winter operation. Trickling wastewater flows are more susceptible to freezing and glacial buildup of ice than steady large flows. Applications with low rate of flow can be stored and pumped in pulses of flow followed by periods of no flow to reduce the buildup of ice.
- Certain cold climate communities have successfully prevented freezing by heating effluent or cleared frozen lines by periodically dosing them with hot water. This strategy is appropriate for short sewer runs, but the energy demand for this strategy increases as the length of the sewer interceptor increases.

Proposed Pipeline Description

The preliminary evaluation assumes an Average Daily Flow of 20,000 GPD and a peaking factor of 6. A breakdown of the wastewater design flow is presented in Table 1. The design flow is estimated conservatively because the pipe size is selected to prevent clogging and not to accommodate peak flows. Therefore, moderate reductions in design flow are not expected to result in significant cost savings. Additionally, allocation of the excess capacity to potential other users (such as a hotel) may reduce the costs to NHDNCR. The Proposed Peak Design Flow is also an appropriate condition to model winter operation with dosed operation using an 83 GPM pump.

Table 1. Proposed Design Flow

Flow Description	Average Daily Flow (ADF)	Peak Hour Flow[1] (PHF)
Summit Existing Capacity	5,000 GPD[2]	30,000 GPD
Summit Future Expansion	2,500 GPD	15,000 GPD
Excess Capacity[3,4]	12,500 GPD	75,000 GPD
Total	**20,000 GPD (0.01 CFS)**	**120,000 GPD (0.18 CFS)**

Note 1. A Peaking Factor of 6 was selected per Env-Wq 704.03 (d)

Note 2. Existing flow data from the Mount Washington Monthly Operating Reports indicate that summertime daily flows average from 2,000 GPD to 5,000 GPD, and existing max daily flow of approximately 7,500 GPD.

Note 3. The design flow of a 35 room hotel is approximately 7,500 gpd

Note 4. No allowance for I/I is included assuming construction above the groundwater table and no lateral connections.

Distances and elevations from the Electrical Transmission Construction Plans (Stantec 2007) provided by the Client were used to determine the layout and elevation profile of the sewer interceptor. The proposed pipeline was assumed to follow the same route as the electrical transmission conduit.

Based on our research and review of similar projects, we propose the following:

- Option A – Summer Operation Only assumes the pipeline is not used during freezing conditions, and is not insulated. This option requires an alternate wastewater system (or storage) for winter operation (Not included in cost estimate).
- Option B – Summer and Winter Operation assumes the pipeline and all appurtenances are insulated. The opinion of cost assumes the bottom 5,000' of the pipeline requires heat trace (As discussed in the Shallow Bury Seasonal Operation section below).
- Construction of the proposed pipeline below the frost line is assumed to be cost prohibitive due to expected depth to frost line, and shallow depth to bedrock. The pipeline is generally assumed to be buried with two feet of cover for physical protection from damage due to temperature fluctuations, wind and ice damage, among other things.
- Preliminary pipe selection is 6" HDPE. The 6" diameter is selected over smaller diameters to reduce the risk of clogging and to increase friction energy loss.
- Concrete pipe anchors are assumed every 50'. Some industry standards (Ten State Standards) specify pipe anchors not be spaced more than 36'. However, one pipe anchor per 50' HDPE pipe is assumed to be sufficient for this project because HDPE pipe is manufactured in 50' sections is joined by butt fusion instead of typical slip joints. The butt fusion welded joints are stronger than slip joints.
- Runoff protection to prevent erosion of the pipe bedding is required due to the steep pipe slope. Pipe bedding is typically more permeable than the surrounding soils, which can lead to the trench forming a conduit for runoff and stripping of the pipe bedding. Runoff protection may include trench dams every 300' and import of engineered low permeability fill material.
- The pipe is assumed to be installed with 10% slack to allow thermal expansion and contraction.
- Cleanouts are assumed every 1,000'. The number of cleanouts is minimized because the EPA Cold Climate Utilities Delivery Design Manual identifies them as a point of vulnerability in shallow buried pipelines due to damage associated with freeze thaw cycles.
- Energy dissipation structures such as drop manholes or stilling basins are typically included to prevent hydraulic jumps and reduce velocity. These structures are susceptible to freezing and design and construction for winter operation would become significantly more difficult and expensive if they are included. Further study of detailed topographic and subsurface information is required to determine whether these structures are necessary.
- Venting, including air and vacuum, may be required for pressure release and should be confirmed during design.
- Primary treatment (septic tank treatment) or screening of the wastewater at the summit is included to remove particulate material to reduce the potential for clogging or damage to the pipeline by scour and erosion. It is assumed that the existing septic tanks on the summit are maintained.

If Option B is pursued, additional considerations for winter operation include:

- Wastewater should be pumped to the pipeline in dosed batches with as large volume as practical. For the purposes of this evaluation 4,000-gallon batches are assumed. Assuming a pump rate of 83 GPM and cycle pump time of 48 minutes matches the hydraulic conditions assumed for peak hour flow.
- Initial temperature of the wastewater entering the pipeline must contain sufficient heat content to maintain the pipe above freezing while flow is present. The wastewater could be stored in the Sherman Adams Building prior to dosing to increase the wastewater temperature. It is anticipated that the old winter system wastewater storage tanks could be used for dosing storage. However, it is unlikely that these storage conditions are sufficient to provide sufficient heat content.
- If ambient temperature wastewater does not contain enough heat for freeze protection for the entire length of the pipe, the wastewater would require a combination of heating at the summit and heat tracing the lower portion of the pipeline. It is estimated that no more than 5,000' of heat trace wire can be run without providing additional power along the length of the sewer interceptor. Preliminary heat transfer calculations (Appendix 2), indicate that if the 5,000' of the pipeline is equipped with heat trace wire, wastewater entering the pipeline would have to be 73 degrees Fahrenheit to keep the wastewater from freezing. It is anticipated that a significant amount of energy would be required to power heat trace and to heat wastewater to this temperature which would increase the life cycle costs of the sewer interceptor.

Preliminary Hydraulic Evaluation

A preliminary analysis of the proposed Mount Washington sewer pipeline was performed using the SewerCAD (Bentley) model. The model includes a virtual representation of the physical pipeline, which is used to estimate the hydraulic characteristics of the pipeline such as hydraulic flows, velocities, capacity and water depth. This information is used to determine design constraints such as the following:

- Design flow depth
- Pressure buildup
- Design sewer velocity
- Sewer capacity

For modeling, distances and elevations from the Electrical Transmission Construction Plans (Stantec 2007) were used to configure the physical attributes of the model (Table 2). All flow to the interceptor was assumed to enter the pipeline at the initial sewer manhole because it is the conservative condition, however the location at which allocations of excess capacity flow into the pipeline should be confirmed if it goes to design.

Table 2. Pipeline elevations and distances

FEATURE	ELEVATION (FT)	SEGMENT ELEVATION (FT)	CUMULATIVE DISTANCE (FT)	SEGMENT DISTANCE (FT)	SEGMENT SLOPE (%)
Base SMH	2,658	0	0		
CS-16	2,737	79	570	570	14%
CS-15	2,930	193	1,570	1,000	20%
CS-14	3,146	216	2,570	1,000	22%
CS-13	3,407	261	3,570	1,000	27%
CS-12	3,699	292	4,570	1,000	31%
CS-11	3,905	206	5,570	1,000	21%
CS-10	4,130	225	6,450	880	26%
CS-9	4,435	305	7,650	1,200	26%
CS-8	4,745	310	8,650	1,000	33%
CS-7	5,060	315	9,650	1,000	33%
CS-6	5,395	335	10,650	1,000	36%
CS-5	5,635	240	11,650	1,000	25%
CS-4	5,825	190	12,650	1,000	19%
CS-3	6,010	185	13,650	1,000	19%
CS-2	6,142	132	14,650	1,000	13%
SUMMIT SMH	6,260	118	15,100	450	27%
TOTAL		**3,602**		**15,100**	**25%**

Note 1. Features, elevations and distances from 2007 Stantec Transmission Line Plans and Profiles

Model results are provided in Appendix 3. Several typical sections of the model hydraulic profile containing grade changes are shown on Figures 2A-2C. The model results include the following:

- Pipeline flow depth ranges from approximately 5.8% to 7.3% of the pipe diameter at ADF and from approximately 28.7% to 35% of the pipe diameter at PHF. This result indicates that straight sections of the pipe will not run full under design conditions and that pressure buildup in the pipe is not a limiting design constraint.
- Design PHF velocities range from 3.95 ft/sec to 10.70 ft/sec. Standard design practice suggests that pipe velocities should be limited to 10 ft/sec, but this guideline may be exceeded if special attention is given to pipe anchoring and the elimination of hydraulic jumps.
- Significant hydraulic jumps are not observed in the model at the specified pitch changes. Note that the model has low resolution and may not reflect sharp changes in local topography. It is assumed that this is not an issue because the railway would also not tolerate sharp changes in grade, but pitch changes in the profile should be confirmed during final design.
- Capacity of the pipeline as determined by full flow is 2.65 CFS (1.7 MGD). The anticipated sewer flow for Mount Washington is far less than the full flow for the 6" pipe. At full flow, sewer velocity is greater than 22 ft/sec for steep sections. This velocity is above

FIGURE 2A
MOUNT WASHINGTON SEWER INTERCEPTOR PIPELINE
HYDRAULIC AND ENERGY GRADE LINE - PEAK HOUR FLOW
CROSS SECTION 1

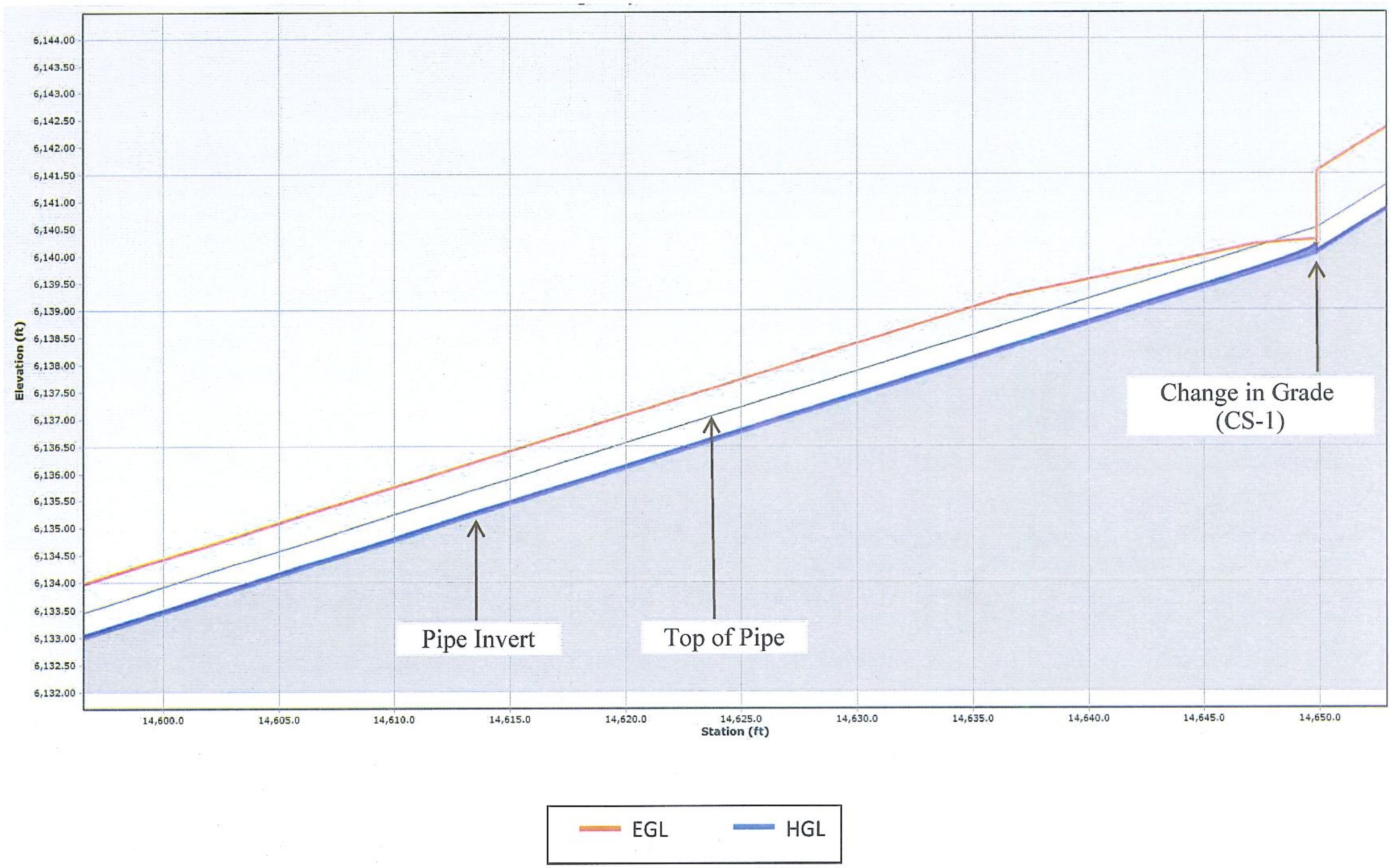


FIGURE 2B
MOUNT WASHINGTON SEWER INTERCEPTOR PIPELINE
HYDRAULIC AND ENERGY GRADE LINE - PEAK HOUR FLOW
CROSS SECTION 3

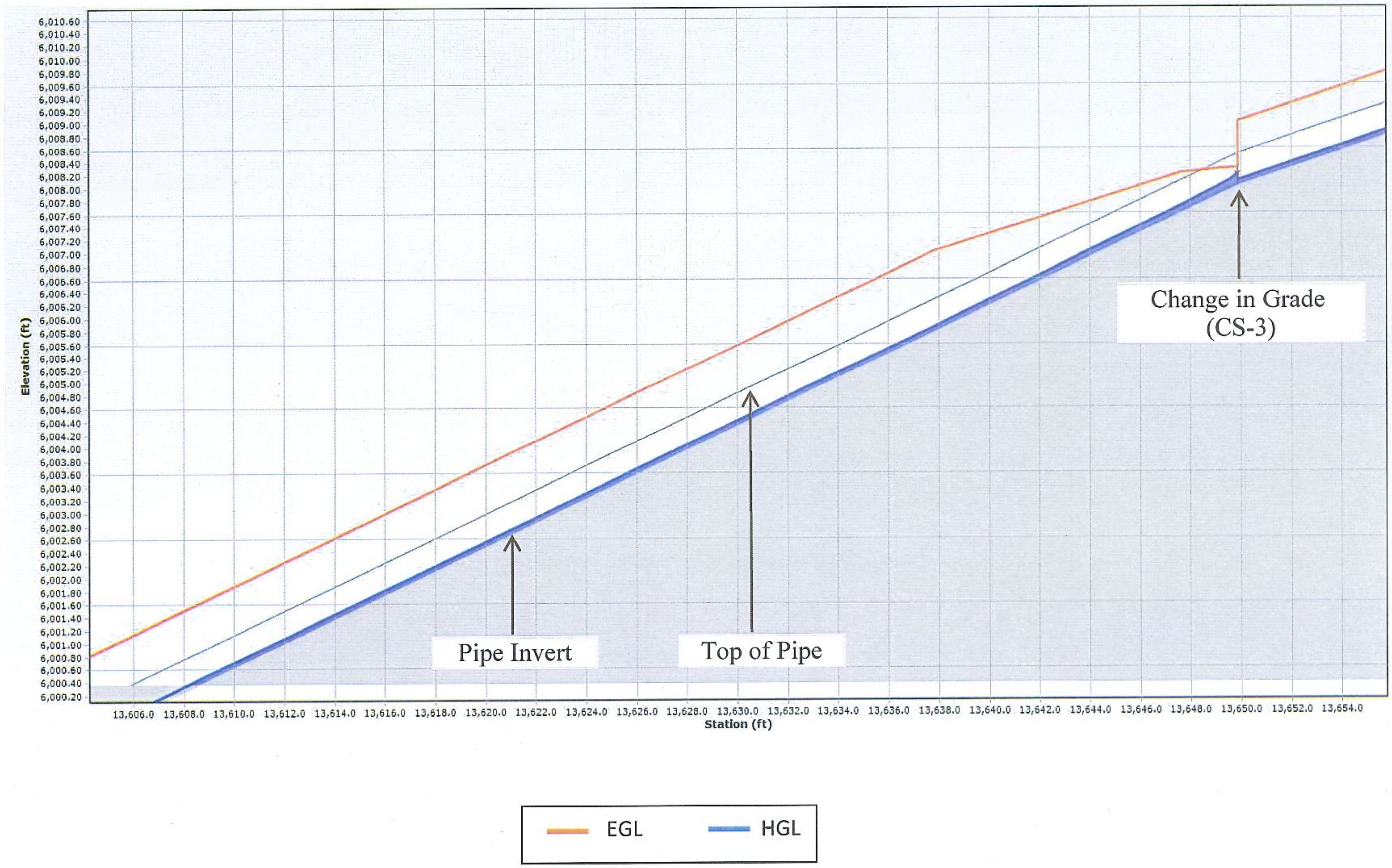
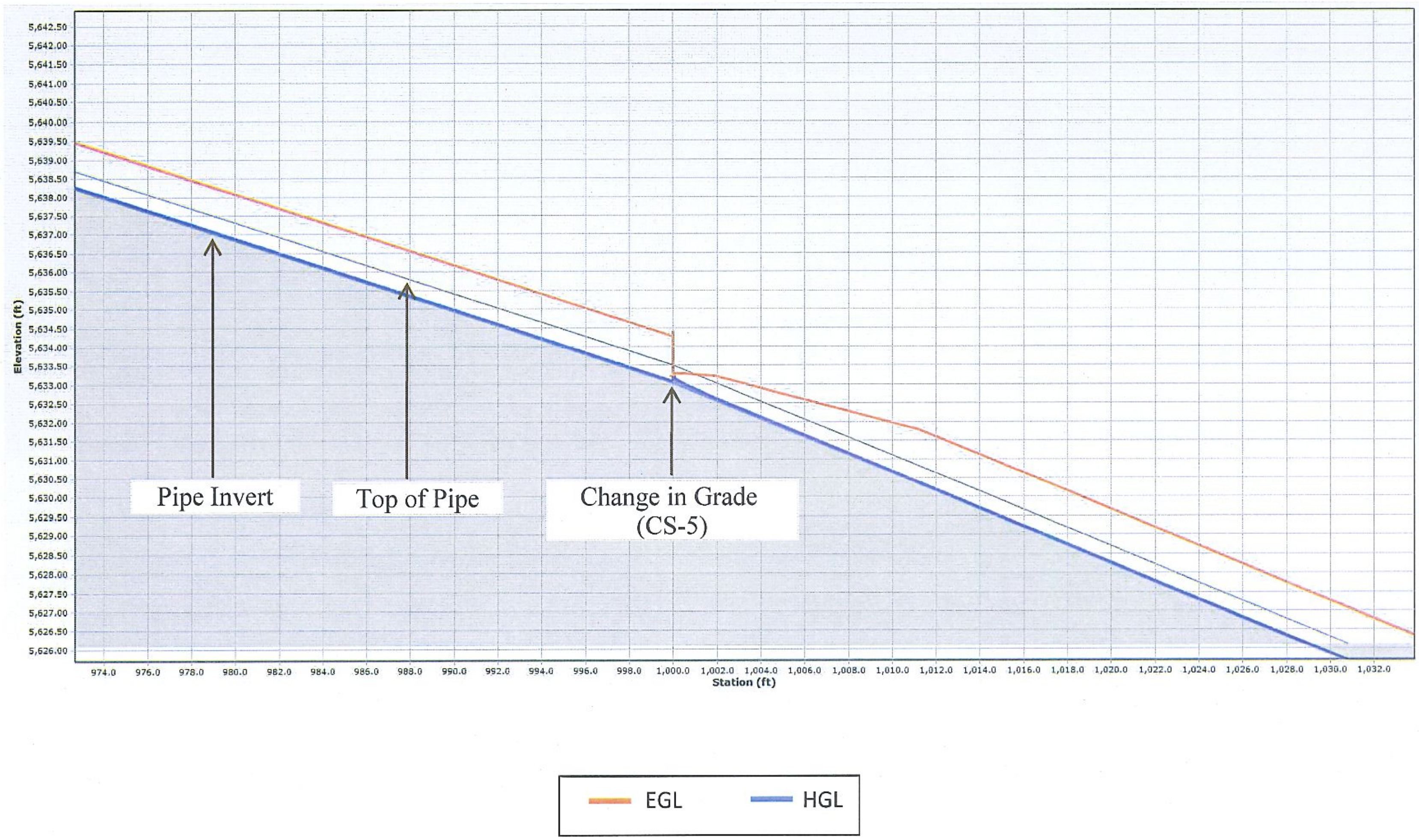


FIGURE 2C
MOUNT WASHINGTON SEWER INTERCEPTOR PIPELINE
HYDRAULIC AND ENERGY GRADE LINE - PEAK HOUR FLOW
CROSS SECTION 5



recommended design values and would cause damage to the pipeline if it occurred. If the sewer interceptor goes to design the sewer capacity should be determined by maximum sewer velocity rather than the full flow condition.

Treatment and Disposal

Consideration of the treatment and disposal of the wastewater is included to define interceptor capital costs and develop a general treatment and disposal cost. If the sewer interceptor goes to design, further study of the treatment and disposal should be conducted.

Treatment and disposal of the wastewater at the terminus of the pipeline is proposed to consist of septic tank treatment and subsurface disposal at the Cog Railway Base Station. Proposed effluent disposal areas include the Old Parking Lot, beneath the New Parking Lot and the Old Coal Ash Stockpile area as identified on Figure 3. For the purposes of this analysis, effluent disposal at the Old Parking Lot is proposed. The Natural Resources Conservation Service Web Soil Survey identifies the soils in this area as Skerry sandy loams. The infiltration rate is based on the saturated hydraulic conductivity (Ksat) values from *K_{sat} Values for New Hampshire Soils* (Society of Soil Scientists of Northern New England, 2009). The lowest Ksat value for the most limiting soil layer was selected and then corrected by applying a safety factor of 2 (0.6 in/hr ÷ 2 = 0.3 in/hr). Based on this information, a percolation rate of 12 min/in and hydraulic loading rate of 0.5 GPD/SF was assumed. The approximate area required for disposal is depicted on Figure 3 assuming one field, however several fields would be installed, requiring more area.

Approved systems with capacity up to 20,000 GPD may discharge wastewater under a subsurface disposal permit. However, recent wastewater characterization of the summit wastewater system septic tank effluent has determined that it is high strength wastewater. Therefore, while the design flow is compatible with a subsurface effluent disposal permit, NHDES will likely require additional study of the nitrogen impacts of the effluent disposal on groundwater prior to permit approval.

Costs for septic tank treatment and subsurface disposal are assumed to be approximately $20/GPD based on previous Underwood Engineers projects of similar size and nature. This cost may increase significantly if advanced treatment for nitrogen removal is required to dispose of the wastewater without causing excess groundwater pollution.

Operational Issues

Solids deposition is a primary sewer maintenance concern because solids that collect in sewer pipes restrict the pipe capacity. Marginal solids deposition in the Mount Washington pipeline is anticipated given that the average slope of the sewer interceptor (approximately 25%) is much higher than the required slope for 6-inch gravity sewer (1%). However, solids removal by septic tank and a screen should be included to remove rags and other solids which may snag in the pipeline and cause a blockage. Pumping of the primary septic tanks is expected to be maintained at the current rate. Typically, sewer cleaning is recommended approximately every three years, however, given the steep slope, small diameter, and corrosion resistant material of the proposed pipeline, it is anticipated that cleaning frequency could be reduced significantly.

DISPOSAL AREAS ASSUMPTIONS:

DESIGN FLOW[1]: 12,500 GPD
FUTURE FLOW: 7,500 GPD

PERCOLATION RATE[2]: 12 MIN/IN

DISPOSAL AREA[3]:

DESIGN: 30,000 SF
FUTURE: 10,000 SF

Note 1. Assumed 7,500 gpd WW design flow + 5,000 gpd I/I allowance.
Note 2. Typical value based on USDA Web Soil Survey.
Note 3. Disposal area required per Env-Wq 1016-1

LEGEND

PROPOSED DISPOSAL AREA

SURFACE WATER SETBACK (75 FEET)

DATE			FIG.
11/30/17	UNDERWOOD engineers 25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733	WASTEWATER DISPOSAL WORKPLAN SEWER PIPELINE FEASIBILITY STUDY MOUNT WASHINGTON SARGENTS PURCHASE, NEW HAMPSHIRE	3
PROJECT 2233			

It is typically recommended that CCTV inspection of 20% of a sewer system be conducted annually. Sewer inspection is a critical maintenance activity to identify pipe defects before they require emergency repair or cause loss of service.

Sanitary sewers have the potential to generate the corrosive and odorous gas hydrogen sulfide (H_2S). Sulfide is generated when the sulfate in wastewater is reduced in anaerobic conditions. The reaction is dependent on temperature, dissolved oxygen, pH, pipe slope and other factors. The steep pipe slope and partially full flow condition of the proposed pipeline are unfavorable for sulfide generation because retention time in the interceptor is short (approximately 1-2 hours at ADF) and turbulent flow reduces the likelihood of anaerobic conditions. However, sulfide generation may occur in the proposed pipeline. If sulfide generation is observed, its occurrence can be reduced by adding chemical (base) to the wastewater to raise the pH. As wastewater pH increases, sulfide is converted to ionic HS^- which remains in solution and is not a nuisance.

Opinion of Cost

Opinion of Capital Cost – Pipeline plus Disposal (See Appendix 4)

Option A: Summer Operation Only	$ 3,500,000
Option B: Summer and Winter Operation	$ 4,300,000

Comparison of Pipeline versus Summit WWTF

Advantages

- Construction of the pipeline may reduce or eliminate the need to operate the existing WWTP depending on whether the new system is designed for seasonal or year-round use.
- The proposed system has higher capacity (20,000 GPD) than the existing wastewater system (5,000 GPD).
- Assuming the groundwater impact study of the proposed septic tank and subsurface disposal system at the Cog Base Station shows no excess pollution to the surrounding groundwater, O&M of the system would be greatly reduced
- The permit and reporting requirements of subsurface discharge are significantly less than the requirements for groundwater discharge.
- If the pipeline wastewater disposal on the Summit is eliminated, the groundwater discharge permit is eliminated.

Disadvantages

- The capital cost of pipeline construction is expected to be higher than the cost of expanding or replacing treatment capacity at the summit.
- Pipeline maintenance may be unfamiliar to the operations staff and requires inspection and maintenance along the entire length of the pipeline instead of only at the summit.
- Exposed and shallow bury pipes are susceptible to damage from freeze thaw cycles.
- Winter operation of the pipeline may be energy intensive to keep the pipeline from freezing and may require winter maintenance along the length of the pipeline.
- The sewer interceptor, septic tanks, and disposal field are not proposed to be constructed on land owned by the State. Additional costs for easements and land use may be required.
- Due to the high strength of the wastewater, additional study of the subsurface disposal system will be required prior to permitting.

Conclusions

- For the assumed conditions the Mount Washington pipeline is not expected to flow full or experience pressure buildup in straight pipe sections. Sharp changes in topography may cause hydraulic issues and should be evaluated further if the design proceeds

- Preliminary modeling indicates that energy dissipation structures are not required for a 6" pipeline at the design peak hourly flow (120,000 GPD) if pipe bends and sudden changes in pitch can be avoided. However, engineering experience has demonstrated that these structures should be included.

- Sewer hydraulic capacity is limited by the effects of high sewer velocity rather than volume limitations.

- The capital cost of pipeline construction is expected to be higher than the cost of expanding or replacing treatment capacity at the summit.

- Winter operation of wastewater pipelines in a shallow bury or exposed condition has been demonstrated in previous projects. However, the combination of long length, low winter flow, and steep slope increase the cost of design and construction for winter operation. Sufficient insulation, appropriate application of heat trace and proper operation (dosing) are required. Energy requirements for heat trace and wastewater heating may significantly increase life cycle costs.

Recommendations

- Underwood Engineers recommends against constructing the proposed sewer interceptor pipeline on the basis of high capital cost. We recommend that wastewater treatment and disposal is maintained at the current location.

- If the sewer interceptor pipeline is further evaluated as an option to eliminate wastewater treatment and disposal on the summit, we recommend that the cost evaluation be extended to full life cycle cost.

APPENDIX 1

TYPICAL INSULATED PIPE (URECON) SPECIFICATIONS

URECON

DETAILED SPECIFICATION

Standard U.I.P.® system for below grade piping

1. GENERAL

The pipe shall be insulated using the unique U.I.P.® factory insulation process, as supplied by Urecon Ltd., complete with integral conduit(s) for electric heat trace cable (if required) and 1.27 mm *(50 mils)* to 2.54 mm (*100 mils*) black polyethylene jacket with UV inhibitor. The jacket thickness is dependent on the insulated pipe diameter and its intended function. The insulation of associated joints, fittings and accessories shall be as per Urecon's recommendations. The product shall be manufactured in accordance to ISO 9001 Standards, or approved equal.

2. PIPE PREPARATION

Pipe shall be cleaned of surface dust or dirt to ensure adhesion of the foam to the pipe.

3. HEAT TRACING CONDUIT

Heat tracing conduit(s) shall consist of an extruded molding and shall be applied to the pipe prior to application of the insulation. The conduit(s) will be securely fastened to the pipe to prevent the ingress of foam therein during the insulation process. All conduit(s) shall be checked after insulating to ensure they are not blocked. The ends shall be sealed prior to shipping to prevent any foreign material from entering the conduit while in transit or during installation.

4. INSULATION

a) Material: Rigid polyurethane foam, factory applied.
b) Thickness: 50.8 mm *(2 in)* or as required.
c) Density: (ASTM D1622) 35 to 48 kg/m³ *(2.2 to 3.0 lbs/ft³)*.
d) Closed cell content: (ASTM D6226) 90%, minimum.
e) Water absorption: (ASTM D2842) maximum 4.0% by volume.
f) Thermal conductivity: (ASTM C518) 0.020 to 0.025 W/m °C *(0.14 to 0.17 Btu • in/ft² • hr • °F)*.
g) Temperature range: Cryogenic to 93.3 °C *(200 °F)*.

5. SYSTEM PROPERTIES

a) System compressive strength: (modified ASTM D1621 with 1.27 mm *(50 mils)* jacket) approximately 414 to 552 kPa *(60-80 lbs/in²)*, varies with pipe diameter.
b) Service temperature range: the overall factory insulated system limitations are dependent on the core pipe type, insulation and application.
c) Temperature limitations: minimum ambient installation temperature -34 °C *(-29 °F)*.

6. OUTER JACKET ON PIPE INSULATION (WITH ENHANCED COLD CLIMATE HANDLING PROPERTIES)

The outer protective jacket shall consist of either:

i.) Tape wrap system: (available from both manufacturing facilities)

a) Jacket material: Scapa #366 polyethylene, UV inhibited, formulated for superior cold environment properties.
b) Sealant: Butyl rubber and resin, applied hot in 0.63 mm (*25 mils*) multiple layers providing a shrink tightened waterproof bond throughout its entire length.
c) Minimum elongation: (ASTM D1000) 300%, 6 month test.
d) Tensile strength: (ASTM D1000) 6.83 kg/cm wide *(38 lbs/in wide)*.

ii.) Extruded system: (available from Calmar, AB only)

a) Jacket material: Extruded black high density polyethylene copolymer, UV inhibited and factory applied.
b) Minimum cell classification 435560A for PE as per ASTM D3350.
c) Minimum 2% carbon black, well dispersed.
d) Density 0.953 g/cm³ *(59.5 lbs/ft³)* ASTM D4883.
e) Tensile Strength at yield (50.8 mm *(2 in)* /min) 26 MPa (*3700 psi*), ASTM D638.

URECON PRE-INSULATED PIPE
Coteau-du-Lac, Quebec (450) 455-0961
Calmar, Alberta (780) 985-3636
Florida (321) 638-2364
www.urecon.com

Recommended PE Jacket thicknesses* for below grade applications-

Jacket OD ≤ 406.4 mm (*16 in*)	@ 1.27 mm (*50 mils)*
Jacket OD > 406.4 mm (*16 in*) to 609.6 mm (*24 in*)	@ 1.90 mm (*75 mils*)
Jacket OD ≥ 609.6 mm (*24 in*)	@ 2.54 mm (*100 mils*)

*other jacket thicknesses are available upon request

7. INSULATED PIPE JOINTS

a) Butt-fused and welded joints

Insulated pipe joints shall be completed using pre-fabricated rigid polyisocyanurate or polyurethane foam half shells and sealed with the application of suitable wrap around adhesive lined heat shrink sleeves as supplied by Urecon. The heat shrink sleeves shall overlap the insulation jacket by a minimum of 75.2 mm *(3 in)* on either side of the joint. The insulation shall be pre-grooved on the inside or slightly oversized to accommodate heat trace cable(s) if applicable.

b) Bell x spigot joints

Insulated pipe joints shall be sealed with a 152.4 mm (*6 in*) wide heat shrink sleeve or butyl mastic tape if the system is not electrically heat traced, 304.8 mm (*12 in*) to 609.6 mm (24 in) wide if traced, depending on pipe size.

8. INSULATION KITS FOR FITTINGS

Insulation kits for fittings shall consist of rigid polyisocyanurate or polyurethane foam half shells with a fully bonded polymer protective coating on all exterior and interior surfaces, including ends. All insulation kits shall be supplied complete with silicone caulking for seams, stainless steel bands and gear clamps.

a) Rigid polyisocyanurate or polyurethane foam

1. Density: (ASTM D1622) 32 kg/m³ *(2.0 lbs/ft³)*.
2. Compressive strength: (ASTM D1621) 124 to 186 kPa (18 to 27 lbs/in²).
3. Closed cell content: (ASTM D2856) 90%, minimum.
4. Water absorption: (ASTM C272) 2.0% by volume.
5. K factor: (ASTM C518) 0.027 W/m°C (0.19 Btu • in/ft² • hr • °F).
6. Thickness: 50.8 mm (2 in), other thicknesses upon request, shall match pipe insulation thickness.

b) Polymer coating, Urecon BL-70-20EP

1. Two component high density polyurethane coating, black in color.
2. Density: 1170 kg/m³ *(73 lbs/ft³)*.
3. Durometer D scale 60.
4. Tensile strength: 11.10 MPa *(1610 lbs/in²)*.
5. Tear strength: 26.5 N/mm *(151 lbs/in)*.
6. Thickness: 1.78 mm *(70 mils)* outside surfaces, 0.51 mm *(20 mils)* inside surfaces.

9. ELECTRIC TRACING SYSTEM

The electric tracing system and associated controls shall be as per the manufacturer's recommendations with particular attention being paid to the watt densities applied through conduits on plastic pipes. All tracing cables and related accessories to be CSA approved and comply with CSA heat tracing standard C22.2 No. 130-03. Standard of acceptance is Urecon's Thermocable or approved equal. Please contact your Urecon representative for further details and design assistance.

Note: *Physical characteristics are nominal and may vary depending on pipe type and diameter.*

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APPENDIX 2

PRELIMINARY HEAT TRANSFER CALCULATIONS

NATIONAL RESEARCH COUNCIL

CANADA

DIVISION OF BUILDING RESEARCH

DESIGN OF EXPOSED SEWER PIPES FOR INTERMITTENT USE UNDER FREEZING CONDITIONS

by

D.G. Stephenson

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DESIGN OF EXPOSED SEWER PIPES FOR INTERMITTENT USE UNDER FREEZING CONDITIONS

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In many locations in northern Canada, the presence of permafrost requires sewage effluent pipes from buildings to be located above grade where they are exposed to ambient air temperature. Since the air temperature is well below 32°F for several months each year, it is necessary to protect against freezing. Experience has suggested that this can be done at minimum cost by designing for intermittent flow through the pipe utilizing a siphon method of discharge from the sewage collection tank. This paper analyzes the heat transfer situation and shows how an exposed pipe may be designed for intermittent use so that ice will not restrict the flow.

The study clearly shows that the pipe should have as thin a wall as possible, that it should be made of a material with a low heat capacity, and the number of gallons of liquid flowing during a siphon cycle should be as large as possible. If the minimum required inlet temperature to prevent freezing in a bare pipe is so high that the sewage must be heated, the economics of adding insulation should be studied.

To determine the optimum pipe diameter (D) and the required sewage inlet temperature, it is necessary to calculate these for each specific case. The optimum diameter for a sewer pipe exposed to freezing conditions can be calculated by the following.

$$\frac{\Delta . S}{N}\left(0.314 . L + 549 \ \alpha^{0.115} \ \nu^{0.8} \ D^{1.345}\right) = \frac{0.113 \ h_o \ L}{\alpha^{0.575} \ D^{2.725}} + \frac{18.1 \ h_o \ \nu^{0.8}}{\alpha^{0.460} \ D^{1.380}}$$

The required inlet temperature for sewage is

$$32 + B{+}C \ {}^{\circ}F$$

where

$$\frac{B+C}{32+A} = \frac{\Delta S}{N}\left(0.314 \ DL + 234 \ D^{2.345} \ \alpha^{0.115} \ \nu^{0.8}\right) + \frac{0.064 \ h_o \ L}{\alpha^{0.575} \ D^{1.725}} + \frac{47.6 \ h_o . \nu^{0.8}}{\alpha^{0.460} \ D^{0.380}}$$

Figures 1 and 2 give all the powers of α and D which are needed for these calculations. The simplicity of the design procedure is shown in Appendix A. Figure A 1 shows the sensitivity of the required inlet temperature to variations in pipe diameter.

NOMENCLATURE

V	=	velocity (ft/hr)
g	=	acceleration of gravity = 4.17×10^8 (ft/hr^2)
X	=	difference in height of pipe between inlet and outlet (ft)
L	=	length of pipe (ft)
D	=	inside diameter of pipe (ft)
f	=	friction factor = $0.34/(Re)^{0.26}$
Re	=	Reynolds number = $V.D/\nu$
ν	=	Kinematic viscosity (ft^2/hr)
μ	=	absolute viscosity (lb/ft hr)
N	=	volume discharged in one siphon cycle (gallons)
t	=	time taken to discharge N gallons (hr)
Nu	=	Nusselt number = $\frac{h \cdot D}{k}$
Pr	=	Prandtl number = $\frac{c \cdot \mu}{k}$
h_i	=	heat transfer coefficient inside pipe (Btu/ft^2 hr F°)
h_o	=	heat transfer coefficient outside pipe (Btu/ft^2 hr F°)
k	=	thermal conductivity of fluid (Btu/ft hr F°)
c	=	specific heat of fluid (Btu/lb F°)
$-A$	=	outside air design temperature (°F)
B	=	sewage outlet temperature -32 (F°)
C	=	sewage inlet temperature -(32+B) (F°)
Δ	=	thickness of pipe wall (ft)
S	=	volumetric specific heat of pipe material (Btu/ft^3 F°)
α	=	$\frac{2\ g\ X/L}{0.34\ \ \nu^{0.26}}$

MOUNT WASHINGTON SEWER INTERCEPTOR PRELIMINARY HEAT TRANSFER CALCULATIONS

Parameter	Description	Unit	Formula	Value	Notes
V	Velocity	ft/s		2	
V	Velocity	ft/hr		7200	
g	Acc due to gravity	ft/hr^2		4.17E+08	
X	Elevation difference (inlet to outlet)	ft		2400	Assumes bottom third is heat traced
L	Length	ft		10000	Assumes bottom third is heat traced
D	Inside diameter	ft		0.500	
v	kinematic viscosity	ft^2/hr		6.95E-02	Sanks, Pumping Station Design 1998
u	absolute viscosity	lb/ft-hr		1.35E-01	Sanks, Pumping Station Design 1998
N	Cycle voume	gal		4000	Larger volume reduces required inlet temperature
t	time to discharge N (Assuming 85 gpm pump rate)	hr		0.80	
hi	heat transfer coefficient inside pipe	Btu/ft^2-hr-F	=(0.021*V^0.8) / (v^0.8*D^0.2)	248	Equation 4, Stephenson 1959
ho	heat transfer coefficient outside pipe	Btu/ft^2-hr-F		0.17	Urecon Specifications for buried insulated pipe
-A	outside design temperature	F		-20	Design soil temperature with two feet cover
B	Sewage Outlet Temp: 32	F		1	
C	Sewage Inlet Temp: (32 + B)	F		37	
del	thickness of pipe wall	ft		0.0229	
S	volumetric specific heat of pipe material	Btu/ft^3-F		83.69	
alpha			(2gX/L) / (0.34v^0.26)	1.18E+09	
Re	Reynolds number		VD/v	5.18E+04	
f	Friction factor		0.34/Re^0.26	0.020	
RHS				0.78	
32+A				52	
B+C				41	
Inlet Temp Required				73	

APPENDIX 3
SEWERCAD MODEL RESULTS

6" Main - ADF (5,000 GPD)

FlexTable: Conduit Table

ID	Label	Start Node	Set Invert to Start?	Invert (Start) (ft)	Stop Node
46	CO-1	MH-1	True	6,258.00	CS-2
47	CO-2	CS-2	True	6,140.00	CS-3
48	CO-3	CS-3	True	6,008.00	CS-4
49	CO-4	CS-4	True	5,823.00	CS-5
50	CO-5	CS-5	True	5,633.00	CS-6
51	CO-6	CS-6	True	5,393.00	CS-7
52	CO-7	CS-7	True	5,058.00	CS-8
53	CO-8	CS-8	True	4,743.00	CS-9
54	CO-9	CS-9	True	4,433.00	CS-10
55	CO-10	CS-10	True	4,128.00	CS-11
56	CO-11	CS-11	True	3,903.00	CS-12
57	CO-12	CS-12	True	3,697.00	CS-13
58	CO-13	CS-13	True	3,405.00	CS-14
59	CO-14	CS-14	True	3,144.00	CS-15
60	CO-15	CS-15	True	2,928.00	CS-16
61	CO-16	CS-16	True	2,735.00	MH-21
62	CO-17	MH-21	True	2,656.00	O-1

Set Invert to Stop?	Invert (Stop) (ft)	Has User Defined Length?	Length (User Defined) (ft)	Length (Scaled) (ft)	Slope (Calculated) (ft/ft)
True	6,140.00	True	450.0	82.5	0.262
True	6,008.00	True	1,000.0	84.8	0.132
True	5,823.00	True	1,000.0	84.8	0.185
True	5,633.00	True	1,000.0	89.7	0.190
True	5,393.00	True	1,000.0	91.1	0.240
True	5,058.00	True	1,000.0	88.0	0.335
True	4,743.00	True	1,000.0	92.0	0.315
True	4,433.00	True	1,000.0	77.1	0.310
True	4,128.00	True	1,200.0	69.8	0.254
True	3,903.00	True	880.0	78.1	0.256
True	3,697.00	True	1,000.0	94.2	0.206
True	3,405.00	True	1,000.0	94.9	0.292
True	3,144.00	True	1,000.0	94.9	0.261
True	2,928.00	True	1,000.0	92.8	0.216
True	2,735.00	True	1,000.0	87.9	0.193
True	2,656.00	True	570.0	90.7	0.139
True	2,655.00	True	50.0	62.1	0.020

Section Type	Diameter (in)	Manning's n	Flow (cfs)	Velocity (ft/s)	Depth (Middle) (ft)
Circle	6.0	0.010	0.01	3.80	0.03
Circle	6.0	0.010	0.01	2.93	0.03
Circle	6.0	0.010	0.01	3.31	0.03
Circle	6.0	0.010	0.01	3.34	0.03
Circle	6.0	0.010	0.01	3.61	0.03
Circle	6.0	0.010	0.01	4.17	0.03
Circle	6.0	0.010	0.01	4.07	0.03
Circle	6.0	0.010	0.01	4.05	0.03
Circle	6.0	0.010	0.01	3.75	0.03
Circle	6.0	0.010	0.01	3.76	0.03

FlexTable: Conduit Table

Section Type	Diameter (in)	Manning's n	Flow (cfs)	Velocity (ft/s)	Depth (Middle) (ft)
Circle	6.0	0.010	0.01	3.43	0.03
Circle	6.0	0.010	0.01	3.96	0.03
Circle	6.0	0.010	0.01	3.79	0.03
Circle	6.0	0.010	0.01	3.48	0.03
Circle	6.0	0.010	0.01	3.35	0.03
Circle	6.0	0.010	0.01	2.99	0.03
Circle	6.0	0.010	0.01	1.52	0.04

Capacity (Full Flow) (cfs)	Flow / Capacity (Design) (%)	Depth (Average End) / Rise (%)	Notes
3.74	0.2	5.8	
2.65	0.3	6.2	
3.14	0.2	6.0	
3.18	0.2	6.0	
3.57	0.2	5.9	
4.22	0.2	5.7	
4.09	0.2	5.8	
4.06	0.2	5.8	
3.68	0.2	5.9	
3.69	0.2	5.9	
3.31	0.2	6.0	
3.94	0.2	5.8	
3.73	0.2	5.9	
3.39	0.2	5.9	
3.20	0.2	6.0	
2.72	0.3	6.1	
1.03	0.7	7.3	

FlexTable: Conduit Table

Section Type	Diameter (in)	Manning's n	Flow (cfs)	Velocity (ft/s)	Depth (Middle) (ft)
Circle	6.0	0.010	0.18	9.01	0.15
Circle	6.0	0.010	0.18	10.14	0.14
Circle	6.0	0.010	0.18	9.79	0.14
Circle	6.0	0.010	0.18	9.16	0.15
Circle	6.0	0.010	0.18	8.80	0.15
Circle	6.0	0.010	0.18	7.84	0.15
Circle	6.0	0.010	0.18	3.95	0.18

Capacity (Full Flow) (cfs)	Flow / Capacity (Design) (%)	Depth (Average End) / Rise (%)	Notes
3.74	4.8	28.7	
2.65	6.8	30.0	
3.14	5.7	29.3	
3.18	5.7	29.3	
3.57	5.0	28.8	
4.22	4.3	28.2	
4.09	4.4	28.3	
4.06	4.4	28.3	
3.68	4.9	28.7	
3.69	4.9	28.7	
3.31	5.4	29.1	
3.94	4.6	28.5	
3.73	4.8	28.7	
3.39	5.3	29.0	
3.20	5.6	29.2	
2.72	6.6	29.9	
1.03	17.4	35.3	

6" Main - Buildout Peak Hour (120,000 GPD)

FlexTable: Conduit Table

ID	Label	Start Node	Set Invert to Start?	Invert (Start) (ft)	Stop Node
46	CO-1	MH-1	True	6,258.00	CS-2
47	CO-2	CS-2	True	6,140.00	CS-3
48	CO-3	CS-3	True	6,008.00	CS-4
49	CO-4	CS-4	True	5,823.00	CS-5
50	CO-5	CS-5	True	5,633.00	CS-6
51	CO-6	CS-6	True	5,393.00	CS-7
52	CO-7	CS-7	True	5,058.00	CS-8
53	CO-8	CS-8	True	4,743.00	CS-9
54	CO-9	CS-9	True	4,433.00	CS-10
55	CO-10	CS-10	True	4,128.00	CS-11
56	CO-11	CS-11	True	3,903.00	CS-12
57	CO-12	CS-12	True	3,697.00	CS-13
58	CO-13	CS-13	True	3,405.00	CS-14
59	CO-14	CS-14	True	3,144.00	CS-15
60	CO-15	CS-15	True	2,928.00	CS-16
61	CO-16	CS-16	True	2,735.00	MH-21
62	CO-17	MH-21	True	2,656.00	O-1

Set Invert to Stop?	Invert (Stop) (ft)	Has User Defined Length?	Length (User Defined) (ft)	Length (Scaled) (ft)	Slope (Calculated) (ft/ft)
True	6,140.00	True	450.0	82.5	0.262
True	6,008.00	True	1,000.0	84.8	0.132
True	5,823.00	True	1,000.0	84.8	0.185
True	5,633.00	True	1,000.0	89.7	0.190
True	5,393.00	True	1,000.0	91.1	0.240
True	5,058.00	True	1,000.0	88.0	0.335
True	4,743.00	True	1,000.0	92.0	0.315
True	4,433.00	True	1,000.0	77.1	0.310
True	4,128.00	True	1,200.0	69.8	0.254
True	3,903.00	True	880.0	78.1	0.256
True	3,697.00	True	1,000.0	94.2	0.206
True	3,405.00	True	1,000.0	94.9	0.292
True	3,144.00	True	1,000.0	94.9	0.261
True	2,928.00	True	1,000.0	92.8	0.216
True	2,735.00	True	1,000.0	87.9	0.193
True	2,656.00	True	570.0	90.7	0.139
True	2,655.00	True	50.0	62.1	0.020

Section Type	Diameter (in)	Manning's n	Flow (cfs)	Velocity (ft/s)	Depth (Middle) (ft)
Circle	6.0	0.010	0.18	9.80	0.14
Circle	6.0	0.010	0.18	7.70	0.15
Circle	6.0	0.010	0.18	8.67	0.15
Circle	6.0	0.010	0.18	8.75	0.15
Circle	6.0	0.010	0.18	9.50	0.14
Circle	6.0	0.010	0.18	10.70	0.14
Circle	6.0	0.010	0.18	10.49	0.14
Circle	6.0	0.010	0.18	10.44	0.14
Circle	6.0	0.010	0.18	9.70	0.14
Circle	6.0	0.010	0.18	9.72	0.14

6" Main - Full Pipe Flow (1,700,000 GPD)

FlexTable: Conduit Table

ID	Label	Start Node	Set Invert to Start?	Invert (Start) (ft)	Stop Node
46	CO-1	MH-1	True	6,258.00	CS-2
47	CO-2	CS-2	True	6,140.00	CS-3
48	CO-3	CS-3	True	6,008.00	CS-4
49	CO-4	CS-4	True	5,823.00	CS-5
50	CO-5	CS-5	True	5,633.00	CS-6
51	CO-6	CS-6	True	5,393.00	CS-7
52	CO-7	CS-7	True	5,058.00	CS-8
53	CO-8	CS-8	True	4,743.00	CS-9
54	CO-9	CS-9	True	4,433.00	CS-10
55	CO-10	CS-10	True	4,128.00	CS-11
56	CO-11	CS-11	True	3,903.00	CS-12
57	CO-12	CS-12	True	3,697.00	CS-13
58	CO-13	CS-13	True	3,405.00	CS-14
59	CO-14	CS-14	True	3,144.00	CS-15
60	CO-15	CS-15	True	2,928.00	CS-16
61	CO-16	CS-16	True	2,735.00	MH-21
62	CO-17	MH-21	True	2,656.00	O-1

Set Invert to Stop?	Invert (Stop) (ft)	Has User Defined Length?	Length (User Defined) (ft)	Length (Scaled) (ft)	Slope (Calculated) (ft/ft)
True	6,140.00	True	450.0	82.5	0.262
True	6,008.00	True	1,000.0	84.8	0.132
True	5,823.00	True	1,000.0	84.8	0.185
True	5,633.00	True	1,000.0	89.7	0.190
True	5,393.00	True	1,000.0	91.1	0.240
True	5,058.00	True	1,000.0	88.0	0.335
True	4,743.00	True	1,000.0	92.0	0.315
True	4,433.00	True	1,000.0	77.1	0.310
True	4,128.00	True	1,200.0	69.8	0.254
True	3,903.00	True	880.0	78.1	0.256
True	3,697.00	True	1,000.0	94.2	0.206
True	3,405.00	True	1,000.0	94.9	0.292
True	3,144.00	True	1,000.0	94.9	0.261
True	2,928.00	True	1,000.0	92.8	0.216
True	2,735.00	True	1,000.0	87.9	0.193
True	2,656.00	True	570.0	90.7	0.139
True	2,655.00	True	50.0	62.1	0.020

Section Type	Diameter (in)	Manning's n	Flow (cfs)	Velocity (ft/s)	Depth (Middle) (ft)
Circle	6.0	0.010	2.65	20.64	0.41
Circle	6.0	0.010	2.65	15.39	(N/A)
Circle	6.0	0.010	2.65	17.92	0.43
Circle	6.0	0.010	2.65	18.11	0.42
Circle	6.0	0.010	2.65	19.92	0.41
Circle	6.0	0.010	2.65	22.71	0.39
Circle	6.0	0.010	2.65	22.17	0.40
Circle	6.0	0.010	2.65	22.04	0.40
Circle	6.0	0.010	2.65	20.38	0.41
Circle	6.0	0.010	2.65	20.43	0.41

FlexTable: Conduit Table

Section Type	Diameter (in)	Manning's n	Flow (cfs)	Velocity (ft/s)	Depth (Middle) (ft)
Circle	6.0	0.010	2.65	18.72	0.42
Circle	6.0	0.010	2.65	21.53	0.40
Circle	6.0	0.010	2.65	20.60	0.41
Circle	6.0	0.010	2.65	19.09	0.42
Circle	6.0	0.010	2.65	18.23	0.42
Circle	6.0	0.010	2.65	15.76	0.50
Circle	6.0	0.010	2.65	13.50	0.50

Capacity (Full Flow) (cfs)	Flow / Capacity (Design) (%)	Depth (Average End) / Rise (%)	Notes
3.74	70.9	81.1	
2.65	100.0	(N/A)	
3.14	84.5	85.2	
3.18	83.3	84.8	
3.57	74.2	82.0	
4.22	62.8	78.7	
4.09	64.7	79.2	
4.06	65.3	79.4	
3.68	72.1	81.4	
3.69	71.9	81.3	
3.31	80.0	83.8	
3.94	67.2	80.0	
3.73	71.1	81.1	
3.39	78.2	83.2	
3.20	82.7	84.6	
2.72	97.6	99.9	
1.03	256.9	99.9	

APPENDIX 4
OPINIONS OF CAPITAL COST

SARGENTS PURCHASE, NH
MOUNT WASHINGTON SEWER PIPELINE
FEASIBILITY STUDY
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION COST
OPTION A - SUMMER OPERATION ONLY

12/12/2017

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
General Requirements	1	LS	$ 193,908.00	$193,908
Clearing and Grubbing	1	LS	$ 10,000.00	$10,000
Rock Removal (Allowance)	500	CY	$ 25.00	$12,500
6" HDPE Pipe, Installed with 2-ft of cover	17000	LF	$ 50.00	$850,000
6" Two Way Tee Cleanout (Every 1000')	16	EA	$ 150.00	$2,400
Energy Dissipation Structure (drop manhole, etc., Allowance	1	LS	$ 100,000.00	$100,000
Concrete Pipe Anchor (Every 50')	302	EA	$ 500.00	$151,000
Erosion Control (permanent, trench dams, drainage swales, ect.)	1	LS	$ 150,000.00	$150,000
Chemical Feed (pH Adjustment)	1	LS	$ 30,000.00	$30,000
Erosion Control (during construction)	1	LS	$ 30,000.00	$30,000
Restoration	1	LS	$ 30,000.00	$30,000
Electrical Allowance	1	LS	$ 10,000.00	$10,000
Subsurface Disposal	1	LS	$ 250,000.00	$250,000
SUBTOTAL				***$1,820,000***
Contractor OH&P - 15%				$273,000
General Contingency - 20%				$364,000
Mount Washington Additional Contingency - 20%				$364,000
TOTAL PROBABLE CONSTRUCTION COST				***$2,821,000***
Design Phase Engineering Services - 10%				***$282,000***
Construction Phase Engineering Services - 15%				***$423,000***
TOTAL PROJECT COST				***$3,526,000***

Notes:
1. Subsurface disposal cost does not include cost of land.
2. Mount Washington Additional Contingency included for site specific construction costs (steep grade, remote location, ect.)

SARGENTS PURCHASE, NH
MOUNT WASHINGTON SEWER PIPELINE
FEASIBILITY STUDY
CONCEPTUAL OPINION OF PROBABLE CONSTRUCTION COST
OPTION B - SUMMER AND WINTER OPERATION

12/12/2017

ITEM	QUANTITY	UNIT	UNIT PRICE	PROBABLE COST
General Requirements	1	LS	$ 236,004.00	$236,004
Clearing and Grubbing	1	LS	$ 10,000.00	$10,000
Rock Removal (Allowance)	500	CY	$ 25.00	$12,500
6" HDPE Pipe plus 2" Urethane Insulation installed 2-ft down	17000	LF	$ 60.00	$1,020,000
Energy Dissipation Structure (drop manhole, etc., Allowance	1	LS	$ 150,000.00	$150,000
Electric Heat Trace	5000	LF	$ 15.00	$75,000
Joint Insulation kit (Every 50')	302	EA	$ 100.00	$30,200
6" Two Way Tee Cleanout Insulated (Every 1000')	16	EA	$ 500.00	$8,000
Concrete Pipe Anchor (Every 50')	302	EA	$ 500.00	$151,000
Erosion Control (permanent, trench dams, drainage swales, ect.)	1	LS	$ 150,000.00	$150,000
Chemical Feed (pH Adjustment)	1	LS	$ 30,000.00	$30,000
Erosion Control (during construction)	1	LS	$ 30,000.00	$30,000
Restoration	1	LS	$ 30,000.00	$30,000
Electrical Allowance	1	LS	$ 20,000.00	$20,000
Subsurface Disposal	1	LS	$ 250,000.00	$250,000
SUBTOTAL				***$2,203,000***
Contractor OH&P - 15%				$330,000
General Contingency - 20%				$441,000
Mount Washington Additional Contingency - 20%				$441,000
TOTAL PROBABLE CONSTRUCTION COST				***$3,415,000***
Design Phase Engineering Services - 10%				***$342,000***
Construction Phase Engineering Services - 15%				***$512,000***
TOTAL PROJECT COST				***$4,269,000***

Notes:
1. Subsurface disposal cost does not include cost to purchase or lease land.
2. Mount Washington Additional Contingency included for site specific construction costs (steep grade, remote location, ect.)