Appendix N

Outfall Drawings and Condition Assessment

Appendix 7: *Existing Outfall Assessment Technical Brief*

Technical Brief

Existing Outfall Assessment

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Acronyms and Abbreviations

ea	each
CCTV	closed-circuit television
FRP	fibreglass-reinforced plastic
ft	foot, feet
ft^3/s	cubic feet per second
GVS&DD	Greater Vancouver Sewerage and Drainage District
HGL	hydraulic grade line
LGWWTP	Lions Gate Wastewater Treatment Plant
LM	linear metre
LS	lump sum
m	metre
m/s	metre per second
ML/d	megalitre per day
nhc	northwest hydraulic consultants
No.	number
psi	pounds per square inch
TB	technical brief

1. Capacity Assessment

1.1 Introduction

The objective of this technical brief (TB) is to assess the theoretical capacity of the existing Lions Gate Wastewater Treatment Plant (LGWWTP) outfall and compare the findings to previous analyses by Metro Vancouver and others.

This capacity assessment assumes a design-treated effluent flow of 320 megalitres per day (ML/d) (peak wet weather flow) and a peak future tide level of 5.26 metres (m) geodetic. The peak tide level assumes a current peak of 4.76 m with an additional 0.5 m added for global sea level rise to 2050.

1.2 Background Information and Assumptions

The current outfall was built in 1970 as part of the Stage 3 expansion of LGWWTP. At that time, the old outfall section was abandoned.

The current outfall pipe has the following specifications:

- Diameter: 1.37 m (54 inches)
- Material: Fibreglass-reinforced plastic (FRP)
- Length: 268 m (880 feet [ft])
- Upstream invert elevation: -0.37 m, geodetic datum or 90.17 ft, Greater Vancouver Sewerage and Drainage District (GVS&DD) datum
- Downstream invert elevation: -23.96 m, geodetic datum or 12.75 ft, GVS&DD datum

There are 10 diffuser ports positioned along the crown of the 1.37-m conduit at 30.5 m (100 ft) from the downstream end prior to releasing flow into the First Narrows. The diffuser ports have the following specifications:

- Diameter: 0.81 m (18 inches)
- Material: FRP
- Height: 21.3 m (7 ft) from the centre of the 1.37-m conduit
- 90 degree elbow at the top end of the diffusers
- 1.37 m (54 inch) concrete protector

Following are the as-built drawings for the current outfall:

- SF-1038, Sheet 1 of 2, Plan and Profile
- SF-1038, Sheet 2 of 2, General Pipe Layout and Details
- SF-1400, G-50-049, General Site Plan and Bore Hole Log

The outfall is located downstream from the existing Parshall flume that has a 2.43-m (8-ft) throat. The 1.37-m-diameter steel discharge from the flume diverts 60 degrees to the west from the abandoned outfall before entering a 1.37-m outfall pipe at invert elevation of -0.37 m, geodetic datum. The outfall pipe discharges into the First Narrows at invert elevation of -23.96 m geodetic datum or 12.75 ft GVS&DD datum.

Metro Vancouver provided the following reports, memoranda, and data to assist in the outfall capacity assessment:

- Report – *Hydraulic Analysis of the Lions Gate Treatment Plant* (nhc, 1996)
- Topic Summary – *Existing Outfall – Background Information* (Metro Vancouver, 2011)

- Memorandum – *Proposed New North Shore Wastewater Treatment Plant: Summary of Miscellaneous Analytical Findings* (Metro Vancouver, 2012a)
- Model – *LGWWTP Outfall Hydraulic model* (Metro Vancouver, 2012b) (based on previous Excel model from 2000)

1.3 Capacity Calculation

The outfall boundary conditions, namely the peak flow and the maximum tide level, are set, and the capacity analysis generally involves determining the required hydraulic grade line (HGL) elevation at the outfall inlet.

At 320 ML/d or 3,700 litres per second peak flow, the velocity in the 1,372-mm outfall pipe is 2.50 metres per second (m/s), which is faster than desirable, but still acceptable. An ideal velocity would be in the range of 1.0 to 1.5 m/s, and a new outfall would be sized accordingly.

A simple calculation based on the Hazen Williams formula was used to estimate the friction losses in the outfall pipe. A pipe roughness coefficient of 130 was used, which is reasonable for FRP pipe. Minor losses in the outfall and at the diffusers were then calculated using typical k values for fittings, entry, and exit losses. Finally, an adjustment was made for the density difference between wastewater and sea water. The calculations are attached in Appendix A.

The estimated losses and required inlet HGL elevation are summarized in Table 1.

Table 1. Outfall Calculation Summary

Item	Elevation/Head Loss (m)
Maximum tide level	5.26
Outfall friction losses	0.85
Outfall minor losses	0.26
Diffusers minor losses	0.48
Density adjustment	0.66
Total losses	2.24
HGL at outfall inlet	7.50

1.4 Comparison to Previous Hydraulic Analyses Findings

Previous hydraulic analyses on the existing outfall Metro Vancouver provided includes the 1996 hydraulic study by northwest hydraulic consultants (nhc) and the Excel model Metro Vancouver assembled and recently updated for global sea level rise.

1.4.1 LGWWTP Hydraulic Analysis, nhc, 1996

This study by nhc analyzed the hydraulics both upstream and downstream of the existing LGWWTP for various flow scenarios. A peak flow of 130 cubic feet per second (ft^3/s) was analyzed, which was the peak pump capacity at the time. However, the report made it clear that this flow would lead to over-topping in the plant at high-tide levels. 130 ft^3/s is equivalent to the peak design flow for the new plant (320 ML/d).

The downstream analysis involved assessing flow through the plant from the influent pumps' discharge chamber through to the outfall. Calculated losses in the outfall pipe and diffusers can be compared to the calculations in this TB by looking at the HGL at the Parshall flume outlet. The high-tide level used in the calculations was equivalent to 2.48 m geodetic and is, therefore, much lower than the current threshold. The comparison to this model would therefore be based only on the calculated losses and the required driving head on the outfall for the peak flow.

The nhc calculations used the Manning's equation and an n value of 0.012 to estimate the friction losses in the outfall pipe. Minor losses and the density adjustment were calculated similarly as was done for this paper. The findings are almost identical to the current calculations and are summarized in Table 2.

Table 2. 1996 nhc Analysis Outfall Calculation Summary

Item	Head loss (ft)	Head loss (m)
Outfall friction losses	3.02	0.92
Outfall minor losses	0.83	0.25
Diffusers minor losses	1.39	0.42
Density adjustment	2.11	0.64
Total losses	7.35	2.23

1.4.2 LGWWTP Hydraulic Analysis, Metro Vancouver Model, 2012a

The Metro Vancouver Excel outfall model was originally developed in 2000, was recently updated in 2012, and includes future maximum tide levels that account for anticipated global sea level rise. The analyzed flows include 143.1 ft^3/s (350 ML/d) and 115.5 ft^3/s (280 ML/d), and the findings for the 320-ML/d design flow can, therefore, be interpolated.

The model is more complex than nhc's previous analysis and uses the direct step method to calculate the HGL and energy grade line profiles for the outfall using the Bernoulli equation and the Energy Loss equation. A detailed description of the methodology is contained in Appendix A of *Proposed New North Shore Wastewater Treatment Plant: Summary of Miscellaneous Analytical Findings* (Metro Vancouver, 2012a).

The HGL levels estimated by the Excel model are lower than the findings from the simplified nhc and current calculations. While the model description in the 2012 memorandum indicates that the density differential between sea water and wastewater is accounted for, this is not clear in the actual model and needs to be verified. The estimated total losses and the required HGL elevation for the analyzed flows, as well as values interpolated for the design flow of 320 ML/d, are summarized in Table 3.

Table 3. 2012 Metro Vancouver Model Outfall Calculation Summary

Item	Elevation (GVS&DD datum)/head loss (ft)	Elevation (geodetic)/ head loss (m)
Maximum tide level	108.6	5.26
Flow = 350 ML/d (143.1 ft^3/s)		
Head losses	6.05	1.84
HGL at outfall inlet	114.65	7.10
Flow = 280 ML/d (115.5 ft^3/s)		

Table 3. 2012 Metro Vancouver Model Outfall Calculation Summary

Item	Elevation (GVS&DD datum)/head loss (ft)	Elevation (geodetic)/ head loss (m)
Head losses	3.95	1.20
HGL at outfall inlet	112.55	6.46
Flow = 320 ML/d (130 ft^3/s)		
Head losses	5.05	1.54
HGL at outfall inlet	113.65	6.80

1.5 Conclusion and Recommendations

The theoretical outfall capacity calculations and models are generally consistent in their findings. A simple Hazen Williams equation-based calculation that was done for this TB provides results identical to nhc's in 1996. A more recent and complex model Metro Vancouver developed in-house yields lower losses in the outfall and diffusers. Therefore, the simplified calculations can be considered to be more conservative.

In conclusion, the existing 1,372-mm-diameter FRP outfall is adequate for treated effluent disposal at a peak flow of 320 ML/d from a hydraulic capacity perspective. The velocity at peak flow is 2.50 m/s and the theoretical HGL is approximately 2.25 m above the maximum tide level. Based on a forecast 2050 maximum tide elevation of 5.26 m, the HGL at the outfall inlet is calculated at elevation 7.50 m geodetic.

The following is recommended to further confirm the outfall capacity:

- Check the Metro Vancouver outfall model to confirm that the density differential between sea water and wastewater is accounted for
- Carry out a condition assessment of the outfall pipe to verify whether the assumed smooth inside pipe wall assumption is reasonable. Any damage or deterioration of the FRP pipe could impact the assumed pipe wall roughness assumptions used in the calculations and the model
- Calibrate the calculations and model against actual data. The existing LGWWTP flows to the outfall are measured at the Parshall flume after the chlorine contact tank. The calibration of the modelled HGL should be a relatively simple task of correlating the measured flows with measured levels at the outlet and actual tide data.

2. Condition Assessment

2.1 Objective

The objective of this TB is to assess the expected condition of the existing LGWWTP outfall and provide recommendations for further investigations. Condition assessments carried out to date include only external dive inspections of the outfall. Therefore, the information in this discussion paper is derived only from the as-built drawings and specifications and research of relevant literature.

In addition, an order of magnitude capital cost estimate for a replacement outfall is included.

2.2 Background Information and Assumptions

The current outfall was installed in 1970 as part of the Stage 3 Expansion of LGWWTP. The outfall pipe is 1.37-m- (54-inch)-diameter FRP and is 268 m (880 ft) in length. There are ten 450-mm- (18-inch)-diameter diffuser ports positioned along the crown of the outfall pipe.

Following are the as-built drawings and specifications for the current outfall:

- SF – 1038, Sheet 1 of 2, Plan and Profile
- SF – 1038, Sheet 2 of 2, General Pipe Layout and Details
- GVS&DD Contract Number (No.) 133 – Supply and Delivery of Outfall Pipe
- GVS&DD Contract No. 134 – Installation of Lions Gate Outfall

2.3 Pipe Material Assessment

Fibreglass is a composite material comprised primarily of glass fibre reinforcement and thermosetting resin. It may contain additives and fillers that impart certain beneficial properties to the composite. A variety of materials have been used in manufacturing composites, with actual material selection depending on the conditions to which the composite will be exposed. The outfall designers specified the pipes to be manufactured using isophthalic polyester resin and without additives excepting, if approved by the engineer, a component to make the resin more flexible.

Fibreglass composites generally are corrosion-resistant materials; however, as with nearly all materials, they are subject to deterioration through exposure to various conditions in their environment. While the outfall pipes are not likely to be exposed to damaging temperatures, they are subject to deterioration through contact with wastewater and seawater and from physical stresses caused by external loading. Most composites will almost immediately begin to absorb moisture from their environment. This may adversely affect the composite in a number of ways, including chemical and dimensional changes (swelling), formation of delamination or blistering (commonly seen on fibreglass boat hulls), and reduction in mechanical and physical properties, such as stiffness, strength, and hardness. Testing has shown that the tensile strength of E-glass fibres commonly used for reinforcement decreases rapidly on exposure to moisture, by as much as 40 percent or more. The degree of degradation that occurs will be related to the amount of moisture absorbed, and although permeation occurs slowly, composites can become saturated in as little as 1 to 2 years' time. Moisture diffusion is accelerated by the presence of tensile stresses, which open existing internal cavities or voids and contribute to micro-crack formation. Environmental stress cracking is one of the most common modes of deterioration in polymers. Gel-coat (neat resin) layers are commonly applied to the surfaces of composites to impede the diffusion of moisture, and were specified by the outfall designer, but studies have found that they are not very effective.

The wastewater handled by the outfall pipe has undergone only primary treatment, so bio-films will be present on the interior of the pipe and the pipes will be exposed to the action of both the organisms that thrive in bio-films and their by-products. Isophthalic polyester resin is chemically resistant to acids and mild bases that may be present in

the treated secondary effluent, so the pipes should not be adversely affected by contact with wastewater or with the hydrogen sulfide and sulfuric acid that may be generated by bacteria. However, studies conducted in the mid-1990s found that composites were adversely affected by some bacteria present in wastewater.

There is ample potential for the fibreglass outfall to have deteriorated substantially in its 42 years of service. Further advice regarding material performance may be obtained from composite product manufacturers and industry organizations. However, it would be prudent to assess the condition of the outfall through direct inspection of the pipes themselves through physical testing of fibreglass samples in the lab, visual inspection for defects and deformation, or both.

Resources reviewed for this preliminary assessment are listed in Section 3, References.

2.4 Structural Assessment

A high-level structural assessment of the outfall pipe has been completed using available information. We used modulus of elasticity values, loading, and internal pressure requirements outlined in the original material specification in Contract 133 and typical material strengths provided in *Fiberglass Pipe Design* (American Water Works Association, 2005) and *Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer and Industrial Pressure Pipe ASTM D3754* (ASTM International, 2011) to determine a required pipe wall thickness. The theoretical wall thickness was used to determine the effects of the material degradation. As discussed above, we have assumed a reduction in material properties of 40 percent.

Our analysis indicates that the reduction in mechanical properties will reduce safety factors applied to the load carrying capacity of the pipe, but it is unlikely that the ultimate deflection and buckling limits for the pipe will be exceeded. This is a preliminary analysis only and must be confirmed with actual material properties, wall thickness, and profile information. An investigation to determine the thickness and profile of the pipe wall, as well as to determine the mechanical properties of the pipe wall, will be required to obtain this information.

The proposed increase in the outfall operating pressure of 2.25-m water column, the proposed future operating condition as outlined in Section 1.0, is considerably less than the 25-pounds per square inch (psi) internal pressure required in the original supply specification, and, therefore, should not pose an issue. This also will be analyzed in greater detail when additional information is available.

Additional information is required to complete a full structural assessment of the pipeline. Critical to this assessment is determining the wall profile and thickness. The original supply specification called for the pipe to be reinforced with ribs around the pipe's circumference. These have not been accounted for in our current assessment, as no information is available regarding the thickness and configuration of the pipe wall. Additionally, retrieving a sample of the pipe wall for material testing would allow us to use actual material property values for the assessment.

2.5 Outfall Replacement Capital Cost Estimate

A replacement outfall would be up-sized from the existing 1.37-m-diameter outfall. Based on a desirable velocity of 1.5 m/s at peak flow, a replacement outfall would be sized at a nominal 1.80-m (72-inch) diameter. This is beyond the size limit for high-density polyethylene pipe, therefore, the assumed material would be internally and externally coated welded steel pipe. Metro Vancouver's index pricing of approximately $75 per centimetre diameter per metre for river crossings was used for the estimate with an additional allowance for fabricating the diffuser. An outfall of the same length, profile, and number of diffusers as the existing outfall pipe was used for the order of magnitude capital cost estimate.

Table 4. Outfall Replacement Cost Estimate

Item	Description	Unit	Quantity	Unit Rate	Amount
1	Supply and install 1,800-mm, coated, welded steel outfall	LM	270	$13,500	$3,650,000
2	Fabricate diffuser	LS	1	$250,000	$250,000
3	Supply concrete ballast weights at 6-m spacing	ea	45	$10,000	$450,000
	Subtotal				$4,350,000
	25% contingency				$1,100,000
	Total Order of Magnitude Cost				**$5,450,000**

Notes: ea – each
LM – linear metre
LS – lump sump

2.6 Conclusion and Recommendations

The high-level assessment of the likely condition of the existing FRP outfall suggests that while material deterioration has probably occurred over the 42 years that it has been in service, it is not likely that the ultimate structural limits will have been exceeded. Furthermore, the slight pressurization of the outfall pipe that will occur during peak flow conditions is not expected to adversely impact the outfall.

These findings are based purely on the as-built drawings and specifications, relevant literature research, and broad assumptions on the pipe wall profile. We have not seen any record of an internal condition assessment of the outfall. We understand that there is closed-circuit television (CCTV) data and reports available for other FRP infrastructure of similar vintage within Metro Vancouver's system; however, they were not reviewed by the author of this TB. It is expected that this data may provide some further insight into the condition of FRP piping that has been in continuous wastewater service for over 40 years.

Metro Vancouver inspects the outfall on a regular basis, and to date, there has been no indication of significant deterioration or failure.

If Metro Vancouver requires additional data on the existing outfall pipe so that a more thorough assessment of its condition can be made, it is recommended that material and condition data be collected. This will aid in the decision of whether it is nearing the end of its service life.

If additional data is required, we recommend that the FRP outfall pipe be exposed at the foreshore so that the rib profile can be determined. Additionally, a coupon should be cut out of the pipe obvert so that the wall thickness can be confirmed and material tests can be conducted. This procedure should be done during low-tide and low-flow conditions, and will require localized repairs to be made.

A feasible option for an internal condition assessment of the entire length of the outfall pipe is to run a narrow-beam profiling sonar tool through the line from either the Parshall flume discharge or the access manhole. The sonar generates an acoustic pulse in a very narrow cone and can provide valuable information regarding the configuration of the pipe profile (shape) that can then be used to assess its structural condition (that is, is the conduit circular, deflected, or broken; are there any serious defects with the diffuser pipe connections; is sediment accumulating in the line). Sonar tools capture pipe profile information at regular time intervals (sampling rate) as the tool advances through the pipeline. The data is then compiled to form a video file that can be viewed by a user. The user views the video file for pipe defects, as one would do with a conventional CCTV file.

The existing outfall will be included as part of the Indicative Design; however, by the time the new wastewater treatment plant is in service, the outfall will have been in service for 50 years, so a good understanding of its physical condition is critical, as it will need to be replaced in the future when it reaches the end of its service life. The regular inspections should continue as is current practice.

3. References

American Water Works Association. 2005. *Fiberglass Pipe Design*.

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Society of the Plastics Industry, Inc. 1989. *Fiberglass Pipe Handbook*.

Wagner et al. 1994. *Microbiologically Influenced Degradation of Fiber-Reinforced Polymeric Composites*. April.

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Appendix A: Friction Loss Calculations

LGWWTP Outfall Calculations

The Hazen-Williams formula was used to calculate head-loss (friction) through the outfall with additional lossess added for fittings, entrance and exit losses at the diffusers. Density differences between fresh and salt water are accounted for as well.

HAZEN-WILLIAMS FORMULA

$$h_f = \frac{10.67 \quad L \quad Q^{1.85}}{C^{1.85} \quad d^{4.87}}$$

where:
hf = pressure loss over a length of pipe, m (head pressure)
L = length of pipe, m (meters)
Q = flow rate, m^3/s (cubic meters per second)
d = inside pipe diameter, m (meters)
C=roughness coefficient (C=130 HDPE/FRP and C=100 for steel pipe)

Existing outfall pipe diameter =	**1372**	mm
Max tide level, based on sea level rise to 2050 =	**5.26**	m
Sea bed elevation at diffusers =	**-21.3**	m

Flow rate	Roughness Coeff. C	Pipe inside diam. d	Area A	Length L	Velocity v	Head-loss (friction) hf	Total head loss (incl. minor losses+ density diff.) H_L	HGL at outfall at PWWF and HHWL
(l/s)		(mm)	(m^2)	(m)	(m/s)	(m)	(m)	(m)
EX Outfall pipe								
3700	130	1372	1.4784	268	2.50	0.85	2.24	7.50

Calculate Minor Head losses

Δh = sum(k*v^2/2/g)
where :
g= acceleration of gravity (9.81 $m/s^{2)}$
v=velocity in pipe (m/s)
sum k= sum of coefficients for singular head losses

Outfall Pipe

	k	number
Inlet	0.5	1
45 deg mitre bend	0.15	2

sum k= 0.8
V= 2.50
Minor head losses at design flow **0.26 m water column**

Diffusers (10 x 450mm)

	k	number
Inlet	0.5	1
90 elbow	0.36	1
exit	1	1

sum k= 1.86
total area = 1.65
V= 2.25
Minor head losses at design flow **0.48 m water column**

Calculate Density Head Loss

Δh= Δρ/ρ0 * y

Density of sea water (kg/m^3)	1025	
Density of water (kg/m3)	1000	
depth of outfall at HHWL=	26.56	m
Δh	**0.66**	**m water column**

Attachment A

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Suite 147; 2906 W. Broadway
Vancouver, BC V6K 2G8
Toll-Free: 888-379-7601

November 5, 2012

Marshall Gibbons, C.E.T.
AECOM
99 Commerce Drive
Winnipeg, MB R3P 0Y7
Canada

RE: CAN Vancouver Lions Gate Outfall Survey #56236

Thank you for considering AquaCoustic Remote Technologies for your pipe condition assessment needs. AquaCoustic hereby expresses and confirms interest in the above-referenced project. We offer accurate and safe remote inspection service to ensure the best data and least risk for your organization.

I am including a description of the scope of work, responsibilities and our terms and conditions. We will provide you our qualifications and references if requested.

AquaCoustic will provide a precision survey with qualified personnel. We will closely coordinate the fieldwork, data analysis and preparation of the final report in order to provide you with a quality product in a timely and cost-effective manner.

We will provide a well-organized and thorough mobilization program, reliable equipment with adequate backup, and skilled, dedicated, technically qualified operators with inshore and offshore experience.

Thank you for your consideration. Should you have any questions, please feel free to contact me at your convenience.

Sincerely,

Michael Blackshaw

1.0 Scope of Work

This proposal includes the design and fabrication of a custom skid with a built-in rigid sail to utilize flow in the pipe and minimize the chance of a soft parachute getting logged in the pipe. We propose a multi-sensor assessment of approximately 270 meters (886 feet) of outfall pipeline, 54 inches in diameter. It is our intention to demonstrate that AquaCoustic Remote Technologies is well versed in projects of this nature and can provide an accurate and useful assessment of the selected pipeline(s).

The work platform is fitted with a digital CCTV camera and profiling sonar head. A suite of computer programs is integrated into the system for data capture and post-processing.

The intent of this contract is to undertake a condition assessment to identify issues compromising flow, structural integrity and level of service of the sewer pipe before and after cleaning.

The data captured through the use of multiple sensors shall provide the ability to provide a conclusion of the overall condition as well as the ability to identify structural deficiencies for each section.

AquaCoustic Project Preparation and Review

- Review of record drawings to confirm location(s).
- Familiarization with site conditions and constraints.
- Discuss standard digital formats for managing data, as well as desired report format for compatibility.
- Conduct audits of incoming inspection data for quality control purposes including standardized file formats.
- Conduct post inspection digital data verification on all data as delivered from the field.
- Produce final report and drawings to accompany inspection binders.

AquaCoustic Deliverable

- Review of record drawings to confirm location(s).
- Familiarization with site conditions and constraints.

2.0 Equipment List

The expected equipment required to conduct the survey include:

- Robotic Skid Platform
- 1,200’ of electro fiber optic cable.
- Digital dome video camera.
- Profiling sonar head
- Solid state bearing and inclinometer.
- Payout positioning using payout counter with digital output.
- Proprietary software.

Fully trained operators with the relevant certification will operate the cameras. All site personnel have been trained in confined space entry procedures. Additional equipment information and specifications are available upon request.

3.0 Preliminary Schedule

The schedule is subject to change after consultation with client.

*AquaCoustic requires an advance notice of at least 21 days to mobilize.

DAYS OF ACTIVITY (System days)	MILESTONE
Day 1-21	Equipment Design/Fabrication
Day 22	Mobilize
Days 23	Survey
Day 24	Demobilization
Day 34	Report Delivery

4.0 Estimated Fee Schedule

Estimated Fee Schedule

	Item/Description	QTY	U/M	Unit Cost	Total Cost
1	Mobilization and Demoblization	1	EA	$ 4,500.00	$ 4,500.00
2	Robotic Design and Custom Fabrication	1	EA	$ 6,000.00	$ 6,000.00
3	CCTV/Sonar Survey	1	EA	$ 12,500.00	$ 12,500.00
4	QA/QC of Collected Data	1	LS	Included	Included
5	Post Processing of Collected Data	1	LS	Included	Included
6	AquaCoustic Report Completion Milestone	1	EA	$ 4,000.00	$ 4,000.00
	Total Estimated Cost				**$ 27,000.00**

Breakout of Stand-By Costs *if applicable

	Item/Description	QTY	U/M	Unit Cost	Total Cost
1	Stand-By Crew and Equipment Daily Rate*	1	DAY	$ 1,500.00	$ 1,500.00

*Stand-by rate must be approved by client and caused by conditions out of AquaCoustic's control.

*Stand-by rate is not applicable for delays caused by AquaCoustic.

5.0 Terms and Conditions

1. AquaCoustic excludes all bonds, unless otherwise stated.
2. AquaCoustic excludes prevailing wage rates, unless otherwise stated.
3. AquaCoustic excludes traffic control, unless otherwise stated.
4. AquaCoustic shall make staff available as necessary to meet the schedule. During the field data collection period, our crew(s) shall work up to 10 hour working days, unless otherwise stated.
5. Standby Rate and Additional Hours - If the schedule is delayed due to circumstances that are beyond AquaCoustic's reasonable control, that time shall be subject to an additional charge based on the fee schedule above. The rates must be approved by the client and are not applicable to delays caused by AquaCoustic.
6. Payments terms are net 30 days from date of invoice, and a finance charge of 1% will be added for each month an invoice remains unpaid after 30 days. Payments shall be remitted to the address shown on the invoice.
7. A full scope of required services often are not fully definable in the initial planning; accordingly, developments may dictate a change in the scope of work to be performed. Where this occurs, changes in the agreement shall be negotiated and agreed upon by all parties and an reasonable adjustment shall be made, prior to the work being done.
8. Delays - Costs and schedule commitments shall be subjected to renegotiation for unreasonable delays caused by the client's failure to provide specified facilities, direction, or information, or if AquaCoustic's failure to perform is due to any act of God, strikes, fire, inclement weather, act of governmental authority, failure of transportation, accident, power failure, or interruption of any other cause beyond reasonable control of AquaCoustic. Temporary work stoppage caused by any of the above may result in additional cost .
9. Certain pipeline construction, operating environments, and field conditions may limit, interfere, or prohibit AQC from obtaining data or performing work. Some of these may be, but not limited to, surface access, manhole construction, manhole chamber construction, chamber to pipeline interface, vertical and or horizontal lay of the pipeline, blind bends, obstructions, debris, lateral connections, flow levels and velocity, transported materials, flow monitors, electrical interference, cables, or other structures or conditions. In the case that these conditions arise, we will notify the client and attempt to remedy the situation along with the client utilizing additional means and services as necessary and agreed upon by all parties.
10. In the case that our work platform cannot pass through the entire section of the pipeline, blockage, etc. if possible shall reset the equipment at a downstream manhole and attempt to inspect the section from the opposite direction. If the work platform fails to pass through the blocked section, the inspection of that pipe section shall be temporarily suspended.
11. In the case that our crew(s) encounters access restrictions, we reserve the right, in consultation with client, to charge an hourly rate of $300 to locate and expose buried manholes, or create access to the work area for continuation of the survey.
12. AquaCoustic will provide support and answer questions regarding the inspection and final report for up to 60 days from the date that the final report is delivered at no additional cost. Support will continue to be available after the 60 day period, however, a fee of $100 per hour plus expenses may apply depending on the level of support required.
13. The terms and prices listed in this proposal will be honored for 90 days from the date of this proposal.

AquaCoustic Responsibilities

1. Work cooperatively with the client and provide accurate and useful condition assessment services.

2. We will deploy our sensor work platform into insertion points at least (460mm) 18” in diameter that will be made accessible for our system deployment by the client.
3. Provide quality equipment and a trained crew to operate the equipment.
4. Adequate backups for our equipment.
5. A safe work environment.

Client Responsibilities

1. Client shall facilitate physical, safe and legal access to manholes needed for deployment to the pipeline to be inspected. Open any sealed, vented or other non-standard manholes, and reinstall and or reseal them as necessary after the inspection is complete. Locate and expose such manholes as are not visible, not accessible, or are partially or completely covered.
2. Client shall provide information on known problems, designs or conditions within the pipeline to be examined so that proper field procedures can be used and necessary precautions can be taken during the inspection process for crew safety and to avoid loss of equipment.
3. Client shall also provide access to available system maps, construction plans, flow data, any videotapes, as-builts, maintenance history and or previous inspection data for the pipeline to be inspected.
4. Client shall facilitate safe and legal access to manholes needed for inspection of the pipeline. Open any sealed, vented or other non-standard manholes, and reinstall and or reseal them as necessary after the inspection is complete.
5. Client shall verify location of manholes and ensure that manholes are unbolted and able to be accessed before AquaCoustic mobilizes to the site. AquaCoustic will notify client of any access issues and reserves the right to charge for additional time spent uncovering or accessing manholes/structures.
6. Client shall provide asset identification for all manholes and pipe segments before AquaCoustic mobilizes to be used in the
7. Client shall ensure that all flow meters and all sensitive equipment is removed from the manholes and pipelines that have been selected to be inspected before AquaCoustic mobilizes to the site.
8. Client shall provide traffic control necessary for pipeline inspection unless otherwise specified in the scope of work and fee schedule.

First Tier Deliverables.

Link: 35C6

Inspected By: T. Taylor
Field Data Input Date: 4/11/2011
QC Review: MB
QC Date: 5/19/2011
Upstream MH: 1016C6
Downstream MH: 1040C5
Length Surveyed (m): 183.8
Map Length (m): 186.94

Pipe Size (mm): 1,050
Pipe Material: CO
Accumulated Volume (m³): 2.11
As-built Capacity (m³): 161.87
As-is Capacity (m³): 159.76

General Comments:

Direction of Travel:	Upstream	Inspection Date:	4/11/2011	Starting m:	0.0	
Sonar Operator:	T. Taylor	Inspection Time:	12:48:00 PM	Ending m:	183.8	
Starting Station (m)	Ending Station (m)	Cross-sectional restriction (%)	Volume of Debris (m³)	Accumulated Volume (m³)	Water Level (%)	Other Findings
0.0	10.0	3.6	0.24	0.24	33.4	
10.0	20.0	4.7	0.40	0.65	35.0	
20.0	30.0	6.1	0.53	1.18	35.0	
30.0	40.0	1.2	0.10	1.28	33.6	
40.0	50.0	1.6	0.14	1.42	32.1	
50.0	60.0	0.5	0.05	1.47	31.9	
60.0	70.0	1.0	0.09	1.56	32.7	
70.0	80.0	0.8	0.07	1.62	32.6	
80.0	90.0	0.0	0.00	1.63	31.5	
90.0	100.0	0.4	0.03	1.66	30.6	
100.0	110.0	0.3	0.03	1.69	29.5	
110.0	120.0	0.3	0.02	1.71	28.5	
120.0	130.0	0.6	0.05	1.76	30.0	
130.0	140.0	0.5	0.04	1.80	29.3	
140.0	150.0	0.7	0.06	1.87	27.6	
150.0	160.0	0.9	0.08	1.94	27.5	
160.0	170.0	0.2	0.02	1.96	27.6	
170.0	180.0	1.4	0.12	2.08	29.3	
180.0	183.8	0.8	0.03	2.11	28.7	
	Maximum Values:	6.1	0.53	2.11	35.0	
	Average Values:	1.4	0.11		30.9	

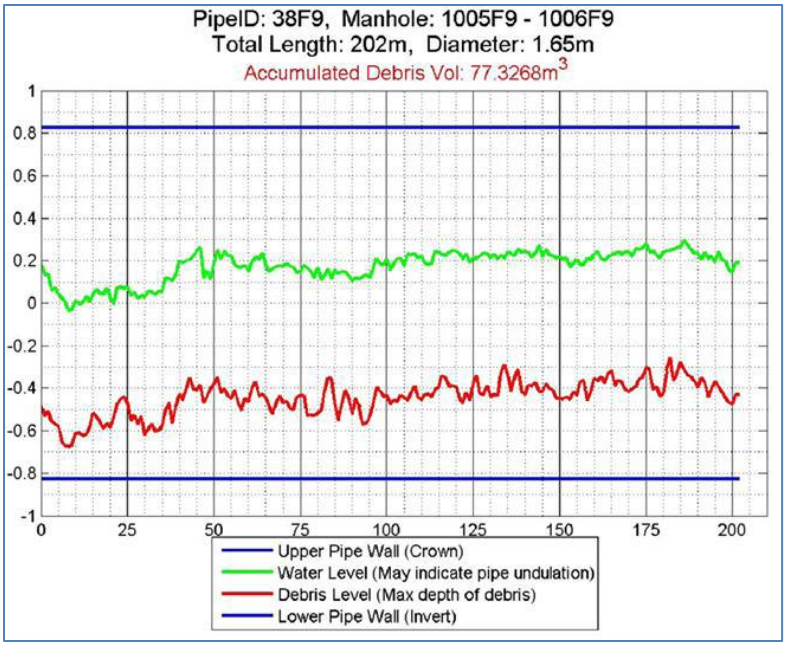
Tabulated data from MH to MH

Showing:

Percentage of pipe restriction

Debris volume and position

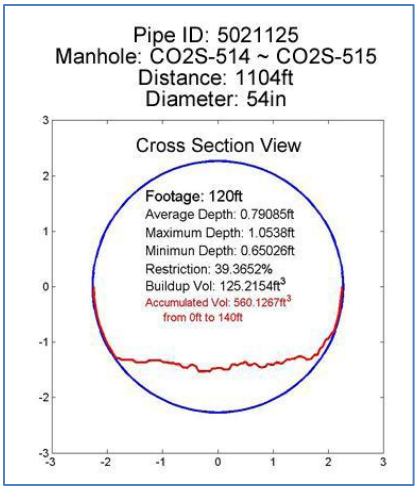
Storage capacity of pipe

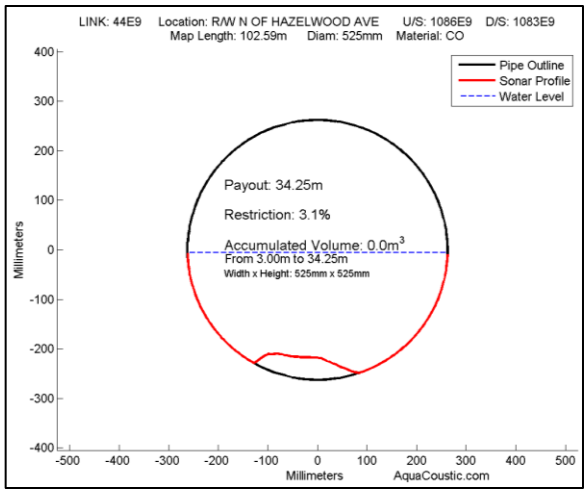


Graphed data showing:

Position and amount of buildup as a percentage of the pipe diameter.

The graphs can be part of a cleaning RFP and should lower the bid prices.





Pipe cross-sections show:

- Pipe restriction
- Buildup volume
- Accumulated volume
- Pipe deformation
- Pipe damage
- Storage volume

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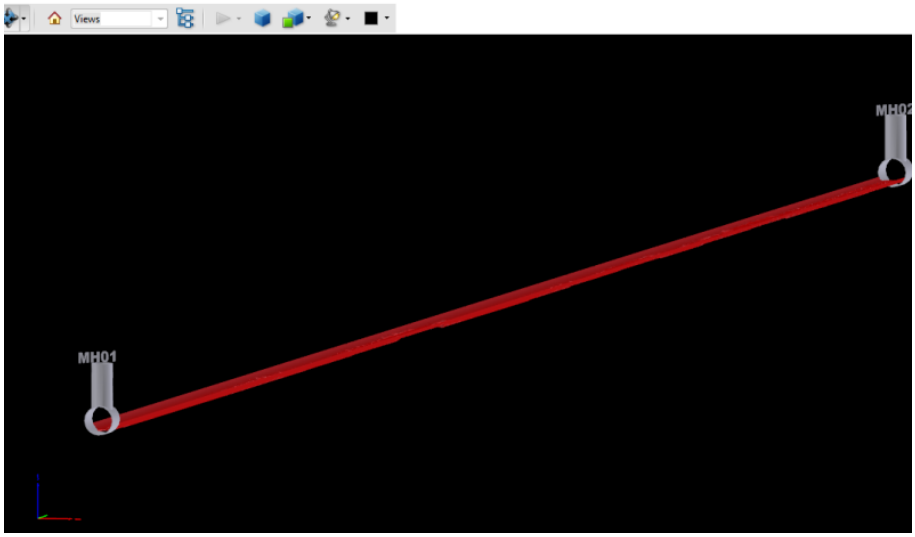
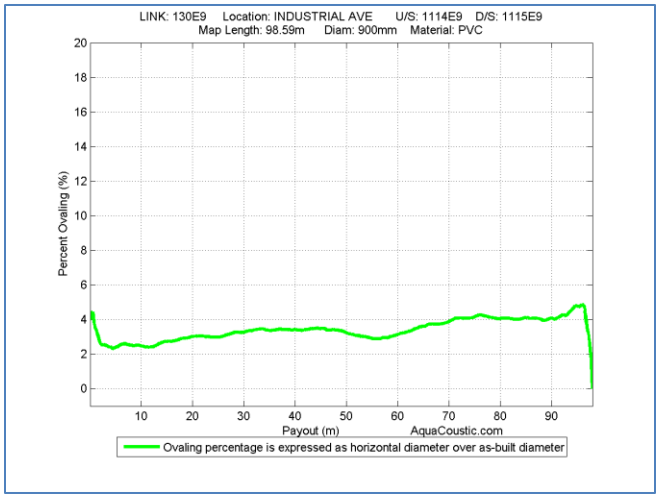
Email: aqc@aquacoustic.com Web page: www.aquacoustic.com



Optional deliverables.

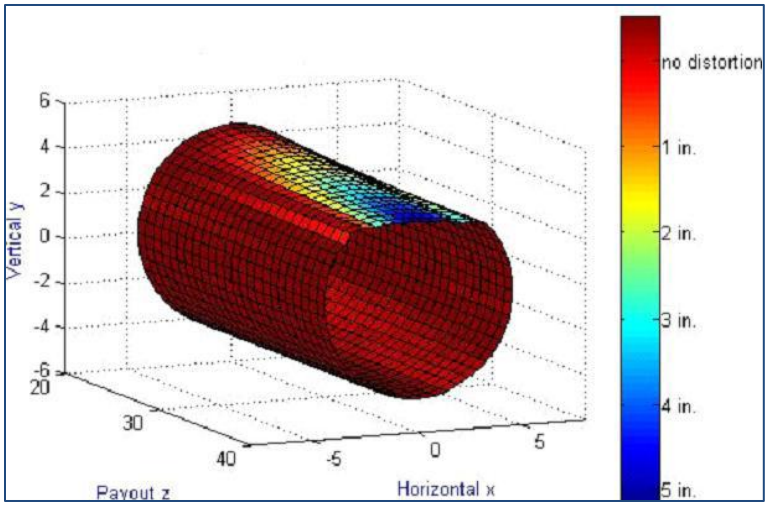
3D PDF

Manipulate and measure sonar data in a PDF document



Pipe ovaling graph.

Shows percentage of ovaling.



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Email: aqc@aquacoustic.com Web page: www.aquacoustic.com

CCTV Defect Scores report for Structural defects

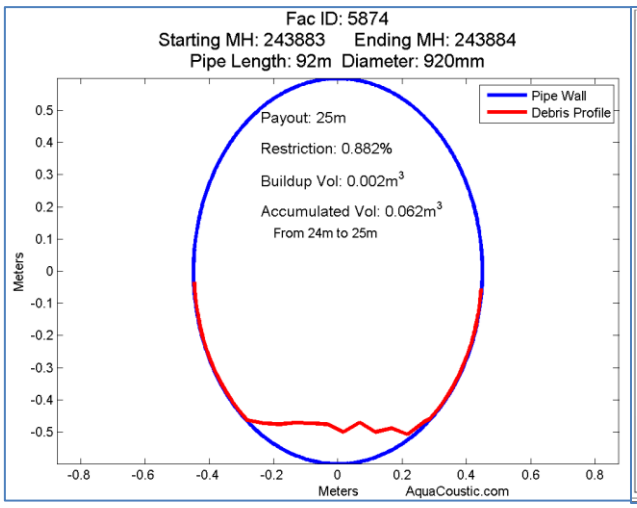
Client SANTA ROSA — **Work Order**
Project SANTA ROSA - 33781 — **Project Start** 08-09-2010
Location — **Start Tape** — **UOM** Ft
Database C:\FLEX6\DATA\SANTA ROSA.MDB — **Printed on** 07-01-2011

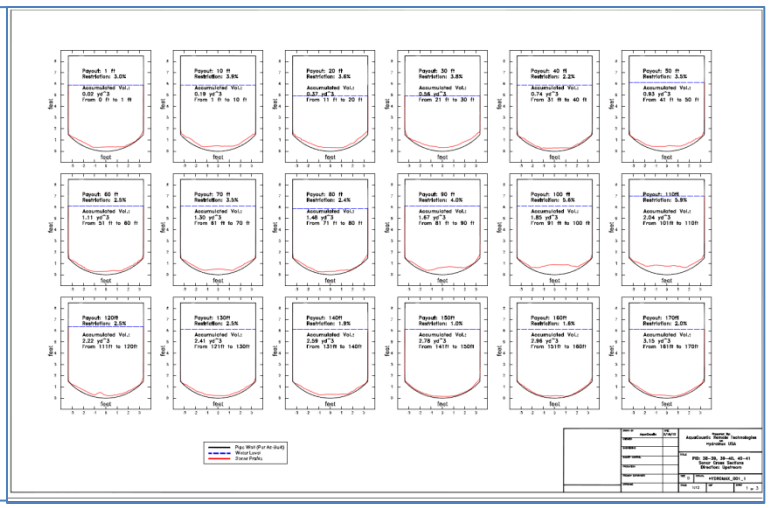
Setup	PLR	Length	Defects	Score	Peak score	Mean Pipe Score	Mean Defect Score	ICG
14	II2718SY902 X	184.0	22	38	0 Excellent	0.30 Excellent	1.70 Excellent	1
33	JJ2802SY005 X	60.0	9	16	0 Excellent	0.30 Excellent	1.80 Excellent	1
9	II2707SY017 X	81.0	9	16	0 Excellent	0.20 Excellent	1.80 Excellent	1
19	II2820SY901 X	229.0	13	16	0 Excellent	0.10 Excellent	1.20 Excellent	1
8	II2703SY078 X	97.0	8	14	0 Excellent	0.20 Excellent	1.80 Excellent	1
5	II2702SY054 X	149.0	10	14	0 Excellent	0.10 Excellent	1.40 Excellent	1
10	II2707SY096 X	120.0	8	14	0 Excellent	0.10 Excellent	1.80 Excellent	1
7	II2703SY071 X	134.0	9	14	0 Excellent	0.10 Excellent	1.60 Excellent	1
4	II2702SY010 X	78.0	7	12	0 Excellent	0.20 Excellent	1.70 Excellent	1
6	II2703SY038 X	96.0	7	12	0 Excellent	0.10 Excellent	1.70 Excellent	1
3	HH2923SY069 X	125.0	6	10	0 Excellent	0.10 Excellent	1.70 Excellent	1
11	II2712SY065 X	37.0	3	4	0 Excellent	0.10 Excellent	1.30 Excellent	1
18	II2820SY068 X	70.0	2	2	0 Excellent	0.00 Excellent	1.00 Excellent	1
12	II2712SY069 X	48.0	4	2	0 Excellent	0.00 Excellent	0.50 Excellent	1
13	II2718SY083 X	184.0	2	2	0 Excellent	0.00 Excellent	1.00 Excellent	1
2	HH2922SY099 X	89.0	2	2	0 Excellent	0.00 Excellent	1.00 Excellent	1
1	HH2922SY066 X	160.0	2	2	0 Excellent	0.00 Excellent	1.00 Excellent	1
25	II2907SY073 X	478.0	3	2	0 Excellent	0.00 Excellent	0.70 Excellent	1
35	JJ2817SY053 X	53.5	2	2	0 Excellent	0.00 Excellent	1.00 Excellent	1
32	JJ2801SY060 X	54.0	2	2	0 Excellent	0.00 Excellent	1.00 Excellent	1
31	JJ2801SY020 X	100.0	3	2	0 Excellent	0.00 Excellent	0.70 Excellent	1
30	JJ2703SY014 X	175.0	2	2	0 Excellent	0.00 Excellent	1.00 Excellent	1
29	II3015SY048 X	266.0	3	2	0 Excellent	0.00 Excellent	0.70 Excellent	1
28	II3007SY026 X	80.0	2	2	0 Excellent	0.00 Excellent	1.00 Excellent	1
26	II2908SY028 X	190.0	2	2	0 Excellent	0.00 Excellent	1.00 Excellent	1
36	JJ2822SY012 X	145.0	2	2	0 Excellent	0.00 Excellent	1.00 Excellent	1

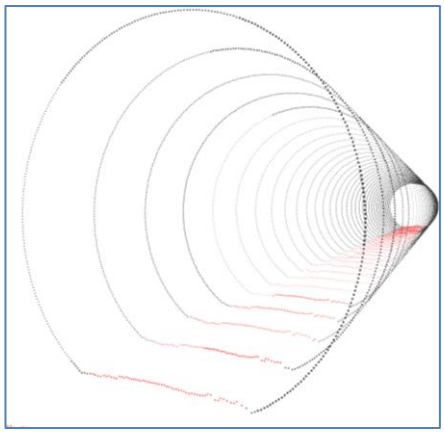
AquaCoustic REMOTE TECHNOLOGIES INC.
AquaCoustic Remote Technologies
Phone: 604-730-8117

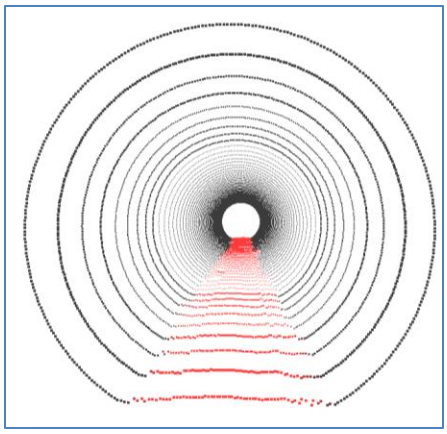
Tabulated structural defect summary.

Non-round pipe.

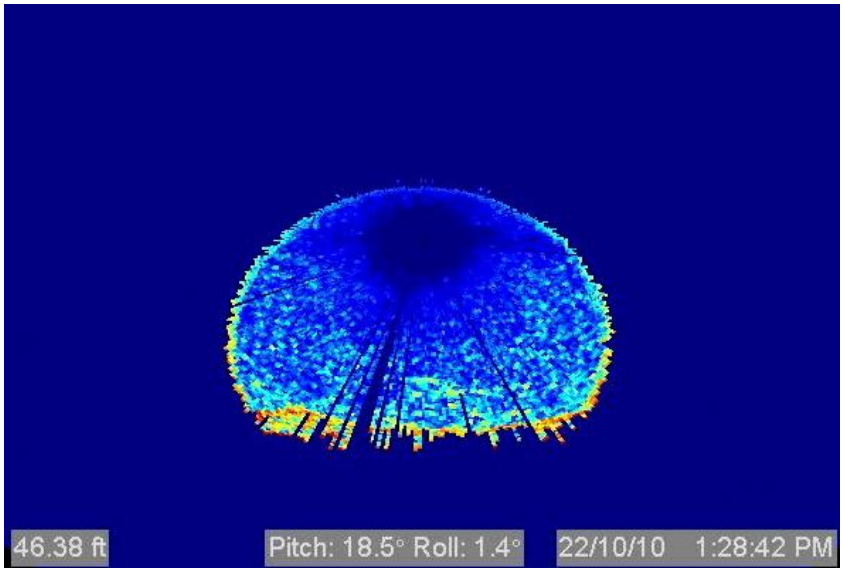








3D AutoCAD ready sonar data.



Sonar Video.

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54" I.D. Fibreglass pipe

36" I.D. Fibreglass Pipe

Air Relief MH

Harbour Headline

Access M.H.

Vancouver Harbour Chart Datum - El. 81.52

Ecc. Taper

Ground Profile at ℄ of Outfall

60.0'

50.0'

2½

Radius 1500'

Channel Bottom 1969-1970

Possible Future Channel Bottom

0.00%

8+80 Inv. 12.75

7+00 E.C. Inv. 12.70

6+50 Inv. 13.60

6+00 Inv. 16.50

5+50 Inv. 19.50

5+00 Inv. 24.30

4+50 Inv. 31.50

4+00 Inv. 40.30

3+00 Inv. 56.50

2+00 Inv. 71.50

1+00 Inv. 85.56

0+88.43 Inv. 87.30 0+87.43 Inv. 87.80

0+31.77 0+23.77 Inv. 88.23 Inv. 89.81

0+00 Inv. 90.17

All Excess Spoil disposed of within this Area.

PROFILE
Scale: Horiz. 1" = 50'
Vert. 1" = 10'

Access Manhole

15.0'

Diffusers

140.0'

℄ New Outfall

P.I. 0+79.05
Δ = 56°00' L
4 Cut Mitred Bend

0+00

Abandoned Outfall Section

335' ±

215'

160'

135'

299'

P.I. 0+14.33
Δ = 60°16' R
4 Cut Mitred Bend

Harbour Headline

South P/L

see Dwg SG-305, Sh. 1

MH

Treatment Plant

Sedimentation and Preaeration Tanks

INDEX TO DRAWINGS

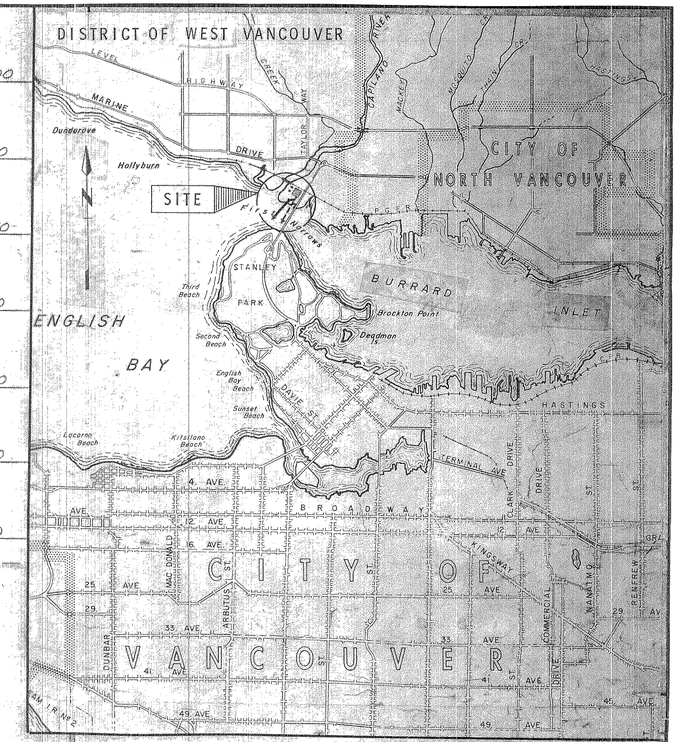
SHEET 1 - PLAN & PROFILE
SHEET 2 - GENERAL PIPE LAYOUT AND DETAILS

BURRARD INLET

Conc. Piers

℄ Lions Gate Bridge

PLAN
Scale: 1" = 50'



KEY PLAN
Scale: 1" = 1 Mile

Contract No. 134

Notes:
1. All elevations refer to G.V.S. & D.D. datum. G.V.S. & D.D. 91.37 = 0.00 Geodetic.

Issue	Date	Desn	Dr'n	Chkd	App'd	Description
C	May 70	R.D.	G.W.	R.D.		As Constructed
B	Nov 69	R.D.	M.D.			General Revision

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design R.D.
Des chkd
Drawn/Tr. G.W.
Dwg chkd
Submitted
Engineer

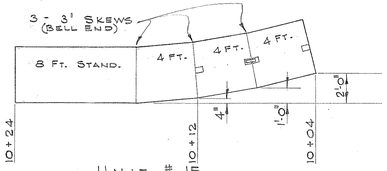
LIONS GATE SEWAGE TREATMENT PLANT
OUTFALL
PLAN AND PROFILE

SCALE: As Shown
DATE: Sept. 1969
Sheet 1 of 2
DRAWING NO. SF - 1038

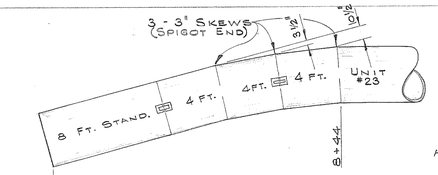
SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO → C

N-160
AREA 1 NORTHERN

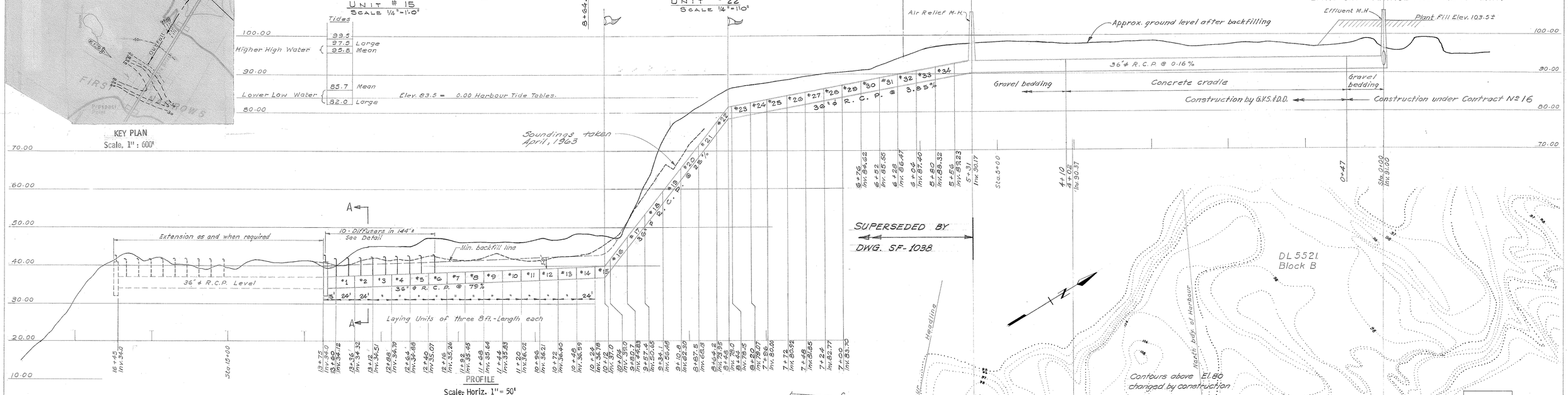
KEY PLAN
Scale. 1" : 600'



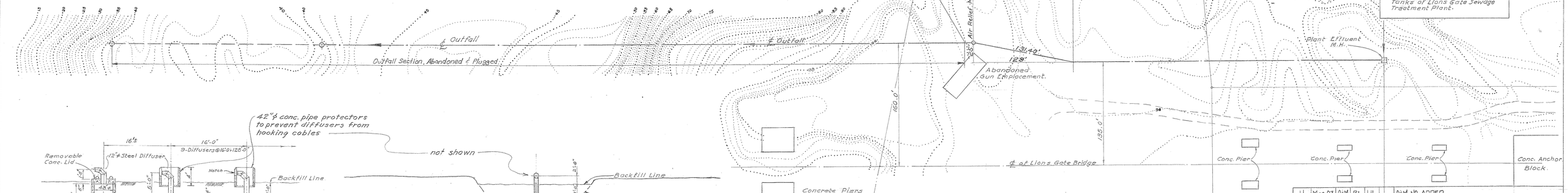
UNIT # 15
SCALE 1/4" = 1'-0"



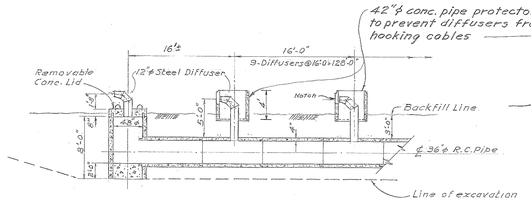
UNIT # 22
SCALE 1/4" = 1'-0"



PROFILE
Scale: Horiz. 1" = 50'
Vert. 1" = 10'

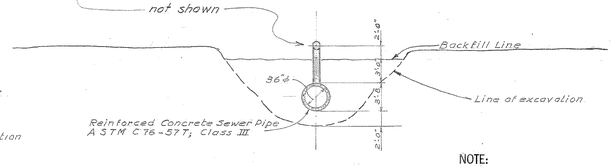


PLAN
Scale. 1" : 50'



DIFFUSER SECTION
Scale. 1/8" : 1'-0"

For details see SF-481, sh 2.



SECTION A - A
Scale. 1/8" : 1'-0"

NOTE:
Diver's survey in June 1968: Inspected from most northerly diffuser south to anchor protection, diffuser nozzle discharge and backfill.
Due to wind and tide change, the diver could only observe to the 7th diffuser, about 40 ft. north of most southerly diffuser. All appeared in good condition. No change from previous inspection.

See Memo from Smith to Terry June 17, 1968.

NOTE:
Soundings taken between Jan. 19th. and Jan. 23rd. 1959 by G.V.S. & D.D.
Contours above El. 80.00 superseded May 1960.
REF. DWGS.
SF-481, Sh. 1. Air Relief Manhole Details.
SF-481, Sh. 2. Diffuser Section Details.
For 1963 soundings refer to F. B. W-615.

Issue	Date	Des'n	Dr'n	Ch	Appd	Description
H	Mar. 03	D.M.	R.I.	W.L.		DFM NO. ADDED
G	Oct '02	D.M.	R.I.			NEW OUTFALL & NOTE ADDED
F	June '61	W.A.M.	W.J.S.			As Constructed
E	Nov. 30/60	N.D.	V.S.B.			ADDED STA. & INV. TO OUTFALL 5+31 TO 10+12. ADDED DETAIL UNIT #15 & 22
D	Sept 23/60	N.D.	V.S.B.			ADDED STA. & INV. TO OUTFALL PIPE FROM STA. 3+54 TO 13+75.
C	May 2, 60	N.D.	D.M.			Revised Ground and Pipe Profiles from Sta. 0+60 to Sta. 12+50.
B	Mar. 31/59	D.M.	W.T.P.			M.H. moved from 6+40 & pipe grade altered. Offset dimensioned.

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

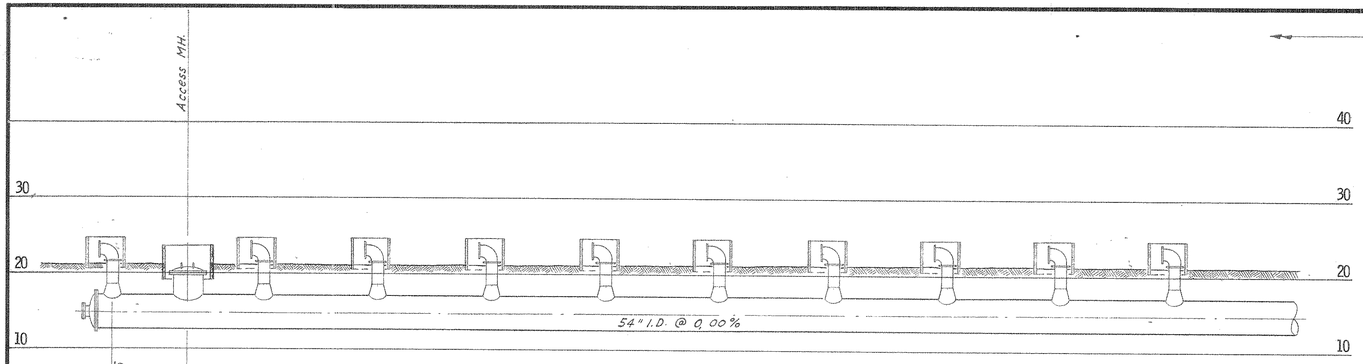
Design A.M.
Dr/Tr. G.G.T.
Checked
Submitted
Engineer

LIONS GATE OUTFALL
PLAN AND PLAN

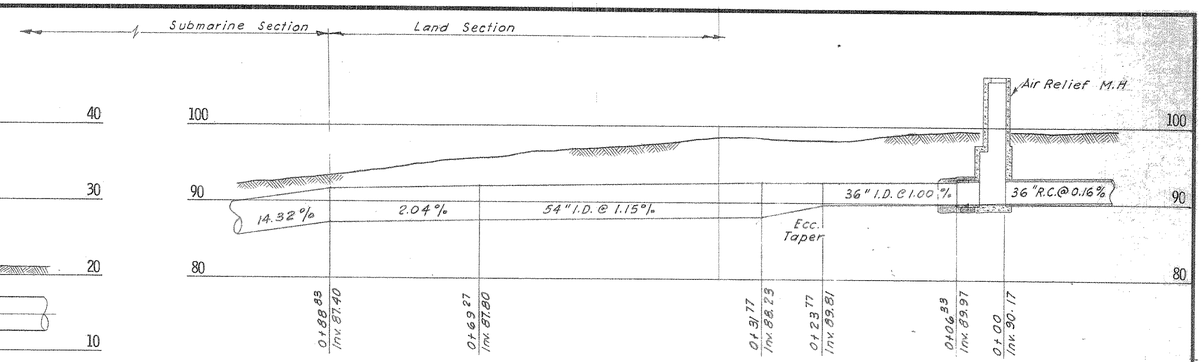
SCALE: As Shown
DATE: March 19-1959
DRAWING NO. SG - 305

SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO → H

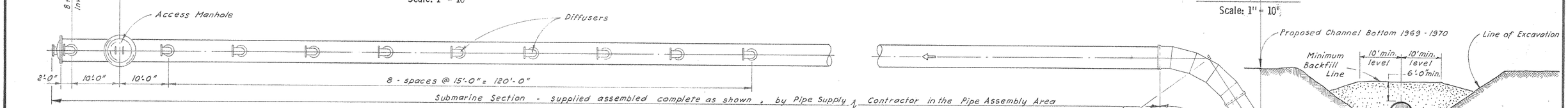
SHEET 1 OF 1



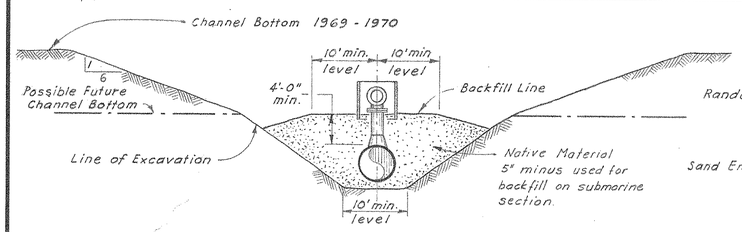
ELEVATION DOWNSTREAM
Scale: 1" = 10'



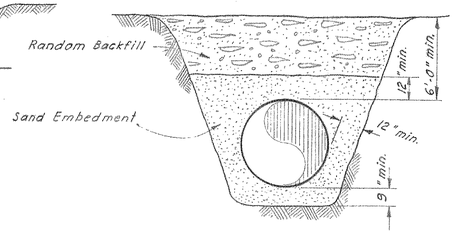
ELEVATION UPSTREAM
Scale: 1" = 10'



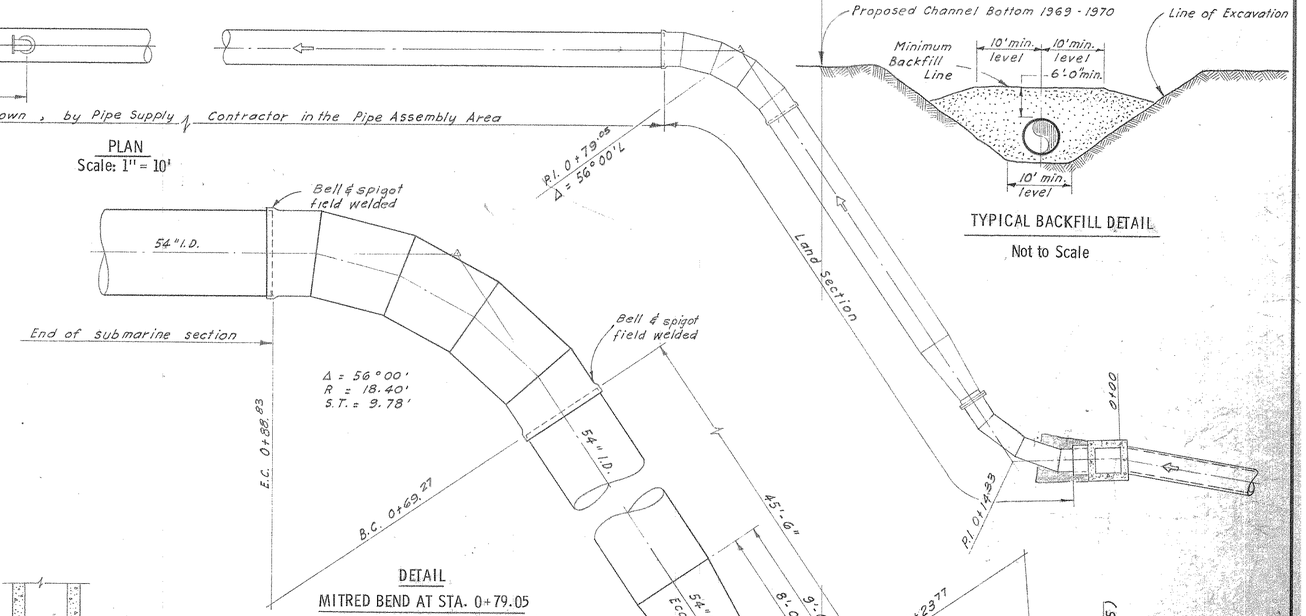
PLAN
Scale: 1" = 10'



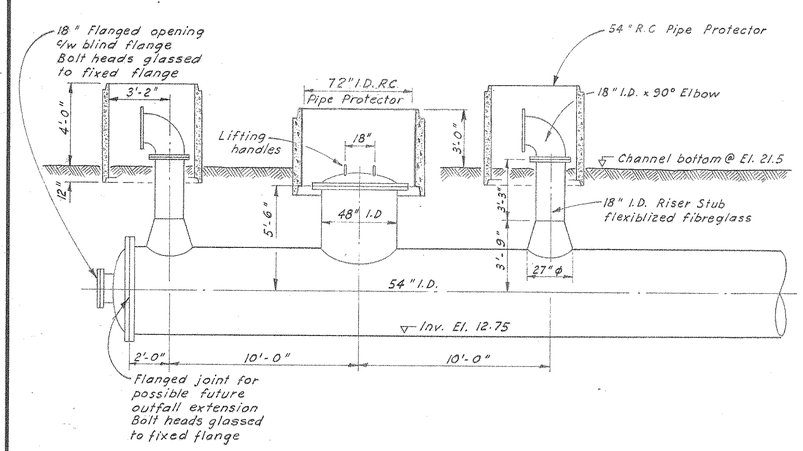
DREDGING AND BACKFILL DETAIL FROM STA. 5+10 TO STA. 8+80
Not to Scale



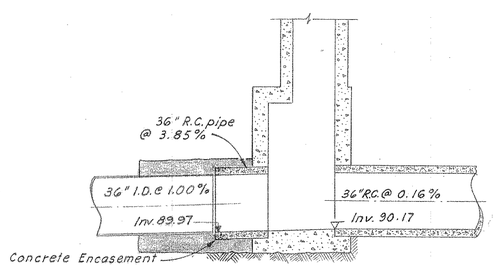
PIPE EMBEDMENT DETAILS
FOR LAND SECTION
Not to Scale



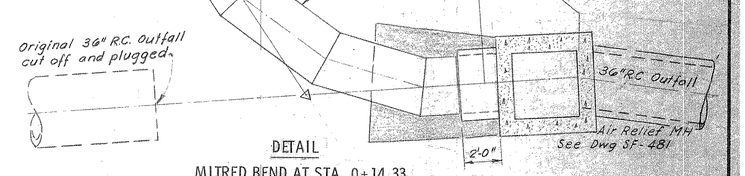
DETAIL
MITRED BEND AT STA. 0+79.05
Scale: 1/4" = 1'-0"



ACCESS MANHOLE & TYPICAL DIFFUSER DETAILS
Scale: 1/4" = 1'-0"



DETAIL
CONNECTION AT
AIR RELIEF MANHOLE
Scale: 1/4" = 1'-0"



DETAIL
MITRED BEND AT STA. 0+14.33
Scale: 1/4" = 1'-0"

Contract No. 134

Notes:
1. All elevations refer to G.V.S.&D.D. Datum. G.V.S.&D.D. 91.37 = 0.00 Geodetic.
2. All pipes & fittings ~~to be~~ fibreglass except where noted.
3. All diffuser pipe ~~to be~~ coloured chrome yellow for diver visibility.

Issue	Date	Desn	Dr'n	Chkd	App'd	Description
B	May 70	R.D.	A.J.L.	R.P.		As Constructed

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design R.D.
Des. chkd
Drawn/Tr. M.V.D.
Dwg. chkd
Submitted
Engineer

LIONS GATE SEWAGE TREATMENT PLANT
OUTFALL
GENERAL PIPE LAYOUT AND DETAILS

SCALE: As Noted
DATE: Nov. 1969
Sheet 2 of 2
DRAWING NO. SF-1038

SUPERSEDES PRINTS OF THIS NUMBER WITH LETTERS PREVIOUS TO → B