CONSTRUCTION SUMMARY (AS-BUILT) REPORT EFFLUENT WATER TREATMENT PLANT, PUMPING STATIONS, PIPELINES, AND DIFFUSER

Meliadine Gold Project, NU

PRESENTED TO

Agnico Eagle Mines Ltd.

SEPTEMBER 2018
ISSUED FOR USE
TETRA TECH PROJECT NUMBER: 28920
AGNICO EAGLE DOCUMENT NUMBER: 6515-E-132-007-132-REP-014

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EXECUTIVE SUMMARY

Tetra Tech was retained by Agnico Eagle Mines Limited (Agnico Eagle) to conduct a detailed design of the water management infrastructures at the Meliadine Gold Project, Nunavut. As a part of this mandate, Tetra Tech designed the pumping stations CP1 and CP5, related pipelines, as well as the effluent water outfall system (including the diffuser) into Meliadine Lake. Tetra Tech previously prepared the design report for these water management infrastructures (Agnico Eagle N° 6515-E-132-005-132-REP-009). The design report also covered the effluent water treatment plant design that was done by Agnico Eagle.

Agnico Eagle requested Tetra Tech to complete on their behalf the following as-built construction record report. It should be noted that Tetra Tech was not involved, nor was on site, during the construction activities for these water management infrastructures. Accordingly, all the construction, quality assurance, and commissioning activities associated with the aforementioned infrastructure was managed by Agnico Eagle and their subcontractors. As such, Tetra Tech has presented the construction data as supplied by Agnico Eagle and therefore Tetra Tech cannot accept any responsibility for the accuracy of any of the data supplied.

The construction for the pumping stations CP1 and CP5, pipelines, and effluent water outfall system were conducted between July and September 2017. The construction for the effluent water treatment plant started in September 2017 and commissioning was completed in June 2018.

This report summarizes the construction as-built information for the effluent water treatment plant, pumping stations, pipelines, as well as the effluent water outfall system into Meliadine Lake.

TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION

Agnico Eagle Mines Limited (Agnico Eagle) retained the services of Tetra Tech to carry out the planning and design work associated with the Water and Environment and the Civil Works components of the Meliadine Project, a gold mine located approximately 25 km north of Rankin Inlet, and 80 km southwest of Chesterfield Inlet in the Kivalliq Region of Nunavut.

Tetra Tech previously prepared the design report for the effluent water treatment plant (EWTP), pumping stations, pipelines, as well as effluent water outfall system (including the diffuser) into Meliadine Lake. As part of the scope of work, Agnico Eagle asked Tetra Tech to:

- Conduct a detailed design for the pumping stations CP1 and CP5, pipelines, and effluent water outfall system to Meliadine Lake while Agnico Eagle was in charge of the effluent water treatment plant design, as part of the 2017 civil work construction schedule
- Produce construction drawings and specifications for the pumping stations CP1 and CP5, pipelines, and effluent water outfall system to Meliadine Lake while Agnico Eagle was in charge of those for the effluent water treatment plant
- Prepare design and construction summary reports of the effluent water treatment plant, pumping stations CP1 and CP5, pipelines, and effluent water outfall system to Meliadine Lake

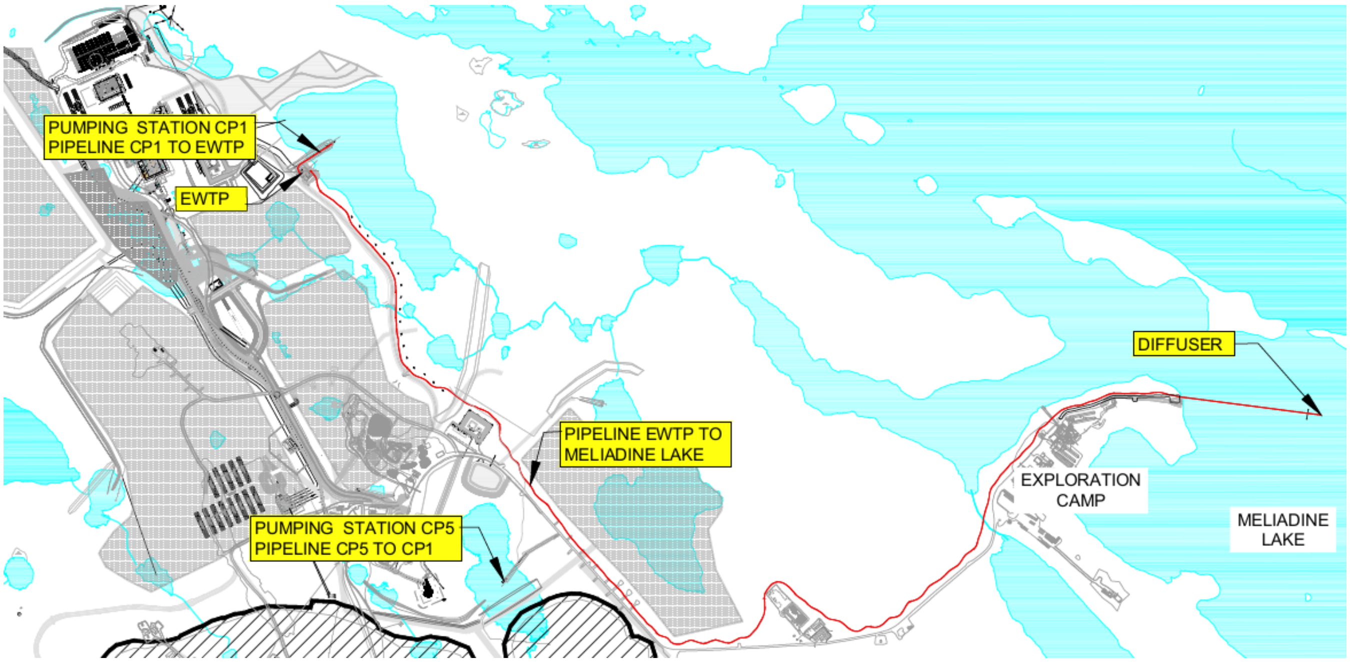
As required by the Water Licence A (No. 2AM-MEL1631), this report summarizes the construction work of those water management infrastructures. Included in this report is:

- A summary of the characteristics of the effluent water treatment plant, pumping stations CP1 and CP5, pipelines, and effluent water outfall system to Meliadine Lake
- Documentation on field decisions that deviate from original plans
- Specifications of equipment
- As-built drawings
- Photographs

2.0 SITE LOCATION PLAN

The figure below presents a site location plan for the effluent water treatment plant (EWTP), pumping stations CP1 and CP5, pipelines, and effluent water outfall (diffuser) in Meliadine Lake.

Figure 2.1: Site Location Plan



3.0 SURFACE CONTACT WATER MANAGEMENT STRATEGY

As presented in the Design Report related to the EWTP, pumping stations, and diffuser (6515-E-132-005-132-REP-009), contact water originating from affected areas on surface are intercepted, diverted, and collected within the existing collection ponds CP1 and CP5. The collected water at the mine site is pumped and stored in CP1, where the contact water is treated by the EWTP prior to discharge to the receiving environment, or will be used as make-up water at the mill.

As part of the Water Management Program, pipelines transfer water during the operation months, from spring freshet to October. Contact water of CP5 is pumped to CP1. Waters directed to CP1 are treated in the EWTP to an approved quality level prior to being discharged in the Meliadine Lake sub-basin through the diffuser system.

CP1 and CP5 are emptied every fall in order to collect all water during the following spring melt.

4.0 CONSTRUCTION SUMMARY

4.1 Construction Schedule

The construction for the pumping stations CP1 and CP5, pipelines, and effluent water outfall system were conducted between July and September 2017. The construction for the effluent water treatment plant started in September 2017 and commissioning was completed in June 2018. Construction was completed according to the milestone dates shown in Table 4.1.

Table 4.1: Construction Milestone Dates

Item	Date of completion
Site Preparation	July 2017
Pumping Stations CP1 and CP5	September 2017
Pipeline from CP1 to EWTP	September 2017
Pipeline from EWTP to Meliadine Lake	September 2017
Pipeline from CP5 to CP1	August 2017
Diffuser installation	August 8th, 2017
Effluent Water Treatment Plant (EWTP) - Installation	October 2017
Effluent Water Treatment Plant (EWTP) – Commissioning	June 2018
Effluent Water Treatment Plant (EWTP) – Operation (start-up)	July 1st 2018

4.2 Effluent Water Outfall System Components

The effluent water outfall system consists of the following five (5) components which are part of this construction summary:

- Pumping station in CP1 collecting pond
- Pumping station in CP5 collecting pond
- Effluent Water Treatment Plant (EWTP)
- Pipelines linking CP5 to CP1 and CP1 to Meliadine Lake
- Diffuser

As-built drawings and final locations of the effluent water outfall system components are available in Appendix A (as-built drawings) and B (survey drawings), respectively. Photographs illustrating the system and its compliance with the construction/permitting design and drawings can be found in Appendix C.

4.2.1 Pumping Stations CP1 and CP5

4.2.1.1 General

The permanent pumping stations CP5 and CP1 were installed respectively on the Jetty CP5 and CP1[1] respectively. The water from CP5 will be pumped to CP1 and the water from CP1 will be pumped through the EWTP to Meliadine Lake.

[1] For information on CP1 and CP5 Jetties, refer to Construction Summary 6515-E-132-005-132-REP-012

As planned in the Design Report[2], the pumping stations were installed over underground sumps located within the pond jetties. The pumping stations were designed to control the water level in the collection ponds and to empty them at the end of the season. The water level in the ponds is regulated with an ultrasonic level transmitter located in the pumping station's sump. When the water reaches the set high level, the pumps start pumping the water until a set low level is reached. The submersible pumps were installed below the lakebed elevation, on the bottom of the sumps, in order to collect the maximum amount of water.

4.2.1.2 Pump Narrative

The amount of water to pump will increase over the years and additional pumps will be needed to meet the pumping requirement. The following tables present the expected pumping stations configuration until the end of the project:

Table 4.2: CP5 pumping station configuration (CP5 to CP1)

	Years -3 to -1 (2017 to 2019)	Years 1 (2020)	Years 2 to 3 (2021 to 2022)	Years 4 (2023)	Years 5 to 6 (2024 to 2025)	Years 7 (2026)	Years 8 (2027)
Maximum flowrate (m^3/day)	19,205	19,205	30,935	30,935	32,775	32,775	32,775
Number of pumps	1	1	2	2	2	2	2

Table 4.3: CP1 pumping station configuration (CP1 to EWTP)

	Years -3 to -1 (2017 to 2019)	Years 1 (2020)	Years 2 to 3 (2021 to 2022)	Years 4 (2023)	Years 5 to 6 (2024 to 2025)	Years 7 (2026)	Years 8 (2027)
Maximum flowrate (m^3/day)	14,880	14,880	14,880	20,640	20,640	35,040	35,040
Number of pumps	1	1	1	1	1	2	2

[2] Effluent System Design Report: 6515-E-132-005-132-REP-009

4.2.1.3 Pumping Station Enclosure

All mechanical and electrical pumping station equipment are housed in a heated and insulated enclosure. Electrical equipment (e.g. control panel, junction boxes, VFD/soft starters, etc.) are separated from the mechanical equipment (e.g. pumps, isolation valves, piping, piping accessories, etc.) by a wall and each room will have its own access door.

The enclosure has been built following the site information and design coefficients (temperature, wind load, snow load, etc.) from the Agnico Eagle general guidelines to resist to the Nunavut climatic conditions. The enclosure is installed on a leveled coarse compacted gravel surface. All surfaces are painted in accordance with Agnico Eagle requirements to ensure good corrosion resistance over the years of operation.

4.2.1.4 Sumps and Suction Lines

Each pumping station was installed over a sump which is connected to the pond with two environmental hazard free high density polyethylene (HDPE) pipes. As the water level in the collection pond rises, the HDPE pipes fill the sumps with water. Both sumps are equipped with two suction lines at different elevations. Every year, at the beginning of the freshet, the top water layer flows through the upper suction line until the bottom line water is thawed. The bottom line diameter is larger than the top one which will reduce water velocity at the bottom sump inlet.

The sumps are made from fusion welded HDPE and were pneumatically tested after fabrication to insure tightness. Before winter season, the two knife gate valves installed on the suction lines used to fill the sump with water, are closed to isolate the sump. Once isolated, the sump is drained and the submersible pumps is pulled out from the sumps and stored during the winter season.

4.2.1.5 Submersible Pumps

Each pumping station is equipped with two (2) identical Flygt submersible pumps used to pump the water from the sump to an HDPE pipeline connected to the pumping station manifold.

The selected pumps are high flow low head type, each one is capable of pumping approximately 20,000 m^3/day. Shut-off pressure is 65 psig for CP1 and 30 psig for CP5.

4.2.1.6 Pipelines

Piping manifold inside the pumping station is made of steel with Victaulic connections for easy dismantlement during maintenance operations. All piping was hydrostatically tested at the manufacturing facility to ensure tightness.

4.2.1.7 Controls

The pumping stations were designed and built to provide easy operation and maintenance. The equipment is locally controlled at the pumping station and remotely controlled from a control room. The complete functional description for the pumping stations is provided in Appendix D. When the pumps are shut-down, the electrically operated valve, installed on the four inch (4'') drain line, opens to allow the water between the manifold and the first high point on the HDPE pipelines to flow back into the sump.

4.2.2 Effluent Water Treatment Plant (EWTP)

The purpose of the EWTP (ACP-700R) is to reduce Total Suspended Solids (TSS) to a maximum concentration of 15 mg/L from the influent water pumped from CP1 prior to its discharge through the diffuser into Meliadine Lake.

The equipment has an operational range of 6,250 to 28,000 m^3/d. It is expected that the EWTP will be in use only during the open water season, approximately four (4) months in the year (June to October).

4.2.2.1 Actiflo® and Multiflo

The first treatment component consists of one Actiflo® clarifier with two (2) recirculation lines and two (2) hydrocyclones. The Actiflo® can be operated with one (1) or two (2) lines, depending on the influent flow rate and TSS content. The Actiflo® overflow is designed to meet the Type A License final effluent discharge criteria for TSS concentrations. The final effluent is monitored for pH, turbidity, and flow rate which are monitored continuously. The end-of-pipe effluent concentration for various conventional constituents will not exceed the values provided by the Metal Mining Effluent Regulation (MMER). Appendix E presents results of water quality testing during commissioning and start-up.

The hydrocyclone overflow is sent to the Multiflo for sludge thickening which overflows by gravity into a break tank and then pumped into the raw water Actiflo® inlet pipe for recirculation. The principal purpose of the Multiflo is to decrease the amount of water sent to the mill, since the total water content volume within the sludge cannot be managed at the mill. This unit does not contribute to the efficiency of the system to reduce dissolved chemical parameters within the water effluent.

The Multiflo will be in operation following the start-up of the mill in early 2019.

The Meliadine EWTP Overall Process Flow Diagram is illustrated attached in Appendix F.

4.2.2.2 Service Water System

The service water system consists of two (2) multimedia filters, two (2) heaters, one (1) filtered water tank and four (4) service water pumps. Service water is used in the preparation of dry chemicals and for polymer makeup systems. Coagulant and polymer require filtered heated water.

4.2.2.3 Reagents

Two (2) types of polymers as well as a coagulant are used to treat the water that flows through the Actiflo® and each are supplied by a dosing system that is adjusted according to the influent flow rate. One (1) cationic and one (1) anionic polymers are used. Treated water from the Actiflo® is used for the mixing of the reagents.

4.2.2.4 Controls

The Actiflo® Feed Pump is equipped with a variable frequency drive (VFD) that allows the flow to be modulated. A controller uses the raw water flow meter’s (65FIT6930001) signal and adjusts the frequency of the pump to obtain the flow specified by the Operator in order to maintain a constant flow rate to the system.

The raw water TSS analyzer is used to monitor the raw water quality. An alarm is triggered when a high-high turbidity is reached and if only one (1) recirculation pump is running.

The effluent water TSS concentration and pH values are monitored continuously with in-line instrumentation. If effluent concentrations reach a set point indicating that final effluent discharge criteria may be exceeded, an alarm is sent to the Operator, who manages the system to meet effluent criteria. A second alarm is sent to the operator if effluent concentrations reach a second set point that is just below the final effluent discharge criteria. This triggers the two (2) outflow valves to automatically divert the final effluent to CP1, preventing discharge to the environment.

Addition of the two (2) required reagents is proportional to the influent water flow. Since this flow is maintained constantly by a control loop, no manual adjustment is required. If the operator has to modify the influent water flow, adjustment of the reagent dosing system is required to maintain the target dosage rate. The reagent dosing systems are equipped with pumps that maintain a constant flow rate when running at a constant frequency. The flow can be modified by changing the electric motor frequency.

The reagent dosing system is equipped with valves and graduated cylinders allowing the operator to measure the addition rate of the reagent using a stop watch. The operator determines the required flow of a specific reagent by a formula based on influent flow rate. Based on this calculation, a manual adjustment to the reagent pump is done in order to obtain the required dosage. Initially, the formula is based on laboratory testing and is adjusted accordingly to the treatment plant performance.

4.2.3 Pipelines

4.2.3.1 General

The pumping stations at CP1, CP5 and the EWTP transfer water through a total of 5.3 km of sections of 400 mm (Ø16 inch) and a section of 500 mm (Ø20 inch) HDPE pipes. The treated water from the EWTP is pumped to a diffuser located in the Meliadine Lake. Sections of the pipelines are insulated where required. The following table presents a summary of the three (3) pipelines:

Table 4.4: HDPE Pipeline Lengths

Description	Actual Length (m)	Diameter (mm)
CP5 to CP1	709	500
CP1 to EWTP	108	400
EWTP to Meliadine Lake	4 517	400

The pipelines were butt welded using a fusion welding machine and a flange connection was installed at every 76 m (250 feet) for easy manipulation during installation. The pipeline spools were transported, handled, and assembled on roads or pads using mobile equipment such as forklifts, front-end loaders, or boom trucks. The routing of the pipelines was chosen in such a way to limit the need of installation equipment to run over the tundra and to stay off a distance of 31 m from water bodies. No archeological sites were encountered in any areas along the pipeline routings.

4.2.3.2 Material

Piping

All pipelines and flanges are made of high quality Sclairpipe HDPE DR17 PE4710. Black HDPE was chosen for its high sunlight Ultraviolet resistance, supported by technical literature stating a life expectancy of 50-100 years of successful service. The complete Sclairpipe datasheet is available in Appendix G of this document. A 50 mm (2 inch) thick factory applied waterproof rigid polyurethane foam was applied over some section lengths.

Fusion of joints was done according to a procedure equivalent to ASTM F2620, Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings, see Appendix H for the complete pipe fusion manual. Service tests were conducted on the pipelines for leak detection at start-up of the EWTP.

Heating and insulation

The sections of pipelines requiring insulation are those where gravitational draining is not possible due to the pipeline's profile shape. The HDPE pipeline as-built drawing in Appendix A shows sections of the pipeline between CP1 and Meliadine Lake that are insulated and drained. This insulation reduces heat transfer and therefore reduces the possibility of water freezing and piping collapse under freezing temperature shutdown.

The section of the pipeline that is submerged and exposed to freezing in Meliadine Lake, over a distance of approximately 50 meters and 5 meters deep, is heat traced and insulated.

Flanges, valves and accessories

All pipelines flanges (stub-ends) are made of the same material as the pipelines, with a pressure rating class 150 lbs and comply with ANSI B16.5 dimensions for perfect mating and minimizing risks of leaks. Flanges and fittings for vents and drains are all made of stainless steel for good corrosion resistance. Aboveground flanges backing rings are made of ductile iron and all hardware is made of stainless steel for strength and corrosion resistance. Submerged hardware in Meliadine Lake is all stainless steel made with magnesium sacrificial anodes to enhance corrosion protection in fresh water. Valves are made of stainless steel or ductile iron with EPDM rubber or Teflon seals, depending of the design requirements.

Culvert sleeves

In locations where the pipelines cross haul or access roads, galvanized corrugated steel sleeves were used across the roads to support the weight of vehicles and backfill, and to maintain the integrity of the pipelines.

4.2.3.3 Equipment

Flowmeter

Magnetic flowmeters are installed on the two major pipelines as presented in the following table:

Table 4.5: Flowmeters Installed on Pipelines

Description	Number of flowmeters
CP5 to CP1	2
CP1 to EWTP	1
EWTP to Meliadine Lake	2

All flowmeters are connected to a PLC where data is logged. This equipment is used to monitor the quantity of water transferred between CP5 and CP1 ponds and the water discharged into the environment. The flowmeters are also intended to be used as a real-time leak detector system. An alarm is set to inform the Control room when the flow reading of a pipeline has a difference greater than 10%. The goal of this system is to mitigate and minimize risks of environmental contamination.

The flowmeters of pipeline CP5 to CP1 are located as follow: one is installed near the discharge of CP5 pumping station and connected to its PLC. The second one is located on the top of D-CP1 at approximately 760 m (2,493 ft) away from the pumping station and it will be connected to the PLC in the electrical room of the evaporators into the P-Area.

The flowmeter of pipeline EWTP to Meliadine Lake is located on the construction pad before the water outfalls to the diffuser. This flowmeter is Wi-Fi connected to the Exploration Camp nearby. A flowmeter was installed at the EWTP to complete the leak protection system.

All flowmeters are skid mounted and are rated for outdoor use in Nunavut.

<u>Drains</u>

Drains assemblies are provided to every pipeline lower points where it is not technically possible to drain gravitationally during shutdown operations. The water will be pumped and discharged where it is safe for the environment. The drains are shown on HDPE pipeline as-built drawing in Appendix A.

<u>Air/Vacuum Valves</u>

An air/vacuum valve is located at every highest points of the EWTP to Meliadine Lake pipeline. This valve is required to exhaust air when filling and admit air while draining. This is an important equipment to protect the integrity of the pipeline and prevent it from collapsing in case of water column separation at shutdown.

No air/vacuum valves are needed on the CP5 to CP1 and CP1 to EWTP as the pipelines are able to safely sustain the possible vacuum stresses and air pockets at high points will be removed with the flow velocity.

4.2.3.4 Pipeline CP5 to CP1

The pipeline centerline routing is straight but the pipeline was designed and installed to snake along its general path. This is required to give free movement of the pipelines under the Nunavut high outdoor temperature range and to limit the induced thermal expansion stress.

Except on pumping stations jetties, the pipelines lie directly on the tundra where sharp stones were removed before installation to reduce the risks of tears and premature wear. Since the pipelines are water tight, no hazards or disturbances are expected after installation. A hydrostatic test was performed to confirm it.

The routing was designed and installed to maintain a minimum distance of 31 m from any natural water body.

CP5 to CP1 pipeline discharges on the shore of CP1 and lies on rip rap to avoid shore erosion.

4.2.3.5 Pipeline EWTP to Meliadine Lakeshore

The first 180 m from the EWTP is supported on a pre-molded cement base. The second section (180 m to 900 m) of the pipeline reaching the dyke D-CP1 is exposed to flooding every year at freshet. For this reason, as defined in the Design Report3, the pipeline is anchored with concrete blocks lying underwater and chains retaining the pipeline from deriving too far from its design centerline routing. This design allows the pipeline to float on the water, minimizing stress loads on the material. Once water is pumped out of CP1, the pipeline eventually reaches its relative designed position on the ground and remains there until the next flooding. All retaining accessories are galvanized to provide protection against rust over the operation years.

Each of the submersible anchors consists of a pair of 1500 kg (3306 lbs) concrete blocks. The pipeline is maintained in place with a chain linking both blocks to the pipe attachment point. An anchor point was installed every 38 m (125 ft) to maintain the pipeline in position. The anchors are sized to resist a maximum wind load corresponding to a 1/100 year event as well as all lake waves and gravity loads.

The section of the pipeline between D-CP1 and Meliadine Lake is the same as described in Section 4.2.3.4. The pipeline routing is at least 31m away from water bodies at the exception of a section along the exploration camp where the area is too narrow and therefore runs at a distance less than 31m.

4.2.3.6 Submarine Pipeline (Between Meliadine Lakeshore and Diffuser)

The section of the pipeline between the shore of Meliadine Lake and the diffuser was designed to be submerged at all time.

In order to avoid sub-marine environment disturbances and limit sub-marine work and marine equipment, on-shore installation was conducted. A construction pad with a ramp, was built on the water outfall shore, within 31m from the edge of waterbody (without entering the limit of the high-water mark), to provide a flat area where material could be stored before being assembled and where heavy equipment could circulate, thus limiting at its minimum the disturbance of the land around the construction area.

The method adopted for the installation of the sub-marine pipeline is named Float-and-Sink. The HDPE spools were fusion jointed on the construction pad in a continuous process. The concrete ballasts were assembled on the pipeline as it went into the water while remaining empty and floated on the surface of the water. Once a ballast was attached to the pipeline, the assembly was loaded on a wheeled bogey and rails smoothly drove the pipeline in the water. The pipeline floated as it was lighter than water; the bogey is then removed and installed back on the next ballast. To maintain the pipeline on the lakebed, a ballast was installed every approximately 8 m along the pipeline for a total of 49 ballast blocks, for a ballast depth chart see Appendix I. A tug boat pulled the pipeline using a pulling head in the Meliadine Lake.

When the pipeline was completed and in position, it was sunk by slowly filling it up with fresh water to avoid air entrapment. As the pipeline sunk, it was carefully installed in its final location on the bed lake.

[3] Effluent System Design Report: 6515-E-132-005-132-REP-009

4.2.4 Effluent Water Outfall System (Diffuser)

Compliance of the diffuser system with the construction/permitting design and drawings has been observed:

- Diffuser connecting with the outfall through a tee connection (diffuser oriented NE-SW)
- Coordinates of the tee: 6,898,150 N / 542,756 E (UTM Zone 15 V)
- Length of diffuser: 30 m, with two arms of 15 m each
- Diameter of the diffuser: 400 mm OD / 355 mm ID
- Water depth at diffuser location: approximately 14.6 m
- Number of ports: 10 ports
- Port diameter: 51 mm
- Port spacing: 3 m
- Tideflex valve mounted on top of diffuser pipe on each port to eliminate fish access (see specifications in Appendix J)
- Vertical angle of valve: 45 degrees, pointing toward the southeast
- Port height from lake bed: 1 m, corresponding to the approximate effluent exit height from lake bed
- 3 ballast blocks on each arm of the diffuser, totalling 6 ballast blocks for the diffuser

5.0 FIELD DECISIONS THAT DEVIATE FROM ORIGINAL DESIGN

This section documents variations from original design which were approved by the designer and/or the field engineer on site for the entire effluent system. The changes listed herein do not affect the original water management strategy.

5.1 Effluent Water Treatment Plant

The construction work led to no variations from the original design in the EWTP.

5.2 Pumping Stations CP1 and CP5

The construction work led to slight variations from the original design in the pumping station CP1 and CP5, as summarized in Table 5.1 below.

Table 5.1: Pumping Station CP1 and CP5 Characteristics

Item	Proposed	Actual
Expansion joints	Expansion joints installed at every tie-in to a building.	None

- No expansion joints were deemed required.

5.3 Pipelines and Accessories

The construction work led to slight variations from the original design in the pipelines and accessories, as summarized in Table 5.2 below.

Table 5.2: Pipeline Characteristics

Item	Proposed	Actual	Difference
Flowmeter CP5 to CP1	2	2	0
Flowmeter CP1 to EWTP	0	1	+1
Flowmeter EWTP to Meliadine Lake	1	2	+1
Earthen berms along pipelines	Every 30m	none	
CP5 to CP1 – Length (m)	832.3 m	709 m	-123.3 m
CP1 to EWTP – Length (m)	154.8 m	108 m	-46.8 m
EWTP to Meliadine Lake – Length (m)	4 340.6 m	4 517 m	+176.4 m

- At the design stage, no flowmeter was deemed required on the CP1 to EWTP pipeline as the water transfer is already monitored by the EWTP to Meliadine Lake flowmeters. Nevertheless, a flowmeter was installed on this section of the pipeline.
- Originally, earthen berms were planned to be put in place at every 30 meters along the reference centerline of the pipelines. However, this was deemed unnecessary and field observations during the first weeks of pumping in 2018 by the site team proved that the set snaking loop is sufficient to ensure stability of the pipeline.
- The length of the pipeline varied as the path had been slightly modified on field to better fit with the other constructions constraints and infrastructures on-site without impacting the design intent and general path.

5.4 Effluent Water Outfall System (Diffuser)

Two (2) deviations from the design were observed and recorded during the construction of the effluent water outfall system, as summarized in Table 5.3 below and the text which follows.

Table 5.3: Effluent Water Outfall System Characteristics

Item	Proposed	Actual	Difference
Location of Tee Connector for Diffuser System	6,989,149.90N / 542,755.74E	6,989,147.41N / 542,797.91E	42 m, mainly eastward
Depth of the Diffuser System at Tee Connector	14.60 m	11.39 m	3.21 m shallower

In order to assess the impact, or not, of these two deviations, a bathymetric survey was conducted, followed by a numerical modelling study to assess conventional constituent concentrations at the edge of the mixing zone and potential concentration build-up over time, based on the as-built system, hence including the two deviations described in Table 5.4 above. A technical memo presented in Appendix K summarizes the results of the analytical work undertaken to assess these potential changes.

As confirmed with the numerical simulation described above, both deviations in the as-built diffuser (horizontal shift and system in shallower water depth) result in water quality guidelines being met for all conventional constituents as summarized in Table 5.4 below.

Table 5.4: Comparison of Diffuser System Dilution Performance

Item	Minimum Dilution at the Edge of the Mixing Zone Obtained over 14-Years Simulation	
	Proposed	Actual
Base Case Scenario	23:1	23:1
Water Quality Guidelines	Met for all conventional constituents	Met for all conventional constituents

5.5 Earthworks

The as-built material quantities for the effluent water treatment plant, pumping stations CP1 and CP5, pipelines, and effluent water outfall system (including diffuser) are presented in Table 5.5 below.

Table 5.5: As-built Material Quantities

Item	Proposed	Actual
Riprap (300-500 mm)	1 500 m^3	Volume installed not available
Non-woven geotextile	yes	no

- Riprap material was only used to build the Construction pad on the shore of Meliadine Lake.
- No geotextile was required in the lakebed underneath the pipeline entrance in the Meliadine Lake.

6.0 AS-BUILT DRAWINGS AND PHOTOGRAPHS

As-built drawings are presented in Appendix A.

Survey drawings conducted during and after the construction of the water management infrastructures can be found in Appendix B.

Photographs of the water management infrastructures during and after construction are shown in Appendix C.

7.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Agnico Eagle Mines Ltd. and their agents. Tetra Tech does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Agnico Eagle Mines Ltd., or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Tetra Tech accepts no responsibility for losses, claims, expenses or damages, if any, suffered by a third party as a result of any decisions made or actions based on this report. Use of this report is subject to the terms and conditions stated in Tetra Tech's Services Agreement.

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Use of this Document acknowledges acceptance of the foregoing conditions.

8.0 CLOSURE

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

Respectfully submitted,
Tetra Tech and Agnico Eagle team

EFFLUENT WATER TREATMENT PLANT

Prepared by:	Reviewed by:
Blandine Arseneault Signature numérique de Blandine Arseneault DN : cn=Blandine Arseneault Date : 2018.09.20 16:19:57 -04'00'	Pierre-Alexandre Bosse Signature numérique de Pierre-Alexandre Bosse DN : cn=Pierre-Alexandre Bosse Date : 2018.09.24 19:00:52 -05'00'
Blandine Arseneault Project Environment Lead	Pierre-Alexandre Bossé Project Process Lead

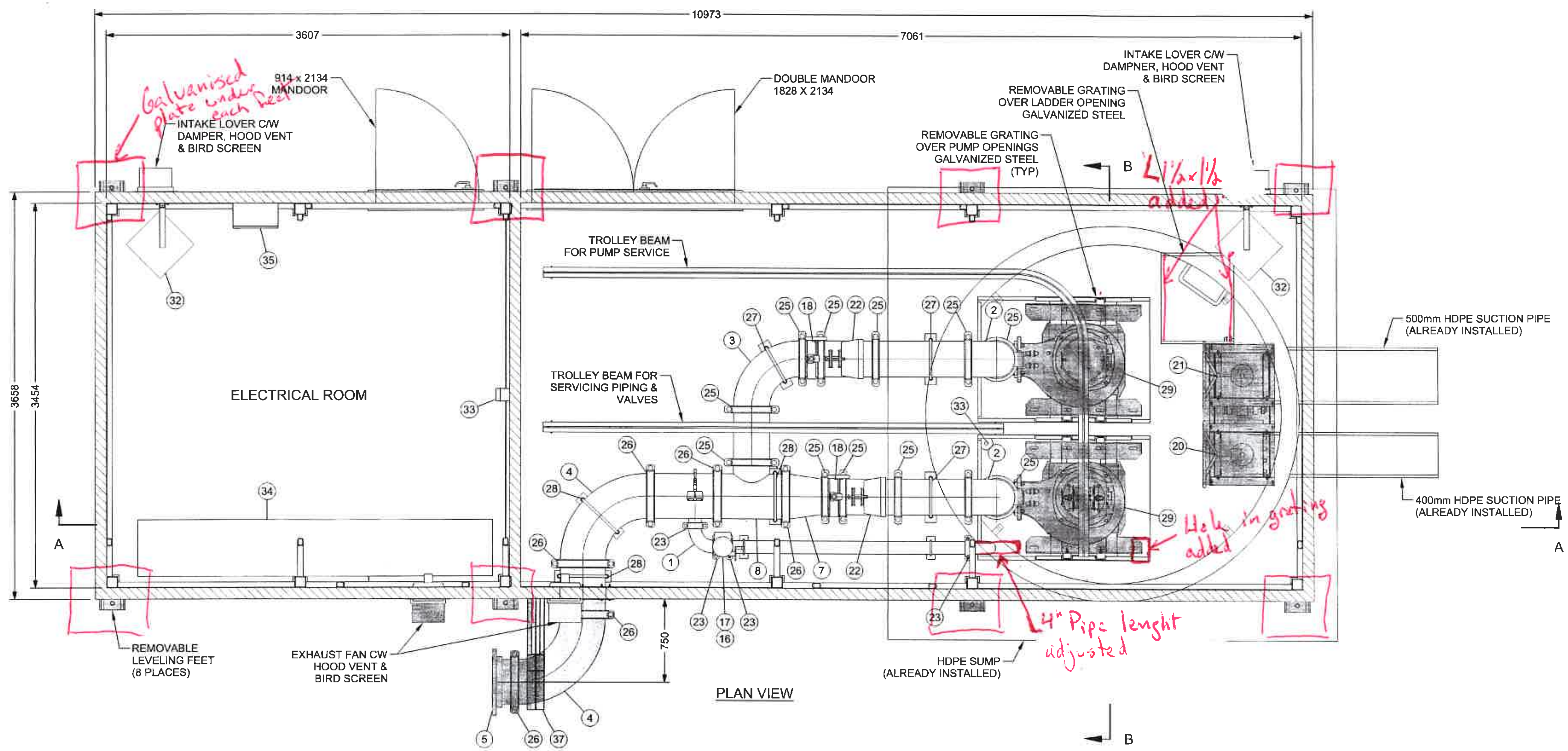
PUMPING STATIONS, PIPELINE AND DIFFUSER

Prepared by:		Reviewed by:
REGISTERED PROFESSIONAL ENGINEER J.M.I.F. ALARIE LICENSEE NT/NU Josée Alarie 2018-09-20	PERMIT TO PRACTICE TETRA TECH INDUSTRIES, INC. O/A TETRA TECH Signature Date 2018-09-20 PERMIT NUMBER: P 1029 NT/NU Association of Professional Engineers and Geoscientists	normand.menard@agnicoeagle.com Signature numérique de normand.menard@agnicoeagle.com DN : cn=normand.menard@agnicoeagle.com Date : 2018.09.24 10:23:24 -05'00'
Josée Alarie Report Coordinator		Normand Ménard Project Mechanical Lead

APPENDIX A
As-built drawings

NO. DESSIN DRAWING NO. 65-695-265-227_2_R1

FORMAT ARCHD



As Built

2017-10-09

FOR CONSTRUCTION
AGNICO EAGLE DATE : 2017-07-11

PLAN CLÉ KEY PLAN

NOTES GÉNÉRALES / GENERAL NOTES

LEGEND: SITE ASSEMBLY REQUIRED

George Floarea P.Eng. July 12th 2017 Rev. 1

George Floarea P.Eng. July 12th 2017, Rev. 1

PERMIT TO PRACTICE
TETRA TECH INDUSTRIES, INC.
O/A TETRA TECH
Signature
Date 2017-07-12
PERMIT NUMBER: P 1029
NT/NU Association of Professional Engineers and Geoscientists

DESSINS EN RÉFÉRENCE / REFERENCE DRAWINGS

TITRE / TITLE	# DWG

AGNICO EAGLE

REV.	DATE	DESCRIPTION	PAR/BY	APP	CLIENT
1	2017/07/11	FOR CONSTRUCTION	G.C.	G.F.	N.M/B.A
0	2017/06/14	ISSUED FOR TENDER	S.G.	G.F.	N.M/B.A

REVISIONS

TETRA TECH
PROJET No : F14103230 FICHIER No : 65-695-265-227

TITRE / TITLE
AGNICO EAGLE – DIVISION MELIADINE
PUMPING STATION
CP1 TO EWTP
PLAN, SECTIONS AND DETAILS

DESSINÉ PAR DRAWN BY	S.G.	DATE 2017/06/07
VÉRIFIÉ PAR CHECKED BY	G.F.	2017/06/07
APPROUVÉ PAR APPROVED BY	G.F.	2017/06/07
ÉCHELLE SCALE	N.T.S.	DATE 2017/06/07

NO. DESSIN DRAWING NO. 65-695-265-227

NO. PROJET PROJECT NO	REVISION	FEUILLE / SHT
6515-C-265-016	1	2 / 7

FILE NO. 65-695-265-227_2-R1.dwg

NO. DESSIN DRAWING NO. 65 695 265 227 3 R1

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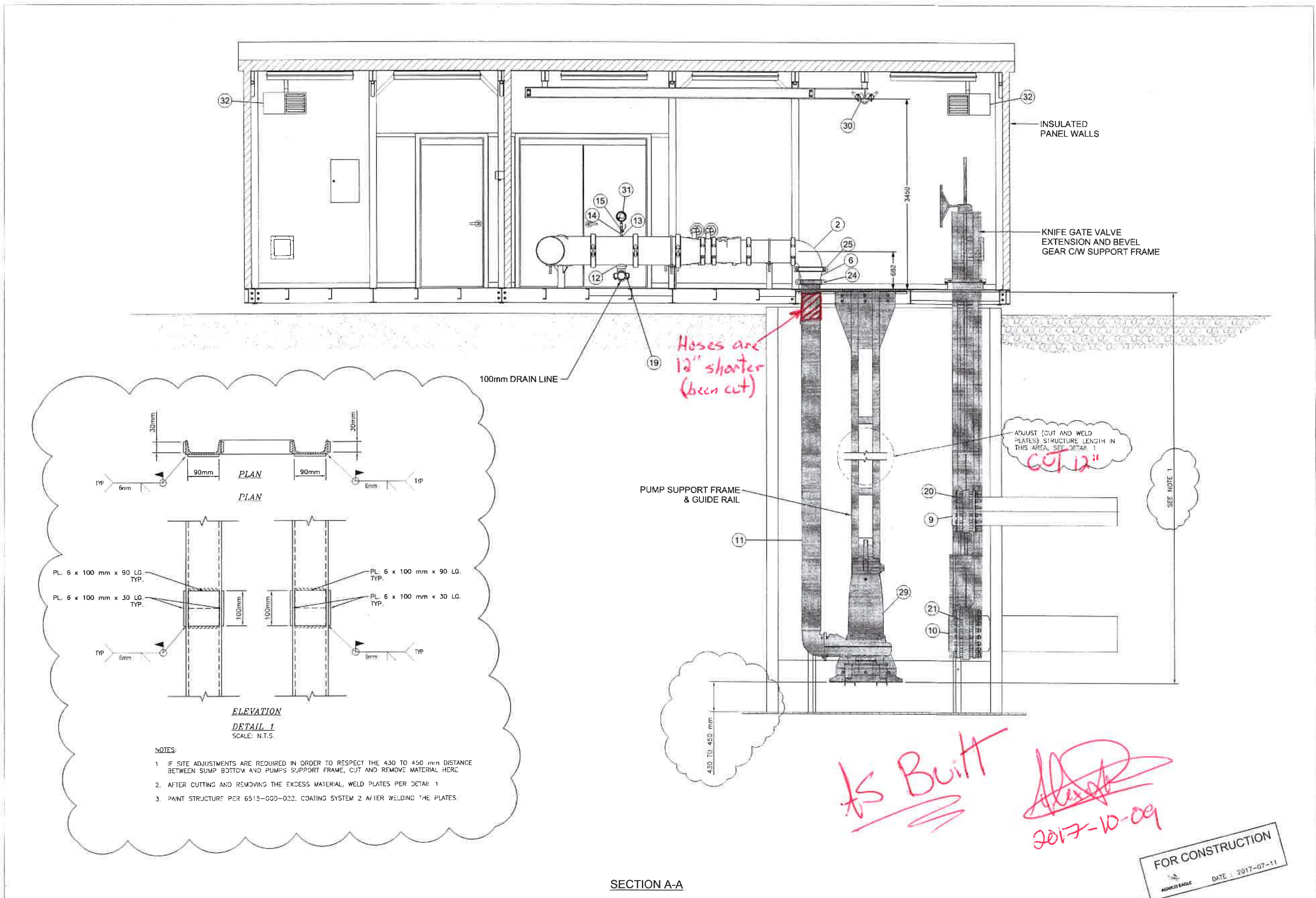

PLAN CLÉ / KEY PLAN

NOTES GÉNÉRALES / GENERAL NOTES

LEGEND: SITE ASSEMBLY REQUIRED

George Fiorino, P.Eng. July 12th 2017 Rev. 2

George Fiorino P.Eng. July 12th 2017 Rev. 1

PERMIT TO PRACTICE
TETRA TECH INDUSTRIES, INC. O/A TETRA TECH
Signature
Date 2017.07.12
PERMIT NUMBER: P 1029
NT/NU Association of Professional Engineers and Geoscientists

DESSINS EN RÉFÉRENCE / REFERENCE DRAWINGS

TITRE / TITLE	# DWG.

AGNICO EAGLE

REV.	DATE	DESCRIPTION	PAR/BY	APP.	CLIENT
1	2017/07/11	FOR CONSTRUCTION	S.G.	G.F.	M.M/B.A
0	2017/06/14	ISSUED FOR TENDER	S.G.	G.F.	M.M/B.A

REVISIONS

TETRA TECH

PROJET No.: E14103230 FICHIER No.: 65-695-265-227

TITRE / TITLE
AGNICO EAGLE – DIVISION MELIADINE
PUMPING STATION
CP1 TO EWTP
PLAN, SECTIONS AND DETAILS

DESSINÉ PAR / DRAWN BY	S.G.	DATE	2017/06/07
VÉRIFIÉ PAR / CHECKED BY	G.F.		2017/06/07
APPROUVÉ PAR / APPROVED BY	G.F.		2017/06/07
ÉCHELLE / SCALE	N.T.S.	DATE	2017/06/07
NO. DESSIN / DRAWING NO.	65-695-265-227		
NO. PROJET / PROJECT NO.	6515-C-265-016	RÉVISION 1	FEUILLE / SHT 3/7

AE-CART-ARCH D

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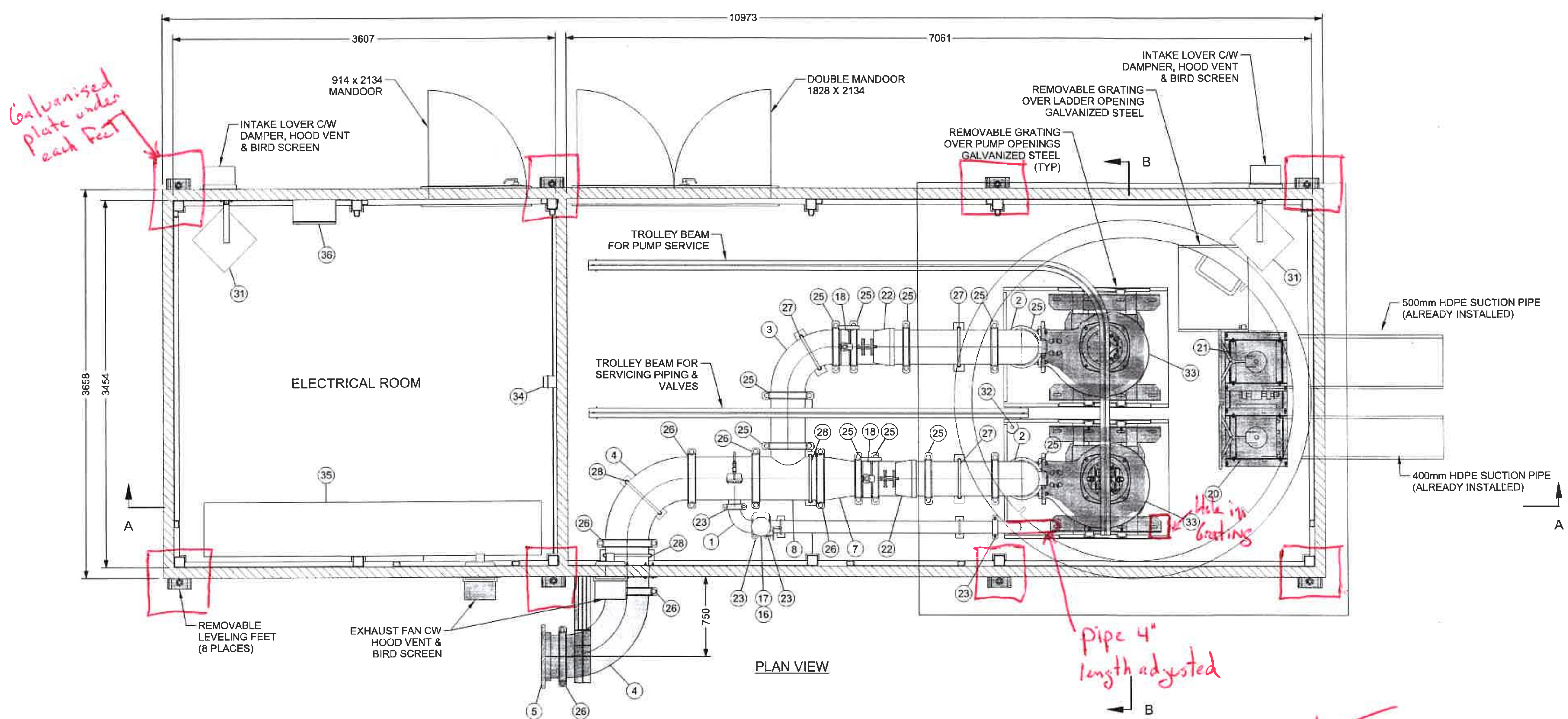

As Built

2017-10-09

FOR CONSTRUCTION
AGNICO EAGLE DATE : 2017-07-11

PLAN CLE
KEY PLAN

NOTES GÉNÉRALES / GENERAL NOTES

LEGEND: SITE ASSEMBLY REQUIRED

George Fiorarea, P.Eng.
July 12th 2017
Rev 1

George Fiorarea, P.Eng.
July 12th 2017, Rev. 1

PERMIT TO PRACTICE
TETRA TECH INDUSTRIES, INC. O/A TETRA TECH
Signature
Date 2017-07-13
PERMIT NUMBER: P 1029
NT/NU Association of Professional Engineers and Geoscientists

DESSINS EN RÉFÉRENCE / REFERENCE DRAWINGS

TITRE / TITLE	# DWG

AGNICO EAGLE

REV.	DATE	DESCRIPTION	PAR/BY	APP.	CLIENT
1	2017/07/11	FOR CONSTRUCTION	G.C.	G.F.	N.M./B.A.
0	2017/06/14	ISSUED FOR TENDER	S.G.	G.F.	N.M./B.A.

REVISIONS

TETRA TECH

PROJET No.: E14103230 FICHIER No.: 65-695-265-222

TITRE / TITLE
AGNICO EAGLE – DIVISION
MELIADINE
PUMPING STATION
CP5 TO CP1
PLAN, SECTIONS AND DETAILS

DESSINÉ PAR DRAWN BY	S.G.	DATE 2017/06/07
VERIFIÉ PAR CHECKED BY	G.F.	2017/06/07
APPROUVÉ PAR APPROVED BY	G.F.	2017/06/07
ÉCHELLE SCALE	N.T.S.	DATE 2017/06/07
NO. DESSIN DRAWING NO.	65-695-265-228	
NO. PROJET PROJECT NO. 6515-S-265-094	REVISION 1	FEUILLE / SHT 2 / 7

AE-CART-ARCH D

FILE NO. 65-695-265-228_2-R1.dwg

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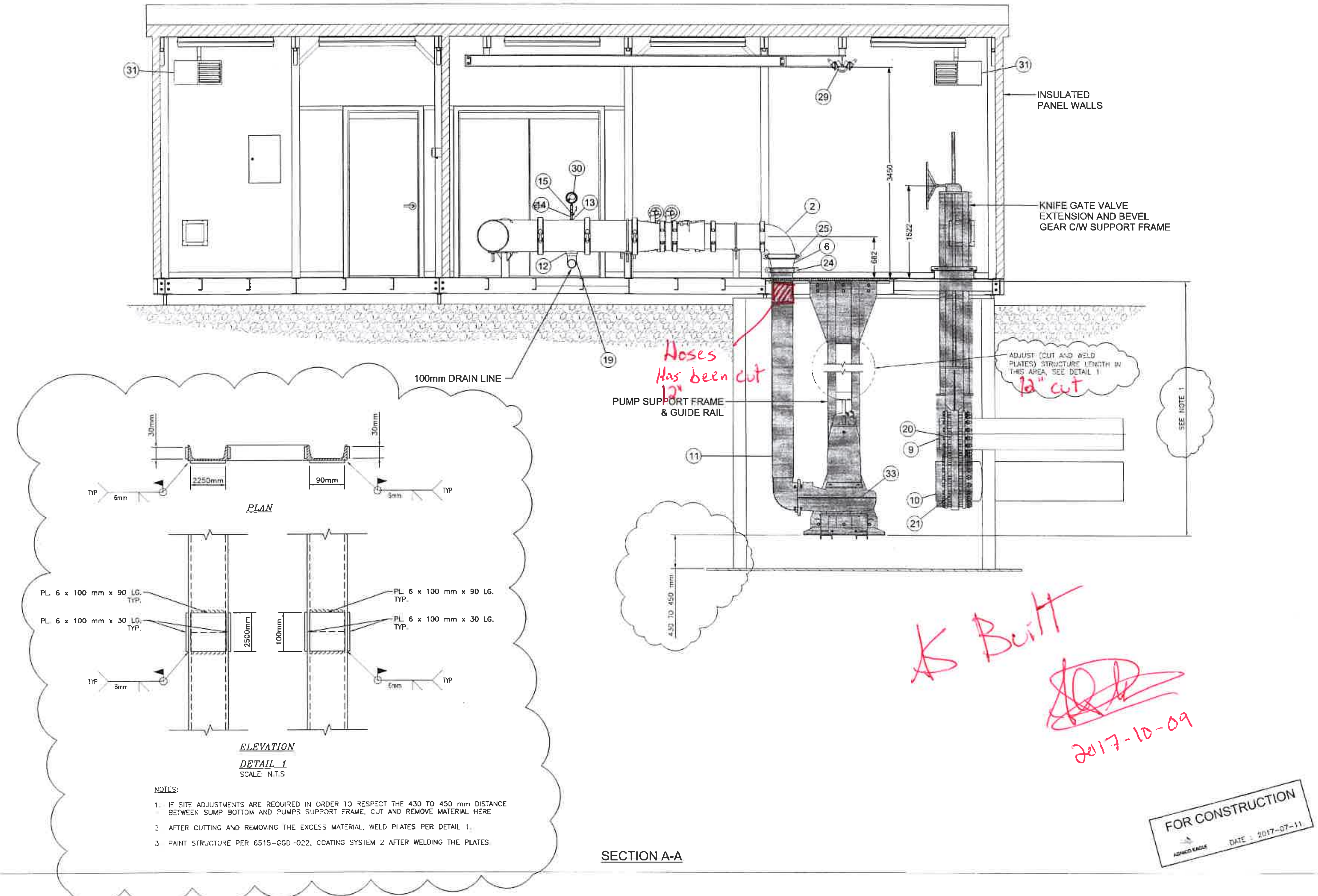


NOTES:

1. IF SITE ADJUSTMENTS ARE REQUIRED IN ORDER TO RESPECT THE 430 TO 450 mm DISTANCE BETWEEN SUMP BOTTOM AND PUMPS SUPPORT FRAME, CUT AND REMOVE MATERIAL HERE
2. AFTER CUTTING AND REMOVING THE EXCESS MATERIAL, WELD PLATES PER DETAIL 1.
3. PAINT STRUCTURE PER 6515-GGD-022, COATING SYSTEM 2 AFTER WELDING THE PLATES.

PLAN CLÉ / KEY PLAN

NOTES GÉNÉRALES / GENERAL NOTES

LEGEND: SITE ASSEMBLY REQUIRED

George Fiorarai, P.Eng. July 12th 2017 Rev. 1

PERMIT TO PRACTICE
TETRA TECH INDUSTRIES, INC.
Date: 2017-07-12
PERMIT NUMBER: P 1029
NT/NU Association of Professional Engineers and Geoscientists

DESSINS EN RÉFÉRENCE / REFERENCE DRAWINGS

AGNICO EAGLE

REV.	DATE	DESCRIPTION	PAR/BY	APP.	CLIENT
1	2017/07/11	FOR CONSTRUCTION	G.C.	G.F.	N.M/B.A
0	2017/06/14	ISSUED FOR TENDER	S.G.	G.F.	N.M/B.A

REVISIONS

TETRA TECH

PROJET No: F14103230 FICHIER No: 65-695-265-228

TITRE / TITLE
AGNICO EAGLE – DIVISION MELIADINE
PUMPING STATION
CP5 TO CP1
PLAN, SECTIONS AND DETAILS

DESSINÉ PAR / DRAWN BY	S.G.	2017/06/07
VÉRIFIÉ PAR / CHECKED BY	G.F.	2017/06/07
APPROUVÉ PAR / APPROVED BY	G.F.	2017/06/07
ÉCHELLE / SCALE	N.T.S.	DATE 2017/06/07

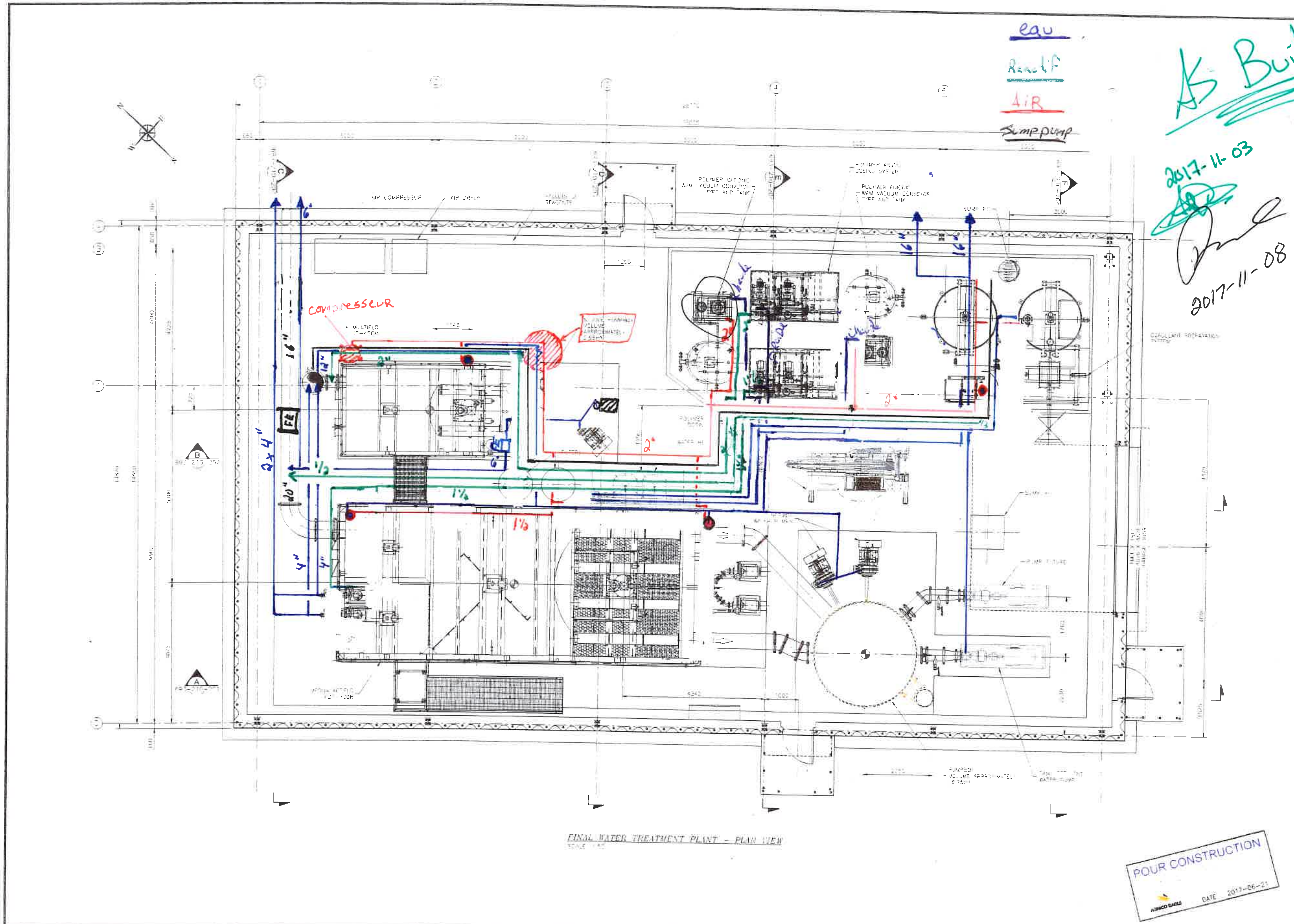
NO. DESSIN / DRAWING NO. 65-695-265-228

NO. PROJET / PROJECT NO. 6515-S-265-094 | RÉVISION 1 | FEUILLE / SHT 3/7

FILE NO. 65-695-265-228_3-R1.dwg

PIPERACK & RELATIVE

NO. DESSIN / DRAWING NO. 65-693-210-200_R4



WSP

NOTES GÉNÉRALES / GENERAL NOTES

DESSINS EN RÉFÉRENCE / REFERENCE DRAWINGS

AGNICO EAGLE

REV.	DATE	DESCRIPTION	PAR/BY	APP.	CLIENT
4	2017-06-21	GENERAL REVISION FOR FENCE BUILDING	V.T.	B.F.	
3	2017-04-28	BUILDING REVISION	V.T.	B.F.	
2	2017-03-24	ISSUED FOR CONSTRUCTION	I.G.	B.F.	
1	2017-03-03	GENERAL REVISION, AFTER RFQ	V.T.	B.F.	
0	2016-12-13	ISSUED FOR TENDER	I.G.	B.F.	

REVISIONS

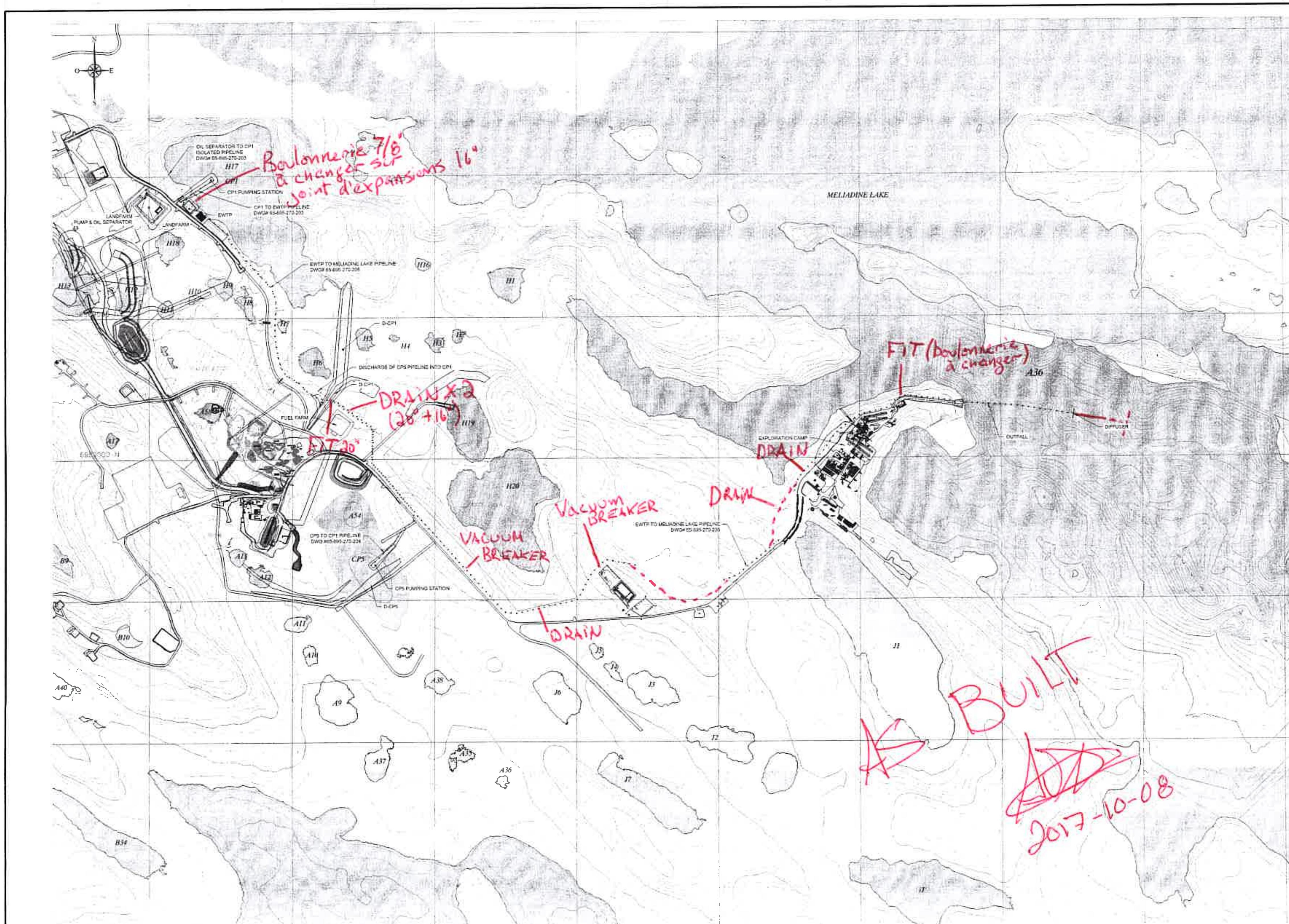
TITRE / TITLE
AGNICO EAGLE – MELIADINE DIVISION
693 – FINAL WATER TREATMENT PLANT
210– GENERAL ARRANGEMENT
PLAN VIEW

DESSINÉ PAR / DRAWN BY	STEVEN PERRON	DATE	2015-11-30
VÉRIFIÉ PAR / CHECKED BY	STEVEN PERRON		2015-12-02
APPROUVÉ PAR / APPROVED BY	BERTRAND FORTIN, ing		2015-12-02
ÉCHELLE / SCALE	INDICATED	DATE	2015-11-30
NO. DESSIN / DRAWING NO	65-693-210-200		
NO. PROJET / PROJECT NO	6515	REVISION 4	FEUILLE / SHT 1/1

FILE NO. 65-693-210-200_R4.dwg

NO. DESSIN DRAWING NO 65-695-270-200

FORMAT ANSI E



HDPE PIPELINES - GENERAL VIEW 2017
SCALE: 1:5000

PLAN CLE KEY PLAN

NOTES GÉNÉRALES / GENERAL NOTES

1. FOR EACH PIPELINE, A 4m ZONE SHALL BE GRADED AND FREE OF BOULDERS AND SHARP ROCKS TO AVOID DAMAGES TO THE PIPE AS IT WANDERS WITH TEMPERATURE VARIATIONS
2. PIPES SHALL BE ANCHORED EVERY 30m WITH EARTHERN FILL (EXCEPT FOR OTHER SECTIONS SPECIFICALLY DETAILED) AND SHALL BE SNAKED BETWEEN EACH ANCHOR POINTS. SEE DETAIL #11 ON DWG #65-695-270-206 SH.3
3. SEE INSTALLATATION SPECIFICATIONS #65-695-265-016-265-SPT-003 #65-695-265-016-265-SOW-001

PERMIT TO PRACTICE TETRA TECH INDUSTRIES INC.
PERMIT NUMBER: P 1026

POUR CONSTRUCTION FOR CONSTRUCTION
DATE 2017/07/11

DESSINS EN RÉFÉRENCE / REFERENCE DRAWINGS

TITRE / TITLE	# DWG
-	-
-	-
-	-
-	-
-	-

AGNICO EAGLE

REV.	DATE	DESCRIPTION	PAR/BY	APP.	CLIENT
2	2017/07/11	FOR CONSTRUCTION	S.C.	O.B.	N.M/B.A
1	2017/06/22	FOR TENDER (CONSTRUCTION)	S.C.	O.B.	N.M/B.A
0	2016/11/30	FOR TENDER (SUPPLY)	M.T.	M.R.	N.M/B.A

REVISIONS

TETRA TECH
PROJET No. C14103230 | FICHIER No. 65-695-270-200

TITRE / TITLE
AGNICO EAGLE - MELIADINE
WATER MANAGEMENT
HDPE PIPELINES - GENERAL ARRANGEMENT
2017 - CONSTRUCTION PLAN

DESSINÉ PAR DRAWN BY	MARIO C.	DATE 2016/11/30
VÉRIFIÉ PAR CHECKED BY	BENOIT T	2017/06/22
APPROUVÉ PAR APPROVED BY	ORPHE B.	2017/06/22
ÉCHELLE SCALE SHOWN	DATE	2017/06/22

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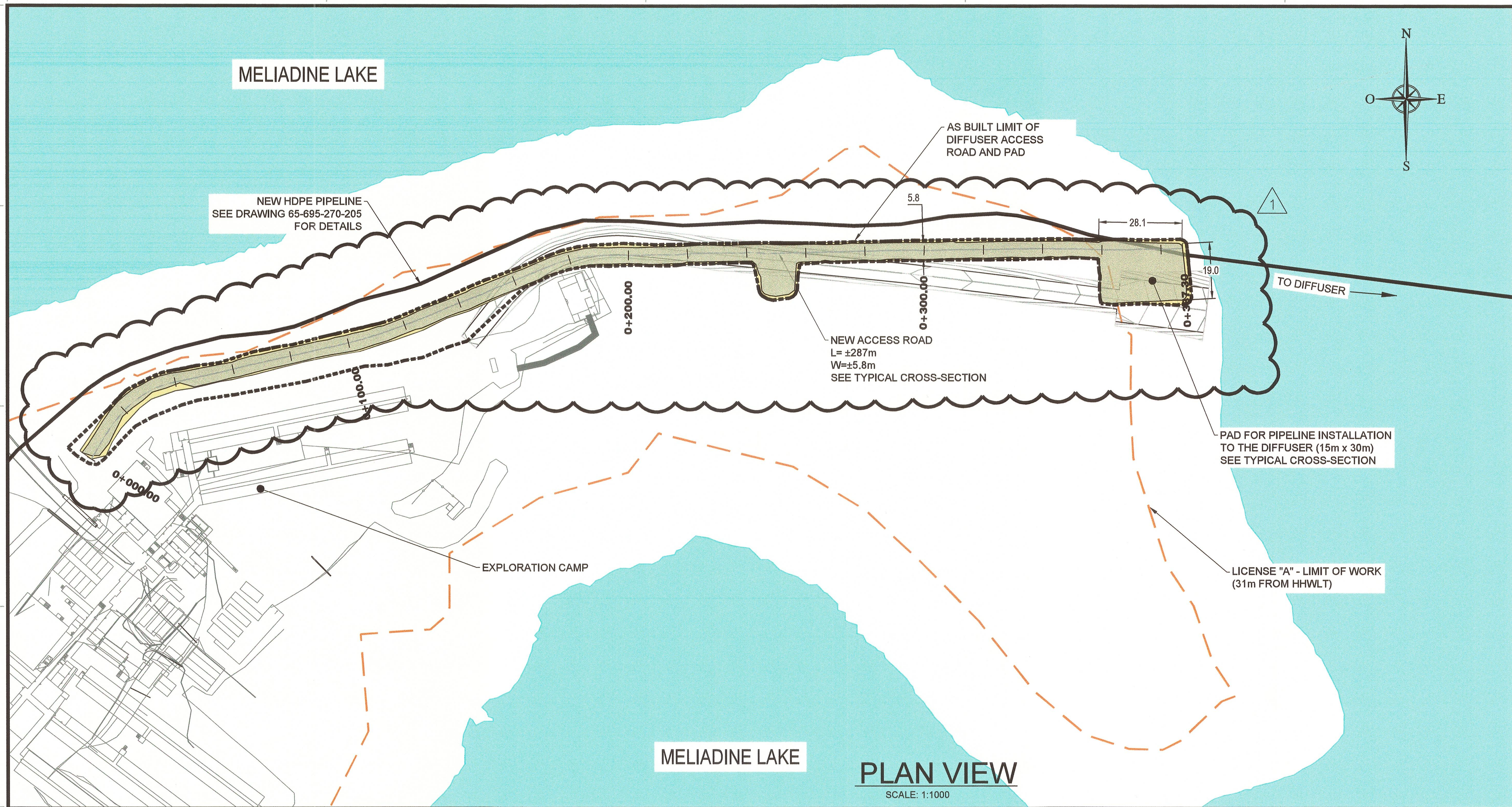
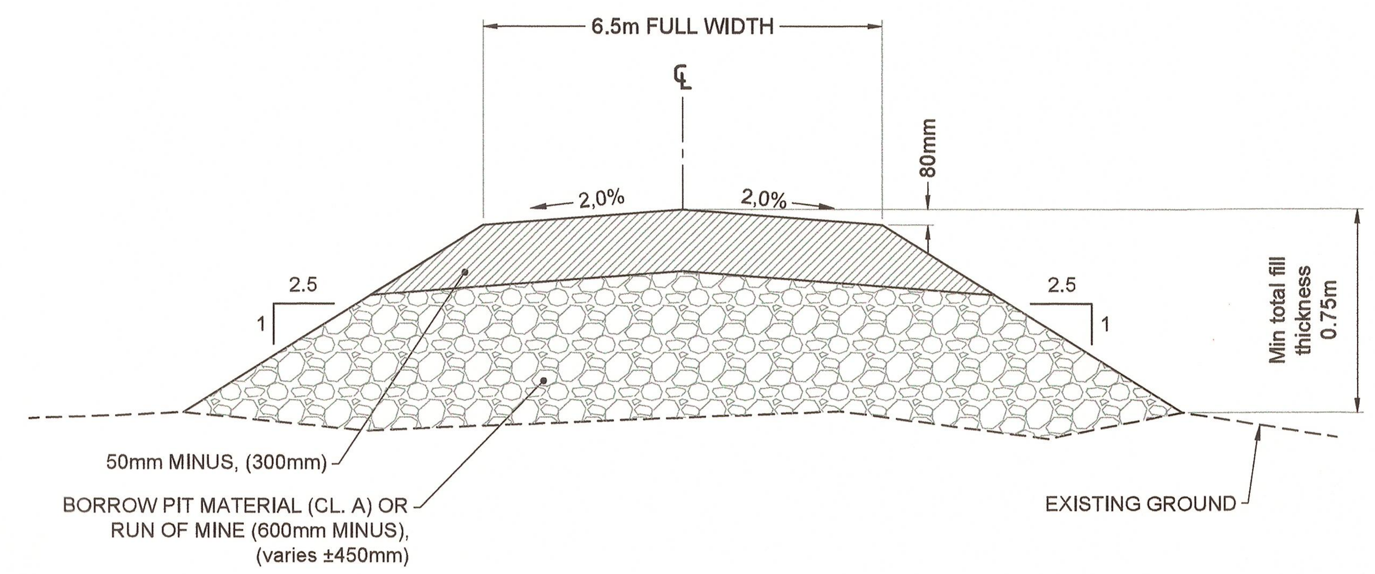


PLAN VIEW

SCALE: 1:1000



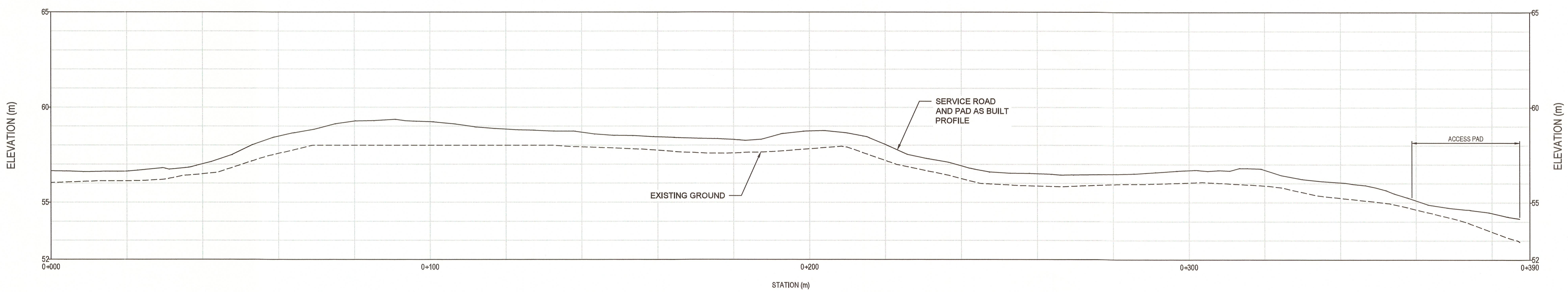
TYPICAL CROSS SECTION
TEMPORARY SERVICE ROAD AND PAD

TEL QUE CONSTRUIT AS BUILT
AGNICO EAGLE DATE : 2018-09-14

Quantity construction chart*
Temporary Diffuser Access Road and Pad
*Theoretical measure in place quantities

	Thickness (mm)	Required (m³)
50mm MINUS	300	587
Run of Mine or Borrow Pit Material (CL. A)	±450	3011
Total	-	3598

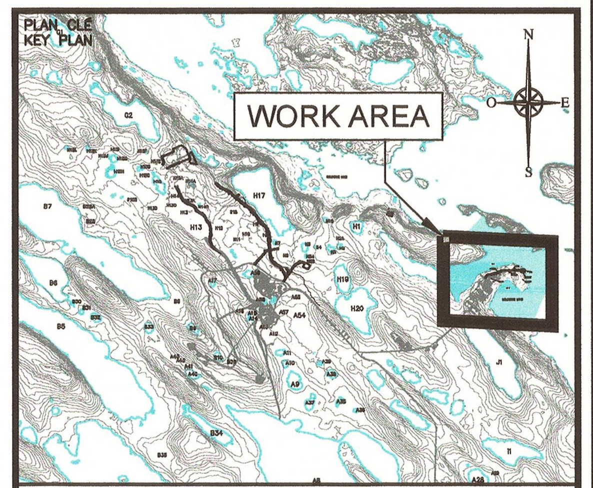
TETRA TECH
FINAL ISSUE AFTER CONSTRUCTION
SOME ANNOTATIONS HAVE BEEN ADDED TO THE DRAWING ISSUED FOR CONSTRUCTION IN ORDER TO INCORPORATE THE INFORMATIONS RECIEVED. IN THIS PROJECT, TETRATECH HADN'T DONE ANY FIELD SUPERVISION AT THE CONSTRUCTION SITE.



Temporary Diffuser Service Road and Pad As Built

HORIZONTAL SCALE: 1:600
VERTICAL SCALE: 1:120

PLAN CLÉ KEY PLAN



TETRA TECH

NOTES GÉNÉRALES / GENERAL NOTES

GENERAL NOTE:
1. EXISTING GROUND DTM PROVIDED BY AEM.
2. ALL UNITS ARE IN METERS.
3. ELEVATIONS IN DRAWING PROVIDE FINISHED GRADE ELEVATIONS AT THE TOP OF THE SURFACE GRAVEL LAYER.
4. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE SAFETY, SECURITY AND SLOPES OF ALL EXCAVATIONS/ BACKFILL AND SHALL ABIDE BY ALL RELEVANT STANDARDS AND REGULATIONS. THE STABILITY, DEWATERING AND MAINTENANCE OF ALL EXCAVATIONS SHALL BE THE CONTRACTOR'S RESPONSIBILITY.
5. GRANULAR MATERIAL SHALL BE PLACED IN LIFTS NOT EXCEEDING 300mm AND COMPACTED TO A MINIMUM OF 95% OF MAXIMUM DRY DENSITY. BORROW PIT OR RUN OF MINE MATERIAL 600mm MINUS SHALL BE PLACED IN LIFTS NOT EXCEEDING 600mm AND COMPACTED TO A MINIMUM OF 90% OF MAXIMUM DRY DENSITY. MOISTURE CONDITIONING MAY BE REQUIRED PRIOR TO COMPACTION.

DESSINS EN RÉFÉRENCE / REFERENCE DRAWINGS

TITRE / TITLE	# DWG
RELEVÉ TQC 2016	65-000-210-200
–	–
–	–
–	–
–	–

AGNICO EAGLE

REV.	DATE	DESCRIPTION	PAR/BY	APP.	CLIENT
1	2018-09-14	ISSUE FOR AS BUILT	M.S.	J.A.	
0	2017-06-14	ISSUED FOR CONSTRUCTION	C.M.	J.A.	

REVISIONS

PERMIT TO PRACTICE
TETRA TECH INDUSTRIES, INC. D/A TETRA TECH
Signature P. Gely
Date 2018-09-18
PERMIT NUMBER: P 1029
NT/NU Association of Professional Engineers and Geoscientists

REGISTERED PROFESSIONAL ENGINEER J.M.I.F. ALARIE LICENSEE
Josée Alarie 2018-09-18

TITRE / TITLE
AGNICO EAGLE – MELIADINE DIVISION
417 – ROADS, YARDS, FENCES, AND OTHER
230 – GENERAL EARTH WORKS
MELIADINE LAKE DIFFUSER TEMPORARY SERVICE ROAD
PLAN AND PROFILE VIEW

		DATE
DESSINÉ PAR DRAWN BY	CHRISTOPHER MORIN	2017-04-26
VÉRIFIÉ PAR CHECKED BY	SOLÈNE MOREAU	2017-04-26
APPROUVÉ PAR APPROVED BY	JOSÉE ALARIE	2017-04-26
ÉCHELLE SCALE	AS SHOWN	DATE 2016-04-26

NO. DESSIN DRAWING NO. 65-417-230-223

NO. PROJET PROJECT NO.	REVISION	FEUILLE / SHT
6515/28920	1	1 / 1

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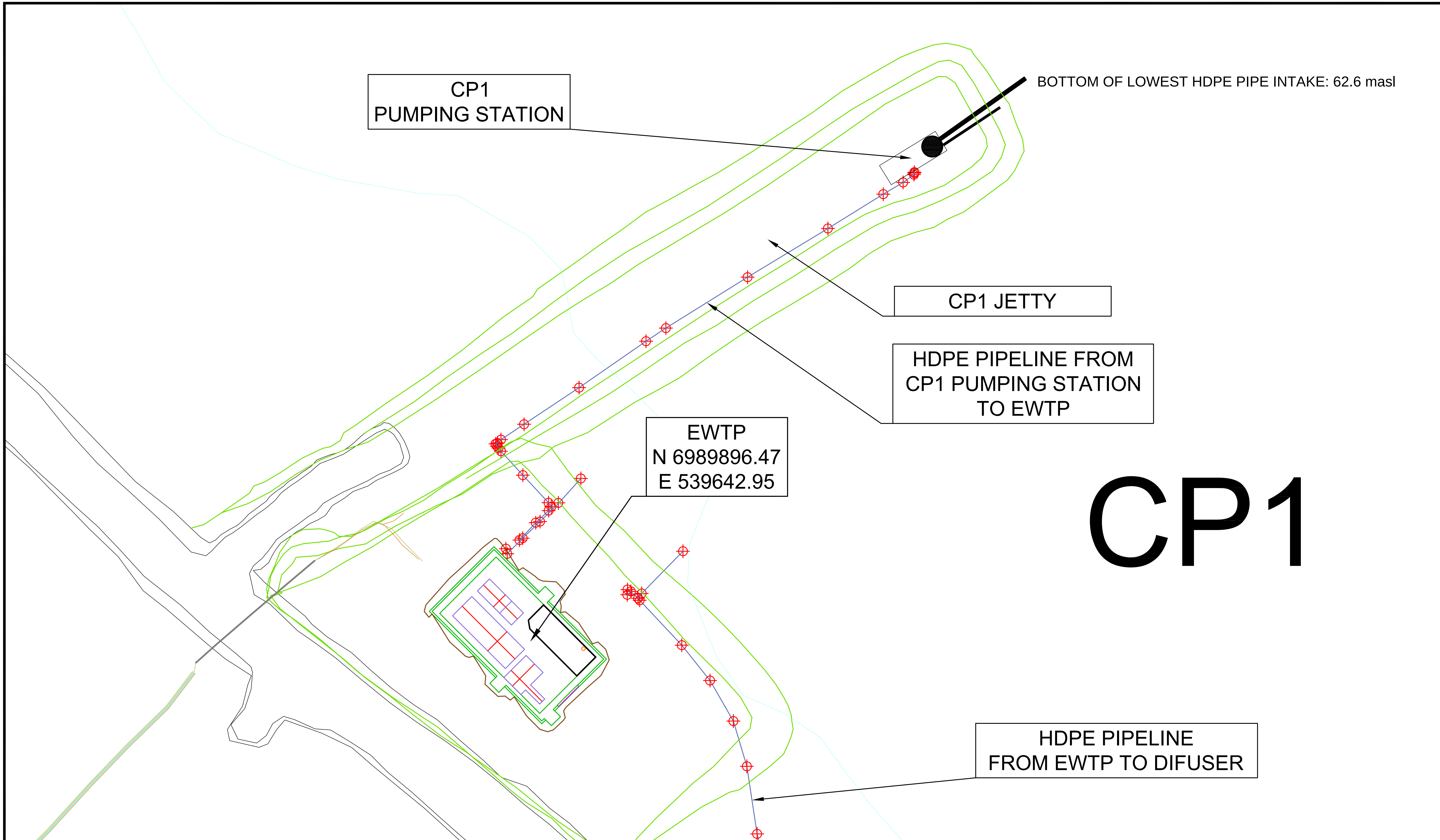
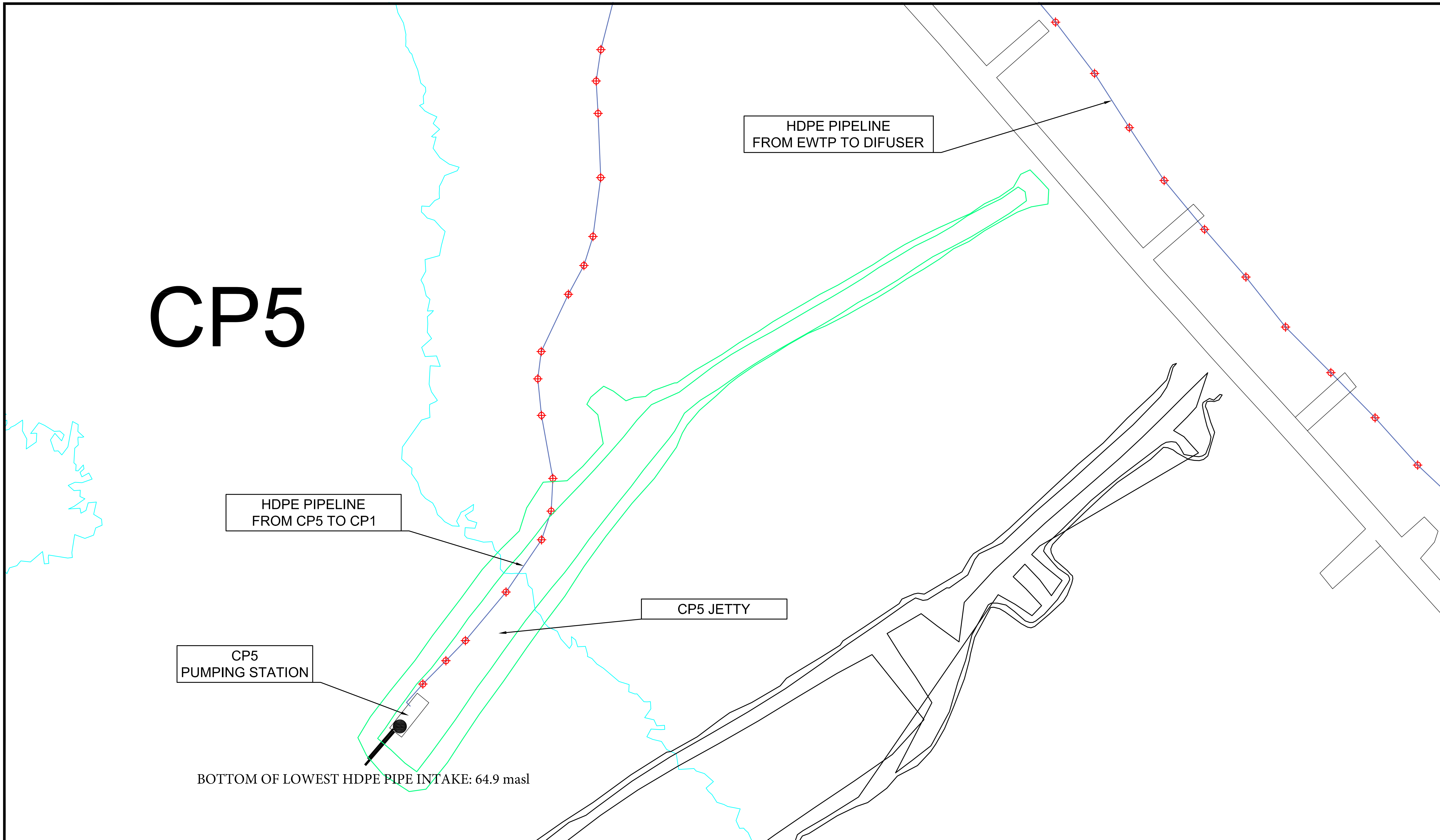
P:\28920\DESSIN\CIV-INFRA\DESSINS DE TRAVAIL\AUTOCAD\65-417-230-223_R1 (AS BUILT).dwg-2018-02-19 14:03:29

FILE NO. 65-417-230-223_R1 (AS BUILT).dwg

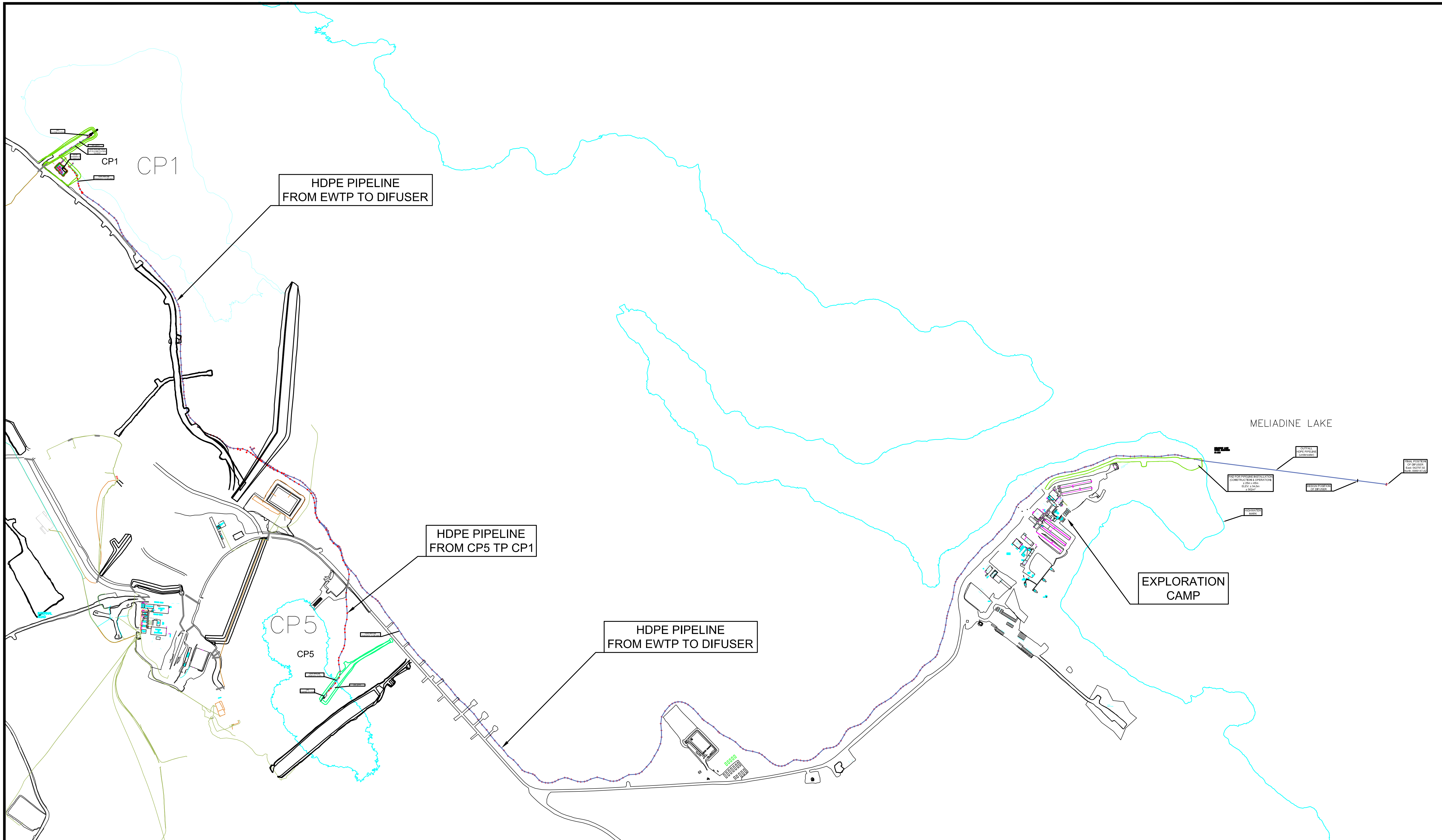
APPENDIX B
Survey drawings



HAMEL ARPENTAGE	Système de Coord.: UTM15 NAD83 Echelle: n.t.s.	No plan: 65-693-142-200-R2-ABD	AS BUILD EWTP & CP1 PUMPING STATION	AGNICO	Date des travaux : 2017 Date d'envoi : 2018-08-18	Dessine par: JF Landreville Approuve par: Hamel Arp.



HAMEL ARPENTAGE	Système de Coord.: UTM15 NAD83 Echelle: n.t.s.	No plan: 65-417-142-200-R0-ABD	AS BUILD CP5 PUMPING STATION	AGNICO	Date des travaux : 2017 Date d'envoi : 2018-08-18	Dessine par: JF Landreville Approuve par: Hamel Arp.



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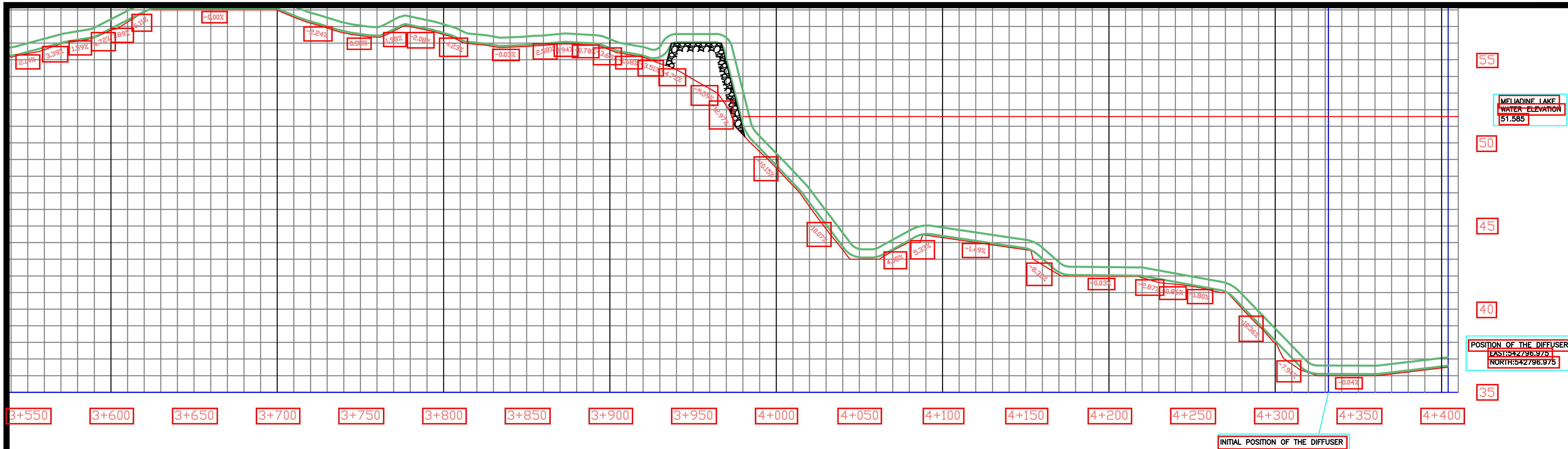
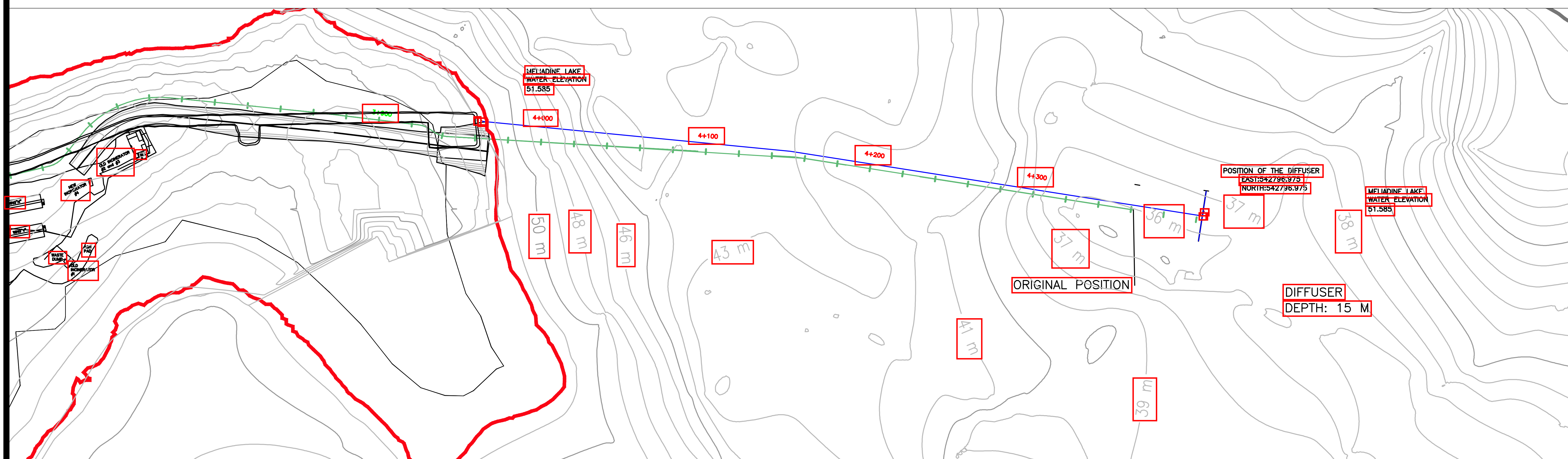
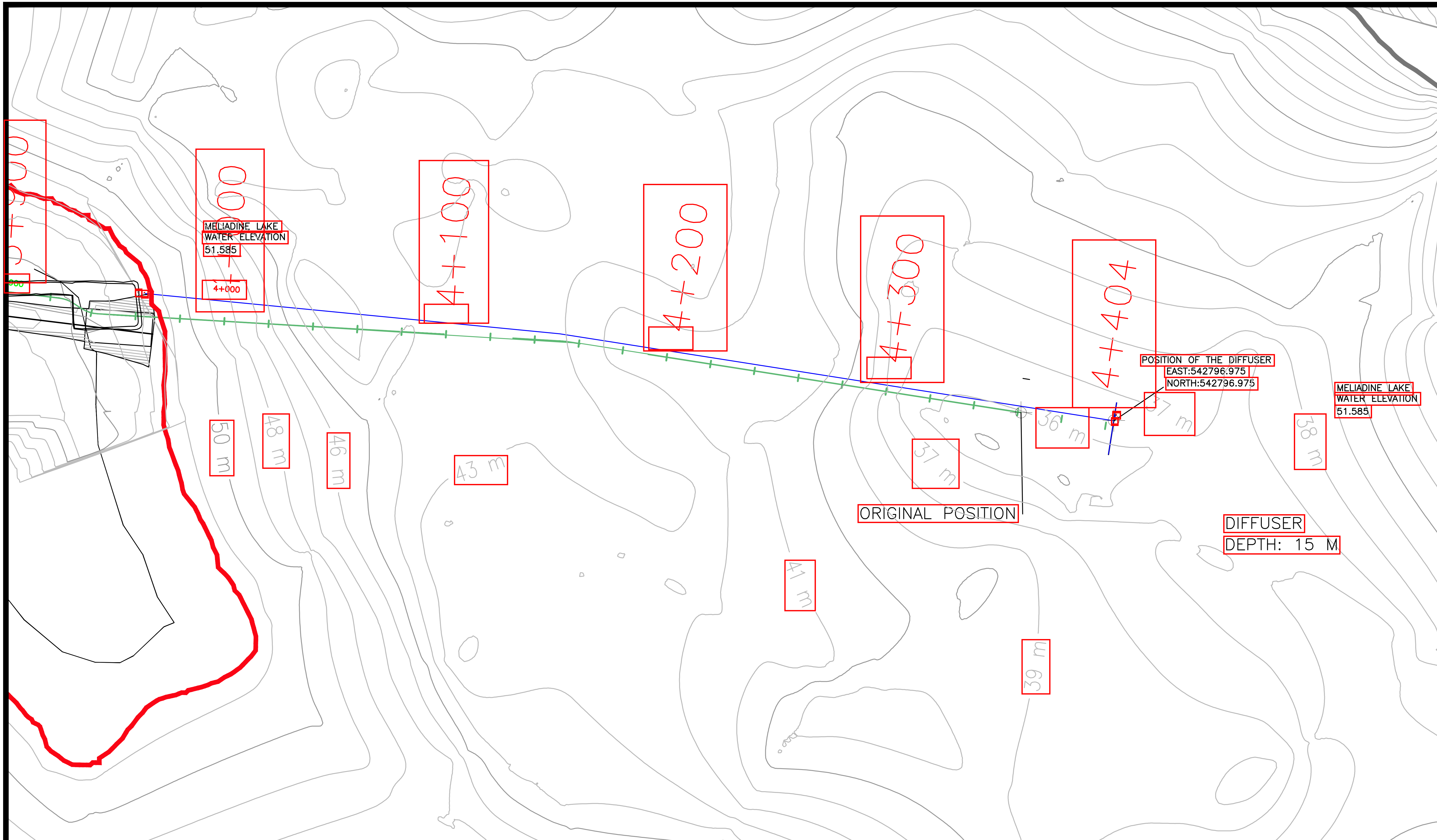
	Echelle: n.t.s.				Date d'envoi : 2018-08-18	Approuve par: Hamel Arp.

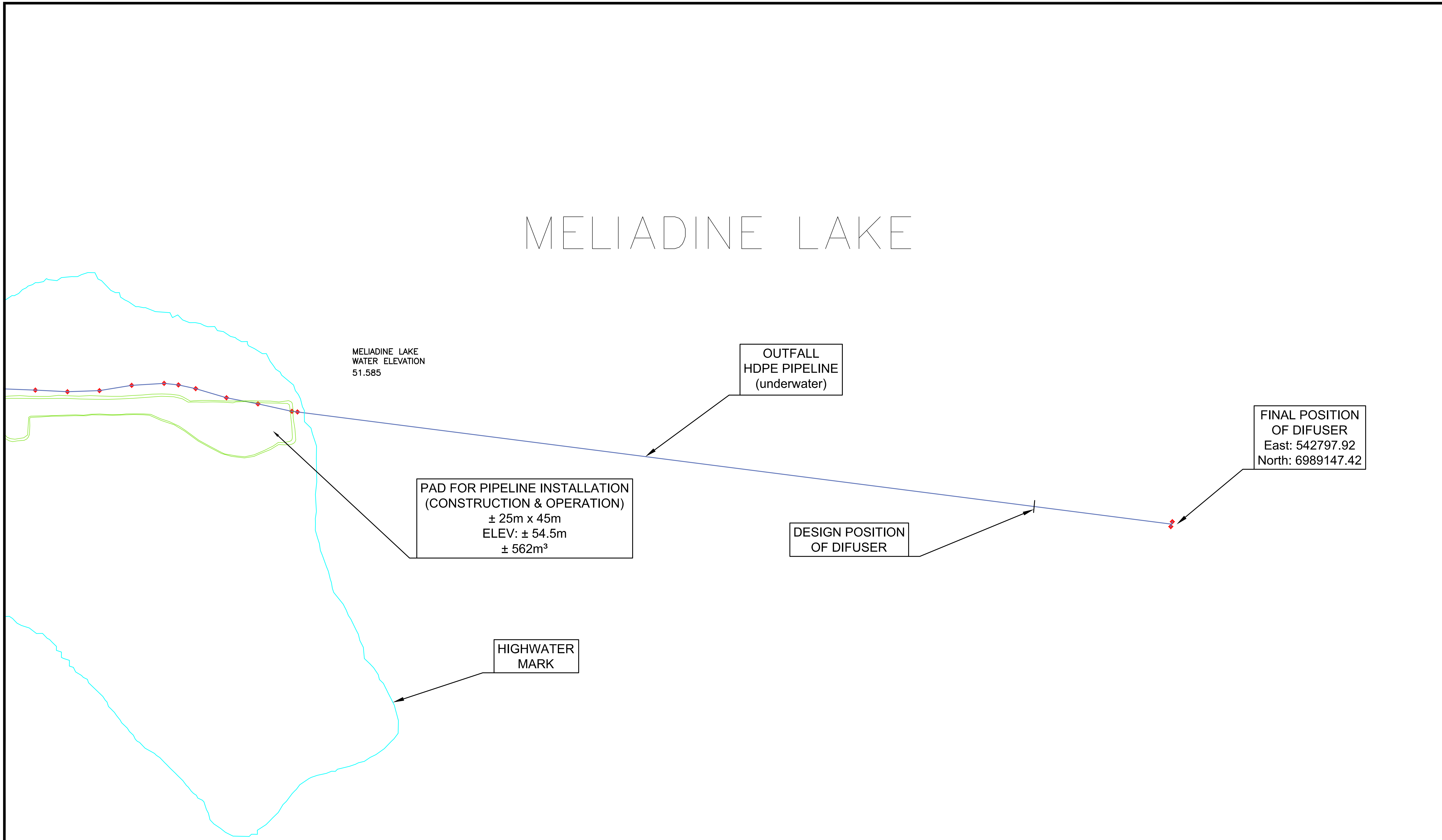




HAMELARPENTAGE	Système de Coord.: UTM15 NAD83	No plan: AB-695-DIFFUSER	AS BUILD DIFFUSER	AGNICO	Date des travaux : 2017-08-03	Dessine par: Y. Hamel
	Echelle: NA				Date d'envoi : 2017-08-23	Approuve par: Hamel arpentage



HAMELARPENTAGE	Système de Coord.: UTM15 NAD83	No plan: 65-695-270-205-2-RA_AB	AS BUILD DIFFUSER	AGNICO	Date des travaux : 2017-08-03	Dessine par: Y. Hamel
	Echelle: NA				Date d'envoi : 2017-08-23	Approuve par: Hamel arpentage



HAMEL ARPENTAGE	Système de Coord.: UTM15 NAD83 Echelle: n.t.s.	No plan: 65-695-142-201-R0-ABD	AS BUILD DIFFUSER	AGNICO	Date des travaux : 2017 Date d'envoi : 2018-08-18	Dessine par: JF Landreville Approuve par: Hamel Arp.

APPENDIX C
Photographs


CP5 PUMPING STATION

CP1 Pumping Station


EWTP - CP1 Pumping Station

Effluent Water Treatment Plant

Effluent Water Treatment Plant

Insulation drain


Insulation drain


Insulation drain

Pipeline Torque

Pipeline Torque


Diffuser System (Left Arm)


Diffuser System (Right Arm)

View of one Tideflex valve mounted on the Diffuser Port

View of a Tideflex Valve following Underwater Installation


View of the flange Adaptor linking
the Tee Connection with one Diffuser

APPENDIX D
Pumping Station Functional Description

TETRA TECH

AGNICO EAGLE

MELIADINE PROJECT
BLOCK 007 – PERMANENT PUMPING STATIONS
PACKAGE 6515-S-265-094
FUNCTIONNAL DESCRIPTION

March 30th, 2017
Revision 0

Prepared by:

Marc Tremblay, Eng.

Verified by:

George Floarea, P.Eng.

George Floarea, Eng.

Verified by:

Normand Ménard, Eng.

Verified by:

Pierre-Alexandre Bossé, Eng.

Verified by:

Sébastien Perron

Approved by:

Benoit Tremblay, Eng.

Table of contents

1. DOCUMENT OBJECTIVE

This document describe the programming of the control logic to be implement for the control system of the 2 pumping stations, 65PST40001 (CP-1) and 65PST40005 (CP-5) for the Agnico Eagle Meliadine mine Project located at Meliadine Lake in Nunavut.

The 65PST40005 pumping station is located upstream approximatively 1 km from the 65PST40001 which is located upstream of the water treatment plant near Meliadine Lake. Each pumping station will have their own PLC and HMI, the programming include both 65PST40001 and 65PST40005 new PLC and HMI.

2. SYSTEM DESCRIPTION

Each pumping station consist of a sump pit, 2 submersibles pumps, piping, valves, electrical equipment, instrumentation and control equipment’s all installed in a heated building. Depending of the pumping capacity requirement, two pumps could be working at the same time, however if only one pump is required, the other will be in standby for back-up. .

2.1 Pumping station 65PST40001 (CP-1)

Surface water from CP-1 pond is brought into the 5.7 m deep sump of 65PST40001 pumping station using two HDPE pipes (400 mm and 500 mm). To pump the water from the sump to the Effluent Water Treatment Plant (EWTP), two 110HP submersible pumps (65PSU40001A and B), with variable speed drives (VFD) are used

An ultrasonic level transmitter 65LIT6950227 measure the sump water level and transfer the signal to the control panel (PLC1) for pump control and indication on the local HMI. A 100 mm drain line with an automatic butterfly valve 65FV6950229 is connected to the discharge line near the pumps to drain the discharge main line back to the sump when the pumps stop. This draining automatic procedure helps draining the portion of pipeline higher than the pumping station and prevent this section to freeze in case of pump failure by example.

Two magnetic flowmeters will be installed on the 400 mm (16") main line going to Meliadine Lake. One flowmeter is located at the EWTP station(65FIT6930001) and the second one downstream of the EWTP, near Meliadine Lake (65FIT6930020). Both flowmeters will be used to check for a possible leak in the line by comparing their readings in real time. , one flowmeter will be supplied loose by the pumping stations manufacturer, the other one by the EWTP manufacturer. Leak detection programing will be done in the EWTP station control system and therefore is not included in this document.

The EWTP is located near CP-1 pond, it treats water incoming from pond CP-1 (and CP-5) before it will pumped to the Meliadine lake. The EWTP package is supplied by others.

2.2 Pumping station 65PST40005 (CP-5)

Surface water from CP-5 pond is brought into the 3.47 m deep sump of 65PST40005 pumping station using two HDPE pipes (400 mm and 500 mm). To pump the water from the sump to the CP-1, two 45HP submersible pumps (65PSU40005A and B), with soft starts are used

An ultrasonic level transmitter (65LIT6950207) measures the sump water level and transfers the signal to the control panel (PLC5) for pump control and indication on the local HMI. A 100 mm drain line with an automatic butterfly valve (65FV6950209) is connected to the discharge line near the pumps to drain the discharge main line back to the sump when the pumps stop. This draining automatic procedure helps draining the portion of pipeline higher than the pumping station and prevent this section to freeze in case of pump failure by example.

Two magnetic flowmeters are installed on the 400 mm main line going to the CP-1. One flowmeter (65FIT6950211) is located close to the pumps' discharge and the second one (65FIT6950213) at the end of the main line, near CP-1 pond. Both flowmeters, which will be used to detect possible leaks in real time by comparing their readings, will be supplied loose by the pumping stations manufacturer. As opposed to the 65PST40001 station, leak detection programing will be done in the PLC-5.

3. 65PST40001 (CP-1) CONTROL

In the first phase of the project, the water volumes in CP-1 require only one pump to be in operation. The second pump will serve mainly as a spare.

Each pump is equipped with a 3 positions selector Manual/Auto/Maintenance at the local HMI, 65HIK6950220 for pump 65PSU40001A, 65HIK6950225 for pump 65PSU40001B, and either a start/stop button for each pump, 65HS6950220 and 65HS695225. The selectors function are as followed:

Manual (left) :	The pump start and stop with the start and stop buttons on the HMI. The pump respect the interlocks (Low low level for example).
Auto (middle) :	The pumps will start and stop automatically according to the PLC command.
Maintenance (middle) :	The pump jog with the start button on the HMI, the pump doesn't respect the interlocks.

3.1 Manual Mode

In this mode the PLC controls the pump via the Start/Stop buttons on the HMI. The pump will respect the interlocks (if the low low level is reached, it won't start back). This mode should be used to keep the pump stopped or for manual operation.

3.2 Maintenance Mode

The pump is not running, it will start when the start button on the HMI is held and automatically stopped when it's release, it does not respect the interlocks.

3.3 Auto Mode

This is the normal operating mode. During normal operation, the selector on the local HMI is set to AUTO position therefore the PLC1 will start and stop the pump and regulating the pump speed according to the process conditions and demand from the EWTP PLC.

The PLC will control the selected pump in this mode, the back-up pump will be in Manual.

1. Pump start-up sequence

   Starting interlock:

   The following interlock are checked to authorize the pump start.

   - No Emergency-Stop
   - Pump in Auto mode
   - VFD is ready
   - No low level in the sump pit
   - EWTP starting command flag is on

   The pump cannot start only by the CP-1 local interlock, the EWTP system will initiate the starting sequence depend on his demand. When all local conditions are true, the pump is ready to start and wait from the EWTP start command, when this command is initiate, the pump starting sequence begin as follows:

   - Starting the pump in auto mode 65PSU40001A or B
   - Close drain valve 65FV6950229
   - Signal output 65FIC6930001 to VFD set to minimum, (?? %, to come)

   Once the pump is started, the following confirmations are check

   - The pump is running
   - The drain valve 65FV6950229 is close after 30 seconds (actuator travel time is 14 sec)

   If these feedback are not confirmed, an alarm shall be initiate at the local HMI and at the EWTP control system. .

2. Pump speed control

   When the pump is running and the drain valve is confirm close, the PLC control the pump speed by the speed Modbus Ethernet register in the VFD according to the 65FIC6930001 output that set the pump speed.

Depending on the flow coming from the CP1 pond and the EWTP capacity, the sump pit level will vary and act as a buffer. The speed set point of the pump will be dictated by the EWTP plant PLC, while the CP-1 PLC will transfer the speed require to the VFD by the local Ethernet network. Therefore the control strategy for the pump speed control will be detailed in the EWTP functional description.

3. Pump stop sequence

The pump could be stopped either by the EWTP plant (normal operating mode) or by the local CP-1 PLC if one of the interlock listed in 3.3.1 is disable.

- Emergency-Stop is activated
- Pump not in Auto mode
- VFD is not ready
- Low level in the sump pit

Under certain circumstances, if the water level becomes too low in the sump, the pump shall be stopped to avoid cavitation.

When the water level reaches a low level (?? %, to come) (65LAL6950227), the pump will be stopped with the following sequence.

- The pump is stop.
- The drain valve 65FV6950229 is open and remains open until the pump is start again.
- Motor status feedback and valve position is sent to the PLC.

If these feedbacks are not confirmed, an alarm shall be initiate at the HMI.

The pump in Auto mode will remain stopped until the level rise above the high level set point 65LAH6950227 and the EWTP PLC initiate the start command, then the start sequence will be initiated again. The pump will stop with the low level 65LAL6950227.

4. <u>Emergency stop 65HSS6950220</u>

An Emergency Stop push-bouton, 65HSS690220 located near the pump will stop the pump immediately (no matter what the process conditions or alarms are). This Emergency Stop shall have a protective cover to avoid accidental actuation.

5. <u>Drain Valve 65FV6950229</u>

The drain valve 65FV6950229 is equipped with a 3 positions selector, 65HIK6950229 (Manual/Auto/Maintenance) and a Close/Open buttons on the HMI, 65HS6950229. The normal operating mode is Auto, in this mode the PLC control the valve opening and closing. In manual mode, the valve can be open and close with the HMI in respect with the interlock, while in maintenance mode the valve is close and can be openned by holding the open command on the HMI independently of the interlocks.

3.4 Alarm List

The following alarms shall be programmed in the HMI 65HMI69501.

Alarm tag #	Description	Set point
65LAHH6950227	High High level Alarm sump CP-1	To come
65LAH6950227	High level Alarm sump CP-1 (Start pump)	To come
65LAL6950227	Low level Alarm sump CP-1 (Stop pump)	To come
65LALL6950227	Low Low level Alarm sump CP-1	To come
65XA40001A/1	65VFD40001A motor VFD fault	n/a
65XA40001A/2	65PSU40001A motor GFI Trip	n/a
65HA40001A	65PSU40001A motor start problem	n/a
65XA40001B/1	65VFD40001B motor VFD fault	n/a
65XA40001B/2	65PSU40001B motor GFI Trip	n/a
65HA40001B	65PSU40001B motor start problem	n/a
65ZA6950229	Drain valve malfunction	n/a
65HA6950220	Emergency stop activated	n/a

4. 65PST40005 (CP-5) CONTROL

Depending of the flow coming from the CP-5 pond, one or two pump will be required, therefore the PLC will controlled one or two pump at the same time. If only one pump is required, the second pump will be used as back-up. CP-5 pumps do not have VFD, only soft start, and therefore they are on-off controlled.

Each pump is equipped with a 3 positions selector Manual/Auto/Maintenance at the local HMI, 65HIK6950200 for pump 65PSU40005A, 65HIK6950205 for pump 65PSU40005B, and either a start/stop button for each pump, 65HS6950200 and 65HS695205. The selectors function are as followed:

Manual (left) :	The pump start and stop with the start and stop buttons on the HMI. The pump respect the interlocks (Low low level for example).
Auto (middle) :	The pumps will start and stop automatically according to the PLC command.
Maintenance (right) :	The pump jog with the start button on the HMI, the pump doesn’t respect the interlocks.

4.1 Manual Mode

In this mode the PLC controls the pump via the Start/Stop buttons on the HMI. The pump will respect the interlocks (if the low low level is reached, it won’t start back). This mode should be used to keep the pump stopped or for manual operation.

4.2 Maintenance Mode

The pump is not running, it will start when the start button on the HMI is held and automatically stopped when it's release, it does not respect the interlocks.

4.3 Auto Mode

This is the normal operating mode. During normal operation the selector is set to AUTO position therefore the PLC5 will start and stop the pump according to the process signal from the level transmitter.

1. Pump start-up sequence

Starting interlock

The following interlock are checked to authorize the pump start.

- No Emergency-Stop
- Pump in Auto mode
- Soft start is ready

When all these conditions are true, the pump is start depending on the water level in the sump pit. When 65LIT6950207 reaches a High level at ?? % (to come), 65LAH6950207, the starting sequence begins as follow:

- Starting the pump in auto mode 65PSU40005A or B
- Close drain valve 65FV6950209

Once the pump is started, the following confirmation are check

- The pump is running.
- The drain valve 65FV6950209 is close after 30 seconds (actuator travel time is 14 sec).

If theses feedback are not confirms, an alarm shall be initiate at the HMI.

2. Pump stop sequence

The pump in Auto will run until the sump pit water level reach is low level alarm 65LAL6950207, than the pump is stopped with the following sequence:

- The pump is stopped.
- The drain valve 65FV6950209 is open and remains open until the pump is start again.
- Motor status feedback and valve position is sent to the PLC.

If theses feedback are not confirms, an alarm shall be initiate at the HMI.

The pump in Auto mode will remain stop until the level 65LIT6950207 rise and reach the high level 65LAH6950207, than the start sequence will be initiated again.

3. Emergency Stop 65HSS6950200

An Emergency Stop push-bouton 65HSS6950200 located near the pumps will stop the pump immediately no matter what the process conditions or alarm are. This Emergency Stop shall have a protective cover to avoid accidental actuation.

4. Flowmeter readings comparison

As describe in section 2.2, two magnetic flowmeter 65FIT6950211 and 65FIT6950213 are install on the main water line going from the pumping station 65PST40005 to CP1 pond. The flow signal from both meter are send to the PLC and display on the HMI in engineering units, 65FI6950211 and 65FI6950213.

The mains goal of the flowmeters is to detect a possible leak in the pipe by comparing the 2 flow in real time and generate an alarm at the HMI if the difference between the two flowmeter readings is more than 10% of the actual flow.

5. Drain Valve 65FV6950209

The drain valve 65FV6950209 is equipped with a 3 positions selector, 65HIK6950209 (Manual/Auto/Maintenance) and a Close/Open buttons 65HS6950209 on the HMI. The normal operating mode is Auto, in this mode the PLC control the valve opening and closing. In manual mode, the valve can be open and close with the HMI in respect with the interlock, while in maintenance mode the valve is close and can be openned by holding the open command on the HMI independently of the interlocks.

4.4 Alarm List

The following alarms shall be programmed in the 65HMI69505

Alarm tag #	Description	Set point
65LAHH6950207	High High level sump CP-5	To come
65LAH6950207	High level Alarm sump CP-5 (Start pump)	To come
65LAL6950207	Low level Alarm sump CP-5 (Stop pump)	To come
65LALL6950207	Low Low level Alarm sump CP-5	To come
65FDAH6950213	High Flow diff 65FI6950213 and 65FI2950211	To come
65XA40005A/1	65PSU40005A motor GFI Trip	n/a
65XA40005A/2	65PSU40005A motor Overload Trip	n/a
65HA40005A	65PSU40005A motor start problem	n/a
65XA40005B/1	65PSU40005B motor GFI Trip	n/a
65XA40005B/2	65PSU40005B motor Overload Trip	n/a
65HA40005B	65PSU40005B motor start problem	n/a
65ZA695209	Drain valve malfunction	n/a
65HSS6950200	Emergency stop activated	n/a

APPENDIX E
Water Quality Testing of EWTP Discharge

		Pre-treatment EWTP		
Date		**17-Jun-18**	**27-Jun-18**	**1-Jul-18**
field pH		7.33	8.5	8.75
field cond.		888	1572 us	1528 uS
field temp		3	2.1	9
Water Bodie: CP1 (MEL-14)				
Year		2018	2018	2018
Date sampled		17-juin-18	27-juin-18	01-juil-18
Lab Reference		B8F2110	B8G3414	B8G4482
LAB		Maxxam	Maxxam	Maxxam
Parameters	**Units**			
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	33	51	56
Carb. Alkalinity (calc. as CaCO3)	mg/L	<1.0	<1.0	<1.0
Total Ammonia-N	mg/L	2.4		2.7
Conductivity	µmhos/cm	840	1500	1600
Total Dissolved Solids (TDS)	mg/L	**540**	**945**	**950**
Free Cyanide (Cn)	mg/L	<0.0010		<0.001
Total Kjeldahl Nitrogen (TKN)	mg/L	2.2		3.5
Dissolved Organic Carbon (DOC)	mg/L	5.3		8.5
Total organic carbon (T.O.C.)	mg/L	5.9		9.8
Orthophosphate (P)	mg/L	0.11		0.015
pH	pH	7.45	7.58	7.62
Total Phosphorus (P)	mg/L	0.15		0.1
Total Suspended Solids (TSS)	mg/L	9	4	30
Dissolved Sulphate (SO4)	mg/L	31	46	52
Total Cyanide (Cn)	mg/L	<0.0050		<0.0050
Turbidity	NTU	3	2.1	3.7
Alkalinity (Total as CaCO3)	mg/L	33	51	56
Dissolved Chloride (Cl)	mg/L	180	350	390
Nitrite (as N)	mg/L	0.07		0.096
Nitrate (as N)	mg/L	4.78		5.54
Nitrite-Nitrate (as N)	mg/L	4.85		5.63
Radium-226	Bq/L	<0.0050		<0.0050
Total Oil & Grease	mg/L	<0.50		1.3
Mercury (Hg)	mg/L	<0.00001		<0.00001
Dissolved Mercury (Hg)	mg/L	<0.00001		<0.00001
Total Hardness	mg/L	201	400	418
Total Aluminium (Al)	mg/L	0.315		0.404
Total Antimony (Sb)	mg/L	<0.00050		<0.00050
Total Arsenic (As)	mg/L	0.00216		0.00213
Total Barium (Ba)	mg/L	0.0491		0.1
Total Beryllium (Be)	mg/L	<0.00010		<0.00010
Total Boron (B)	mg/L	0.065		0.104
Total Cadmium (Cd)	mg/L	0.000023		0.00003
Total Chromium (Cr)	mg/L	0.001		0.0011
Total Copper (Cu)	mg/L	0.00336		0.0025
Total Iron (Fe)	mg/L	0.58		0.711
Total Lead (Pb)	mg/L	0.00062		0.00055

		Pre-treatment EWTP		
Date		**17-Jun-18**	**27-Jun-18**	**1-Jul-18**
field pH		7.33	8.5	8.75
field cond.		888	1572 us	1528 uS
field temp		3	2.1	9
Water Bodie: CP1 (MEL-14)				
Year		2018	2018	2018
Date sampled		17-juin-18	27-juin-18	01-juil-18
Lab Reference		B8F2110	B8G3414	B8G4482
LAB		Maxxam	Maxxam	Maxxam
Parameters	**Units**			
Total Lithium (Li)	mg/L	0.0555		0.115
Total Manganese (Mn)	mg/L	0.169		0.376
Total Molybdenum (Mo)	mg/L	<0.0010		<0.0010
Total Nickel (Ni)	mg/L	0.0029		0.0039
Total Selenium (Se)	mg/L	<0.00010		<0.00010
Total Silver (Ag)	mg/L	<0.000020		<0.000020
Total Strontium (Sr)	mg/L	1.25		2.48
Total Thallium (Tl)	mg/L	0.000022		0.000028
Total Tin (Sn)	mg/L	<0.0050		<0.0050
Total Titanium (Ti)	mg/L	0.0102		0.0059
Total Uranium (U)	mg/L	0.00035		0.00061
Total Vanadium (V)	mg/L	<0.0050		<0.0050
Total Zinc (Zn)	mg/L	0.0074		0.0063
Total Calcium (Ca)	mg/L	62.8		131
Total Magnesium (Mg)	mg/L	10.7		22.1
Total Potassium (K)	mg/L	6.06		11.3
Total Sodium (Na)	mg/L	55.2		108
BTEX & F1 Hydrocarbons				
Benzene	ug/L	<0.20		<0.20
Toluene	ug/L	<0.20		<0.20
Ethylbenzene	ug/L	<0.20		<0.20
o-Xylene	ug/L	<0.20		<0.20
p+m-Xylene	ug/L	<0.40		<0.40
Total Xylenes	ug/L	<0.40		<0.40
F1 (C6-C10)	ug/L	<25		<25
F1 (C6-C10) - BTEX	ug/L	<25		<25
Hydrocarbons (L) (Fraction F1 (C6-C10))	µg/L			
Hydrocarbons (L) (Fraction F2 - F4))				
F2 (C10-C16 Hydrocarbons)	µg/L	<100		<100
F3 (C16-34 Hydrocarbons)	µg/L	<200		<200
F4 (C34-50 Hydrocarbons)	µg/L	<200		<200
Reached Baseline at C50	µg/L	yes		Yes
Diesel (C10-C24)	µg/L			
Diesel (C11-C32)	µg/L			
F4G-sg (Grav. Heavy Hydrocarbons)	ug/L			
1,4-Difluorobenzene	%	99		105

		Pre-treatment EWTP		
Date		**17-Jun-18**	**27-Jun-18**	**1-Jul-18**
field pH		7.33	8.5	8.75
field cond.		888	1572 us	1528 uS
field temp		3	2.1	9
Water Bodie: CP1 (MEL-14)				
Year		2018	2018	2018
Date sampled		17-juin-18	27-juin-18	01-juil-18
Lab Reference		B8F2110	B8G3414	B8G4482
LAB		Maxxam	Maxxam	Maxxam
Parameters	**Units**			
4-Bromofluorobenzene	%	97		103
D10-Ethylbenzene	%	94		96
D4-1,2-Dichloroethane	%	98		111
o-Terphenyl	%	96		100
Dissolved Hardness	mg/L	28.9		421
Dissolved Aluminium (Al)	mg/L	0.0613		0.0879
Dissolved Antimony (Sb)	mg/L	<0.00050		<0.00050
Dissolved Arsenic (As)	mg/L	0.00076		0.00133
Dissolved Barium (Ba)	mg/L	0.0082		0.0998
Dissolved Beryllium (Be)	mg/L	<0.00010		<0.00010
Dissolved Boron (B)	mg/L	0.069		0.106
Dissolved Cadmium (Cd)	mg/L	0.000013		0.000024
Dissolved Chromium (Cr)	mg/L	<0.0010		<0.0010
Dissolved Copper (Cu)	mg/L	0.00104		0.00175
Dissolved Iron (Fe)	mg/L	0.0355		0.0893
Dissolved Lead (Pb)	mg/L	<0.00020		<0.00020
Dissolved Lithium (Li)	mg/L	<0.0020		0.116
Dissolved Manganese (Mn)	mg/L	0.128		0.328
Dissolved Molybdenum (Mo)	mg/L	0.0011		<0.0010
Dissolved Nickel (Ni)	mg/L	<0.0010		0.003
Dissolved Selenium (Se)	mg/L	<0.00010		<0.00010
Dissolved Silver (Ag)	mg/L	<0.000020		<0.000020
Dissolved Strontium (Sr)	mg/L	0.0452		2.53
Dissolved thallium (Tl)	mg/L	<0.000010		0.00003
Dissolved Tin (Sn)	mg/L	<0.0050		<0.0050
Dissolved titanium (Ti)	mg/L	<0.0050		<0.0050
Dissolved Uranium (U)	mg/L	<0.00010		0.00059
Dissolved Vanadium	mg/L	<0.0050		<0.0050
Dissolved Zinc	mg/L	0.0051		<0.0050
Dissolved Calcium (Ca)	mg/L	7.76		131
Dissolved Magnesium (Mg)	mg/L	2.3		22.6
Dissolved Potassium (K)	mg/L	3.9		11.5
Dissolved Sodium (Na)	mg/L	14.6		109
Dissolved Sulphur (S)	mg/L	-		
Reactive Silica (Si)	mg/L	0.83		0.31
Cobalt (Co)	mg/L			

		Pre-treatment EWTP		
Date		**17-Jun-18**	**27-Jun-18**	**1-Jul-18**
field pH		7.33	8.5	8.75
field cond.		888	1572 us	1528 uS
field temp		3	2.1	9
Water Bodie: CP1 (MEL-14)				
Year		2018	2018	2018
Date sampled		17-juin-18	27-juin-18	01-juil-18
Lab Reference		B8F2110	B8G3414	B8G4482
LAB		Maxxam	Maxxam	Maxxam
Parameters	**Units**			
Cobalt (Co)	mg/L			
Daphina Toxicity	**U.T (Toxic Units)**			
Rainbow Trout Toxicity	**U.T (Toxic Units)**			

Post treatment EWTP

Date		**License A 2AM-MEL1631 Part F, Item 3**	**1-Jul-18**
field pH			7.35
field cond.			1510 uS
field temp			10.4
Water Bodie: EWTP-POST TREATMENT (MEL-14)			
Year			**2018**
Date sampled			1-Jul-18
Lab Reference			B8G4482
LAB			Maxxam
Parameters	**Units**		
Bicarb. Alkalinity (calc. as CaCO3)	mg/L		34
Carb. Alkalinity (calc. as CaCO3)	mg/L		<1.0
Total Ammonia-N	mg/L		2.6
Conductivity	µmhos/cm		1600
Total Dissolved Solids (TDS)	mg/L	Max Avg (1400 mg/L) Max grab (1400 mg/L)	930
Free Cyanide (Cn)	mg/L		0.0027
Total Kjeldahl Nitrogen (TKN)	mg/L		2.8
Dissolved Organic Carbon (DOC)	mg/L		4.8
Total organic carbon (T.O.C.)	mg/L		5.9
Orthophosphate (P)	mg/L		<0.01
pH	pH	Max avg (6.0 to 9.5) max grab (6.0 to 9.5)	7.11
Total Phosphorus (P)	mg/L	Max avg (2 mg/L) Max grab (4 mg/L)	0.034
Total Suspended Solids (TSS)	mg/L	Max avg (15 mg/L) Max grab (30 mg/L)	**10**
Dissolved Sulphate (SO4)	mg/L		49
Total Cyanide (Cn)	mg/L	Max avg (0.5 mg/L) Max grab (1.0 mg/L)	<0.005
Turbidity	NTU		**0.7**
Alkalinity (Total as CaCO3)	mg/L		34
Dissolved Chloride (Cl)	mg/L		400
Nitrite (as N)	mg/L		0.092
Nitrate (as N)	mg/L		5.52
Nitrite-Nitrate (as N)	mg/L		5.61
Radium-226	Bq/L		<0.0050
Total Oil & Grease	mg/L		1.30
Mercury (Hg)	mg/L		<0.00001
Dissolved Mercury (Hg)	mg/L		<0.00001
Total Hardness	mg/L		400
Total Aluminium (Al)	mg/L	Max avg (2 mg/L) Max grab (3 mg/L)	1.22

Post treatment EWTP

Date		**License A 2AM-MEL1631 Part F, Item 3**	**1-Jul-18**
field pH			7.35
field cond.			1510 uS
field temp			10.4
Water Bodie: EWTP-POST TREATMENT (MEL-14)			**2018**
Year			
Date sampled			1-Jul-18
Lab Reference			B8G4482
LAB			Maxxam
Parameters	**Units**		
Total Antimony (Sb)	mg/L		<0.00050
Total Arsenic (As)	mg/L	Max avg (0.3 mg/L) Max grab (0.6 mg/L)	0.0011
Total Barium (Ba)	mg/L		0.0979
Total Beryllium (Be)	mg/L		<0.00010
Total Boron (B)	mg/L		0.1
Total Cadmium (Cd)	mg/L		0.000024
Total Chromium (Cr)	mg/L		<0.0010
Total Copper (Cu)	mg/L	Max avg (0.2 mg/L) Max grab (0.4 mg/L)	0.00129
Total Iron (Fe)	mg/L		0.118
Total Lead (Pb)	mg/L	Max avg (0.2 mg/L) Max grab (0.4 mg/L)	0.00033
Total Lithium (Li)	mg/L		0.113
Total Manganese (Mn)	mg/L		0.309
Total Molybdenum (Mo)	mg/L		<0.0010
Total Nickel (Ni)	mg/L	Max avg (0.5 mg/L) Max grab (1.0 mg/L)	0.0025
Total Selenium (Se)	mg/L		<0.00010
Total Silver (Ag)	mg/L		<0.000020
Total Strontium (Sr)	mg/L		2.41
Total Thallium (Tl)	mg/L		0.000026
Total Tin (Sn)	mg/L		<0.0050
Total Titanium (Ti)	mg/L		<0.0050
Total Uranium (U)	mg/L		0.00011
Total Vanadium (V)	mg/L		<0.0050
Total Zinc (Zn)	mg/L	Max avg (0.4 mg/L) Max grab (0.8 mg/L)	0.0054
Total Calcium (Ca)	mg/L		126
Total Magnesium (Mg)	mg/L		20.8
Total Potassium (K)	mg/L		10.8
Total Sodium (Na)	mg/L		104
BTEX & F1 Hydrocarbons			
Benzene	ug/L		<0.20

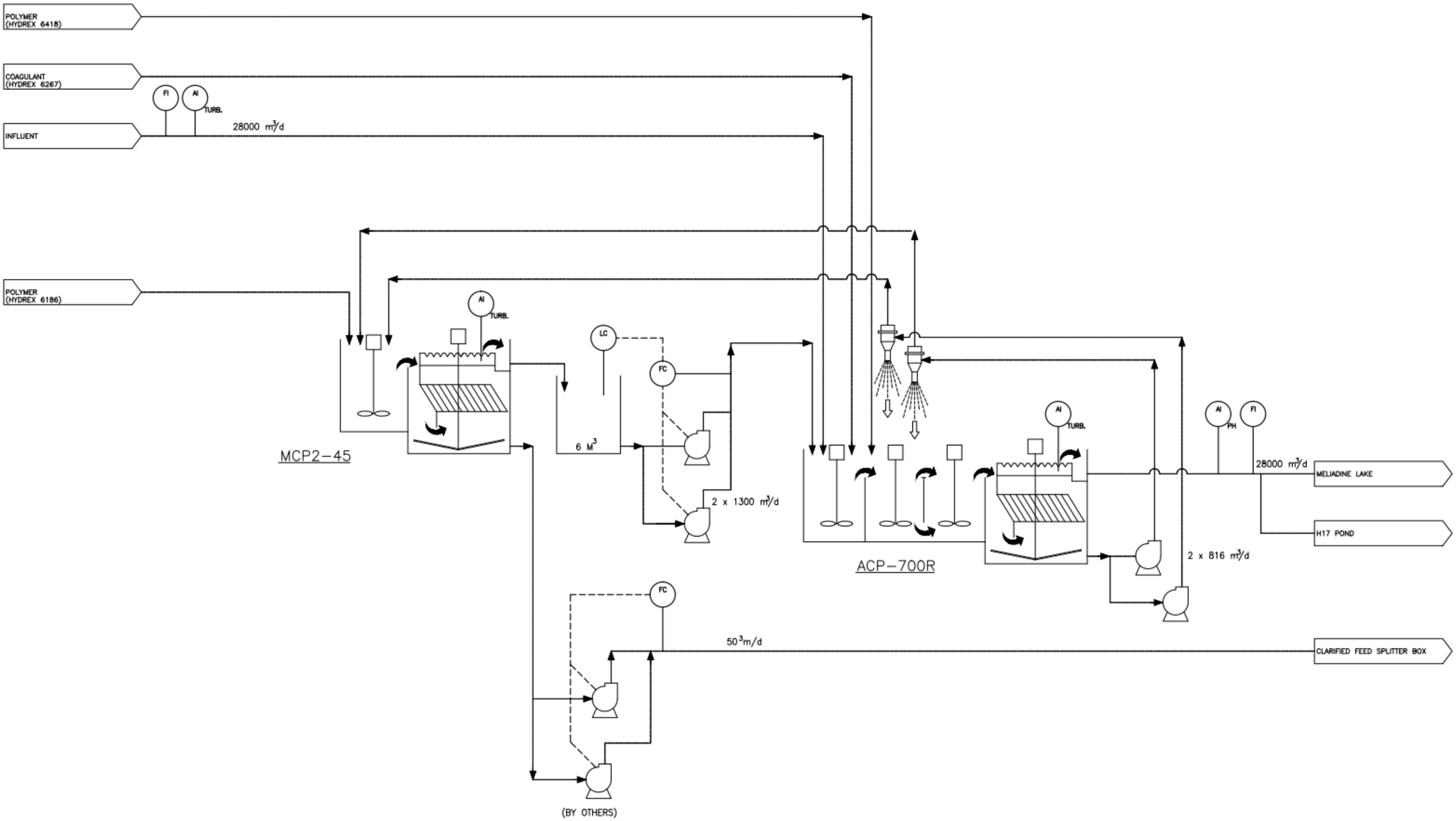
Post treatment EWTP

Date		**License A 2AM-MEL1631 Part F, Item 3**	**1-Jul-18**
field pH			7.35
field cond.			1510 uS
field temp			10.4
Water Bodie: EWTP-POST TREATMENT (MEL-14)			**2018**
Year			
Date sampled			1-Jul-18
Lab Reference			B8G4482
LAB			Maxxam
Parameters	**Units**		
Toluene	ug/L		0.32
Ethylbenzene	ug/L		<0.20
o-Xylene	ug/L		<0.20
p+m-Xylene	ug/L		<0.40
Total Xylenes	ug/L		<0.40
F1 (C6-C10)	ug/L		<25
F1 (C6-C10) - BTEX	ug/L		<25
Hydrocarbons (L) (Fraction F1 (C6-C10))	µg/L		
Hydrocarbons (L) (Fraction F2 - F4))		TPH : 5 mg/L avg and grab	
F2 (C10-C16 Hydrocarbons)	µg/L		<100
F3 (C16-34 Hydrocarbons)	µg/L		<200
F4 (C34-50 Hydrocarbons)	µg/L		<200
Reached Baseline at C50	µg/L		Yes
Diesel (C10-C24)	µg/L		
Diesel (C11-C32)	µg/L		
F4G-sg (Grav. Heavy Hydrocarbons)	ug/L		
1,4-Difluorobenzene	%		115
4-Bromofluorobenzene	%		104
D10-Ethylbenzene	%		107
D4-1,2-Dichloroethane	%		115
o-Terphenyl	%		100
Dissolved Hardness	mg/L		398
Dissolved Aluminium (Al)	mg/L		0.0174
Dissolved Antimony (Sb)	mg/L		<0.00050
Dissolved Arsenic (As)	mg/L		0.00088
Dissolved Barium (Ba)	mg/L		0.0977
Dissolved Beryllium (Be)	mg/L		<0.00010
Dissolved Boron (B)	mg/L		0.101
Dissolved Cadmium (Cd)	mg/L		0.000021
Dissolved Chromium (Cr)	mg/L		<0.0010
Dissolved Copper (Cu)	mg/L		0.00099

Post treatment EWTP

Date		**License A** **2AM-MEL1631** **Part F, Item 3**	**1-Jul-18**
field pH			7.35
field cond.			1510 uS
field temp			10.4
Water Bodie: EWTP-POST TREATMENT (MEL-14)			**2018**
Year			
Date sampled			1-Jul-18
Lab Reference			B8G4482
LAB			Maxxam
Parameters	**Units**		
Dissolved Iron (Fe)	mg/L		0.028
Dissolved Lead (Pb)	mg/L		<0.00020
Dissolved Lithium (Li)	mg/L		0.113
Dissolved Manganese (Mn)	mg/L		0.302
Dissolved Molybdenum (Mo)	mg/L		<0.0010
Dissolved Nickel (Ni)	mg/L		0.0022
Dissolved Selenium (Se)	mg/L		<0.00010
Dissolved Silver (Ag)	mg/L		<0.000020
Dissolved Strontium (Sr)	mg/L		2.44
Dissolved thallium (Tl)	mg/L		0.000027
Dissolved Tin (Sn)	mg/L		<0.0050
Dissolved titanium (Ti)	mg/L		<0.0050
Dissolved Uranium (U)	mg/L		<0.00010
Dissolved Vanadium	mg/L		<0.0050
Dissolved Zinc	mg/L		0.0068
Dissolved Calcium (Ca)	mg/L		125
Dissolved Magnesium (Mg)	mg/L		21
Dissolved Potassium (K)	mg/L		10.9
Dissolved Sodium (Na)	mg/L		101
Dissolved Sulphur (S)	mg/L		
Reactive Silica (Si)	mg/L		0.28
Cobalt (Co)	mg/L		
Cobalt (Co)	mg/L		
Daphina Toxicity	**U.T (Toxic Units)**	TPH : 5 mg/L avg and grab	
Rainbow Trout Toxicity	**U.T (Toxic Units)**	TPH : 5 mg/L avg and grab	

APPENDIX F
Meliadine EWTP Overall Process Flow Diagram



Meliadine EWTP Overall Process Flow Diagram

APPENDIX G

Pipeline Pre-insulated Pipe Specification

MODEL SPECIFICATION
FOR
SCLAIRPIPE® HIGH DENSITY POLYETHYLENE PIPE

KWH Pipe

1. PIPE & FITTINGS SPECIFICATIONS

1.1 Reference Specifications

ASTM	*D638*	*Standard Test for Tensile Properties of Plastics*
	D792	*Standard Test Methods for Density and Specific Gravity of Plastics by Displacement*
	D1238	*Flow Rates of Thermoplastics by Extrusion Plastomer*
	D1598	*Standard Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure*
	D1599	*Standard Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings.*
	D1693	*Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics*
	D2290	*Standard Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe by Split Disk Method*
	D2837	*Standard Test Method for Obtaining Hydrostatic Design Basis for thermoplastic Pipe Materials*
	D3350	*Standard Specification for Polyethylene Plastic Pipe and Fittings Materials*
	F714	*Standard Specification for Polyethylene Plastic Pipe Based on Outside Diameter*
	F2164	*Standard Practice for Field Leak Testing of Polyethylene(PE) Pressure Piping Systems Using Hydrostatic Pressure*
	F2620	*Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings*
AWWA	*C906*	*Polyethylene Pressure Pipe and Fittings, 4" Through 63" for Water Distribution*
ISO	*9001-2008*	*Quality Systems, Model for Quality Assurance in Production and Installation*

1.2 Material

1.2.1 The resin compound shall be qualified to meet the following:

The pipe shall be made from materials meeting the designations of PE3608 or PE4710 as assigned by the Plastics Pipe Institute.

The pipe shall be made from a polyethylene resin compound with a minimum cell classification of 344464C for PE3608 and 445474C for PE4710 as defined in ASTM D3350.

The Hydrostatic Design Stress (HDS) at 23°C (73.4°F) shall be 800 psi for resin designated by PE3608 and 1,000 psi for resin designated by PE4710 (PPI TR-4 , Table 1.A.8 for PE3608, Table 1.A.13 for PE4710).

1.2.2 The pipe material shall contain 2% - 2 ½% well dispersed carbon black. Additives which can be conclusively proven not to be detrimental to the pipe may also be used, provided the pipe produced meets the requirements of this specification.

1.2.3 The pipe shall contain no recycled compound except that which is generated in the manufacturer's own plant, from resin of the same specification and from the same raw material supplier.

1.2.4 The pipe supplier shall certify compliance with the requirements of this section in writing.

1.3 Pipe Design

1.3.1 The pipe shall be designed in accordance with the relationships of the ISO modified formula as stated in ASTM F714.

1.3.2 The design pressure rating shall be derived using an HDS of 800 psi at 23°C (73.4°F) for a PE3608 designation and an HDS of 1,000 psi at 23°C (73.4°F) for a PE 4710 designation, resulting in the following maximum continuous Working Pressure Rating (WPR, psi) for the respective pipe classes:

	DR32.5	DR26	DR21	DR17	DR15.5	DR13.5	DR11	DR9	DR7.3	DR6.3
PE3608	50	64	80	100	110	128	160	200	254	300
PE4710	63	80	100	125	138	160	200	250	317	379

1.3.3 Overpressure limits for pipe shall be allowed a specific magnitude greater than the maximum continuous working pressure of the pipe. Simple guidelines for frequent and infrequent surge conditions are as follows:

i) Frequent surge pressures shall be permitted where the magnitude of the total pressure is not greater than 150% of the maximum allowable continuous working pressure of the pipe. Frequent surge pressures are typically generated by normal pump flow changes and valve operations.

ii) Infrequent surge pressures shall be permitted where the magnitude of the total pressure is not greater than 200% of the maximum allowable continuous working pressure of the pipe. Infrequent surge pressures are described as pump power-out shut down or quick emergency valve closures.

1.4 Fittings

1.4.1 HDPE pipe flange assemblies shall meet the following requirements unless otherwise specified by the engineer:

i) Solid HDPE stub ends or flange adapters shall be made from the same resin grade (PE3608 or PE4710) and shall be formed using extrusion or molding methods.

ii) Flange rings shall be ductile iron (ASTM A536-84) made to Class 150, ANSI B16.1/B16.5 dimensional standards with exceptions.

iii) Methods for flange assembly, gasket selection and bolt torque application shall be as outlined in PPI Technical Note TN-38.

2. QUALITY ASSURANCE

2.1 General Requirements

2.1.1 The general quality assurance practices and methods shall be in accordance with ISO 9001-2008 or equivalent quality management program.

2.1.2 The customer or engineer shall be allowed free access to the manufacturer's plant facilities to audit, witness and inspect the methods, practices, tests and procedures of the quality assurance program.

2.2 Incoming Material Inspection

2.2.1 All incoming materials shall be inspected and tested by the pipe manufacturer for verification of the resin supplier's adherence to the material specification. The test shall include:

i) Density ASTM D792
ii) Melt Flow Rate ASTM D1238
iii) Thermal Stability (DSC) ASTM D3350

2.2.2 In Addition, the resin supplier shall provide certification of the following physical properties with each lot shipment of material:

i) Density ASTM D792
ii) Melt Flow Rate ASTM D1238
iii) Tensile Strength ASTM D638
iv) Elongation ASTM D638
v) E.S.C.R. ASTM D1693 Condition C
vi) Thermal Stability, DSC ASTM D3350

2.3 Finished Goods Evaluation

2.3.1 The following shall be checked or verified on a daily and controlled basis:

i) Pipe dimensions and tolerances as per ASTM F714
ii) Pipe workmanship as per ASTM F714
iii) Pipe attributes of density and melt flow rate
iv) Reverse bend and DSC testing
v) Carbon black content

2.3.2 In addition to the above, pipe physical test requirements shall be verified on a periodic basis with the emphasis of accumulating data to demonstrate conformance for each respective pipe size range to ASTM F714. Test reports shall be submitted for review to the engineer to qualify a manufacturer for conformance purposes. This report shall include as a minimum the following:

Test data dating over one year covering the following production per plant location:

i) Two pipe sizes manufactured in each of the three size ranges: 4” to 12” (100 to 300mm), greater than 12” to 24” (300 to 600mm), and greater than 24” (600mm) shall be tested by elevated temperature sustained pressure test as per Table 3 in ASTM F714, for each polyethylene resin used.

ii) Two pipe sizes manufactured in each of the three size ranges: 4” to 12” (100 to 300mm), greater than 12” to 24” (300 to 600mm), and greater than 24” (600mm) shall be tested for tensile properties. One of the following tests may be used to verify pipe tensile properties:

- Tensile Test as per ASTM D638
- Apparent Tensile Test as per ASTM D2290

2.3.3 Additional tests to be performed to meet the requirements of AWWA C906 shall be as follows (minimum once per year):

i) Apparent ring tensile test as per ASTM D2290
or
Quick burst hydrostatic pressure test as per ASTM D1599

ii) Elevated temperature sustained pressure test as per ASTM D1598 at 80°C
or
Short term 5 second hydrostatic pressure test at four times the working pressure rating

3. MARKING AND SHIPPING

3.1 Marking

3.1.1 The pipe shall be clearly marked using an inkjet printing method such that the marking is visible, legible and permanent.

3.1.2 The marking shall include the following and shall be applied so as to repeat this information at least once in every 5 feet:

i) Name or trademark of manufacturer (i.e. KWH SCLAIRPIPE)

ii) Nominal pipe size (i.e. 14” IPS or 400mm)

iii) Pipe rating (DR 17)

iv) Standard material code designation (i.e. PE3608 or PE4710)

v) Appropriate Manufacturing Standard (i.e. ASTM F714 or AWWA C906)

vi) Production code which describes the resin compound, manufacturing location, year, month and day

Additional markings may be required by the purchaser and shall be added to the markings on the pipe.

3.2 Shipping

Unless otherwise specified by the purchaser, all pipe and fittings shall be prepared for standard commercial shipment. Care shall be taken to prevent cuts, scratches and other damage.

Unless specifically requested by the customer in writing, pipe shipments shall not be nested.

4. CONSTRUCTION PRACTICES

4.1 Inspection of Materials

4.1.1 The customer shall inspect all pipe and accessories for shortages, loss or damage upon receipt of the shipped material at the time of unloading, recording this information directly on the waybill received from the carrier.

4.1.2 Acceptable limits for cuts, gouges or scratches are as follows:

i) Pipe outer surface shall not be cut, scratched or gouged to a depth greater than 10% of the pipe minimum wall thickness.

ii) Pipe internal surface shall be free of all cuts, gouges or scratches.

4.2 Handling and Storage

4.2.1 Pipe shall be stored on clean, level ground to prevent undue scratching or gouging of the pipe.

4.2.2 Stacked pipe shall be stored in accordance with manufacturer's recommendations to minimize pipe ovalization.

4.2.3 Pipe shall be handled using suitable slings or lifting equipment. Also, pipe shall not be dragged over sharp objects or surfaces.

4.3 Thermal Butt Fusion

4.3.1 Butt fusion joining of pipe and fittings shall be performed in accordance with the procedures outlined in the manufacturer's 'butt fusion procedures' requirements which are based upon PPI's 'Generic Butt Fusion Procedures' as set out in PPI's TR-33 and as described in ASTM F2620.

4.3.2 Fusion technicians that have been trained in the use of the appropriate procedures (see 4.1.6) and evaluated by fusion equipment manufacturers, must conduct the butt fusion joining.

4.3.3 Butt fusion shall be performed using suitable machinery.

5. TESTING

The intent of leak testing is to find unacceptable faults in a piping system. Leakage tests may be performed if required by the Contract Specifications.

5.1 Pressure Testing Precautions

5.1.1 The pipe system under test and any closures in the test section should be restrained against any unanticipated separation during pressurization. Refer to ASTM F2164. .

5.1.2 Test equipment should be examined before pressure is applied to ensure that it is tightly connected. All low pressure filling lines and other items not subject to the test pressure should be disconnected or isolated.

5.1.3 Testing may be conducted on the system, or in sections. The limiting test section size is determined by test equipment capability. If the pressurization equipment is too small, it may not be possible to complete the test within allowable testing time limits. If so, higher capacity test equipment or a smaller test section may be necessary.

5.1.4 If possible, test medium and test section water temperatures should not exceed 80° F (27° C). At temperatures above this level, reduced test pressure is required. Before applying test pressure, time may be required for the test medium and test pipe section to temperature equalize.

5.2 Test Procedure

5.2.1 For a test pressure that is 1.5 times the system design pressure, the total test time including initial pressurization, initial expansion, and the time at the test pressure, must not exceed eight (8) hours[1].

5.2.2 Hydrostatic pressure testing should be done in accordance with ASTM F2164. Clean water is strongly recommended as the test medium. The test section should be completely filled with water, taking care to bleed off any trapped air. Venting at high points may be required to purge air pockets while the test

[1] For test durations longer than 8 hours, the test pressure should be reduced. Refer to PPI Engineering Handbook, Chapter 2 for test methods.

sections are filling. Venting may be provided by loosening flanges or by using equipment vents. Retighten loosened flanges before applying test pressures.

5.2.3 Pressurize the pipe up to the desired test pressure. The test procedure consists of initial expansion, and test phases. For the initial expansion phase, the test section is pressurized to test pressure and make-up test liquid is added as required to maintain maximum test pressure for four (4) hours. For the test phase, the test pressure is reduced by 10 psi. This is the target test pressure. If the pressure remains steady (within 5% of the target test pressure) for an hour, leakage is not indicated.

5.2.4 If leaks are discovered, depressurize the test section before repairing leaks. Correctly made fusion joints do not leak. Leakage at a butt fusion joint may indicate imminent pressurized rupture. Depressurize the test section immediately if butt fusion leakage is discovered. Leaks at fusion joints require the fusion joint to be cut out and redone.

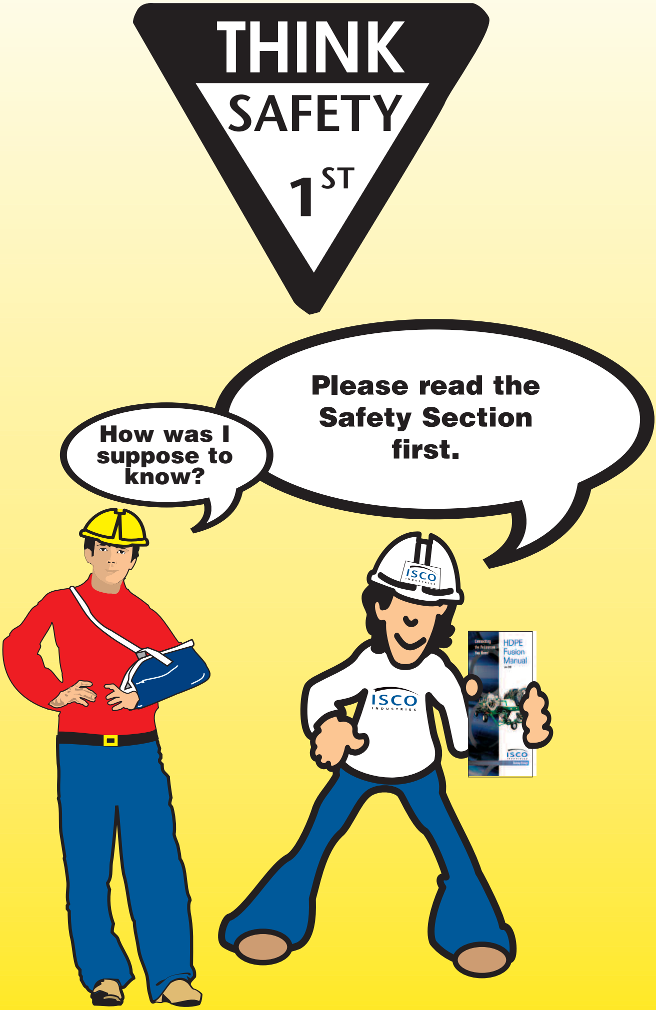
5.2.5 If the pressure leak test is not completed due to leakage, equipment failure, etc., the test section should be de-pressurized and repairs made. Allow the test section to remain depressurized for at least eight (8) hours before retesting.

APPENDIX H
Pipe Fusion Manual

Table of Contents

This manual contains accurate and reliable information to the best of our knowledge as of the publication date. The results of using our suggestions and recommendations cannot be guaranteed because the conditions of use are beyond our control. Failure to follow these procedures in this manual may result in damage to or destruction of property and/or serious injury to or death of a person. The user of such information assumes all risk connected with the use thereof. ISCO Industries, LLC assumes no responsibility for the use of information presented herein and hereby disclaims all liability in regard to such use.

Fusion Equipment Safety Information



Fusion Equipment Safety Information

Safety Alerts

This hazard alert sign ⚠ appears in this manual. When you see this sign, carefully read what it says. YOUR SAFETY IS AT STAKE.

You will see the hazard alert sign with these words: DANGER, WARNING, and CAUTION.

⚠ DANGER Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

⚠ DANGER

⚠ WARNING Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠ WARNING

⚠ CAUTION Indicates a hazardous situation which, if not avoided, may result in minor or moderate injury.

⚠ CAUTION

In this manual you should look for two other words: NOTICE and IMPORTANT.

NOTICE:
Can keep you from doing something that might damage the machine or someone's property. It may also be used to alert against unsafe practices.

IMPORTANT:
Can help you do a better job or make your job easier in some way.

Read And Understand

Do not operate fusion equipment until you have carefully read, and understand the "Safety" and "Operation" sections of this manual, and all other equipment manuals that will be used with it.

Your safety and the safety of others depends upon care and judgement in the operation of this equipment.

Follow all applicable federal, state, local, and industry specific regulations.

Fusion Equipment Safety Information

ISCO Industries, LLC cannot anticipate every possible circumstance that may involve a potential hazard. The warnings in this manual and on the machine are therefore not all inclusive. You must satisfy yourself that a procedure, tool, work method, or operating technique is safe for you and others. You should also ensure that the machine will not be damaged or made unsafe by the method of operation or maintenance you choose.

General Safety
Safety is important. Report anything unusual that you notice during set up or operation.

Listen for thumps, bumps, rattles, squeals, air leaks, or unusual sounds.

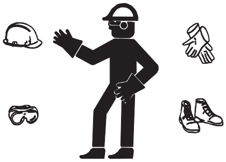
Smell odors like burning insulation, hot metal, burning rubber, hot oil, or natural gas.

Sense any changes in the way the equipment operates.

See problems with wiring and cables, hydraulic connections, or other equipment.

Report anything you see, feel, smell, or hear that is different from what you expect, or that you think may be unsafe.

Wear Safety Equipment
Wear a hard hat, safety shoes, safety glasses, and other applicable personal protection equipment.



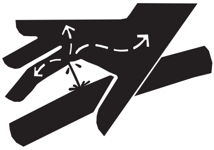
Remove jewelry and rings, and do not wear loose-fitting clothing or long hair that could catch on controls or moving machinery.

Fusion Equipment Safety Information

Units With Hydraulics

Although the hydraulic pressures in the machine are low compared to some hydraulically operated equipment, it is important to remember that a sudden hydraulic leak can cause serious injury or even be fatal if the pressure is high enough.

WARNING Escaping fluid under pressure can penetrate the skin causing serious injury. Keep hands and body away from pinholes which eject fluid under pressure. Use a piece of cardboard or paper to search for leaks. If any fluid is injected into the skin, it must be immediately removed by a doctor familiar with this type of injury.



NOTICE:
Wear safety glasses, and keep face clear of area when bleeding air from hydraulic system to avoid spraying into eyes.

Heaters Are Not Explosion Proof

DANGER Heaters are not explosion proof. Operation of a heater in a hazardous environment without necessary safety precautions will result in explosion and death. When operating in a hazardous environment, heater should be brought up to temperature in a safe environment, then unplugged before entering the hazardous atmosphere for fusion.

Fusion Equipment Safety Information

Electric Motors Are Not Explosion Proof

⚠ DANGER Electric Motors are not explosion proof. Operation of these components in a hazardous environment without necessary safety precautions will result in explosion or death. When operating in a hazardous environment, keep pump motor and chassis in a safe area by using hydraulic extension hoses.

Electrical Safety

⚠WARNING Always ensure power cords are properly grounded. It is important to remember that when you are working in a wet environment with electrical devices, proper ground connections help to minimize the chances of an electric shock.

Frequently inspect electrical cords and unit for damage. Damaged components need to replaced and service performed by a qualified electrician. Do not carry electrical devices by the cord.

NOTICE:
Always connect units to the proper power source as listed on the unit, or in the owner's manual. On units with two power cords, plug each cord into separate power circuits. Do not plug into both outlets of one duplex receptacle.

NOTICE:
Disconnect the machine from the power source before attempting any maintenance or adjustment.

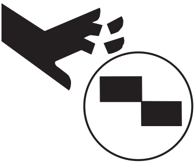
Fusion Equipment Safety Information

Crush Points

⚠WARNING Hydraulically operated jaws are operated under pressure. Anything caught in the jaws will be crushed. Keep fingers, feet, arms, legs, and head out of the jaw area. Always check pipe alignment with a pencil or similar object.

Facer Blades Are Sharp

⚠WARNING Facer blades are sharp and can cut. Never attempt to remove shavings while the facer is running, or is in the facing position between the jaws. Use care when operating the facer, and handling the unit.



NOTICE:
Disconnect power from the facer, and remove the facer blades before attempting any maintenance or adjustment.

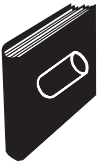
Heater Is Hot

⚠CAUTION The heater is hot and will burn clothing and skin. Keep the heater in its insulated heater stand or sling blanket when not in use, and use care when heating the pipe.

NOTICE:
Use only a clean non-synthetic cloth such as a cotton cloth to clean the heater plates.

Fusion Procedures

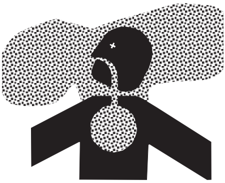
⚠CAUTION Follow the procedures carefully, and adhere to all specified parameters.
Failure to follow procedures could result in a bad weld. Always follow the proper fusion procedures.



Fusion Equipment Safety Information

Units With Gas Engines

⚠WARNING Handle fuel with care. Fuel is highly flammable. Do not refuel the machine while smoking or near open flames or sparks. Always stop the engine before refueling machine. Fill fuel tank outdoors. Help prevent fires by keeping machine clean of accumulated trash, grease, debris, and facer shavings. Always clean up spilled fuel.

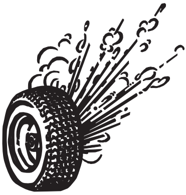


⚠WARNING Breathing exhaust gases can cause sickness or death. Always operate machine outdoors in an area with adequate ventilation.

Units With Batteries

⚠CAUTION Sulfuric acid in battery electrolyte is poisonous. It is strong enough to burn skin, eat holes in clothing, and cause blindness if splashed into eyes. Avoid contact with eyes, skin, and clothing. Exploding gases from battery could cause blindness or serious injury. Keep sparks, flames, and cigarettes away.

Have Tires Properly Serviced



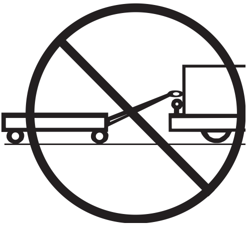
⚠WARNING Failure to follow proper procedures when mounting a tire on a wheel or rim can produce an explosion which may result in serious injury or death. Have tires mounted by someone that is experienced, and has the equipment to perform the job safely.

Fusion Equipment Safety Information

Periodically Check Temperature

NOTICE:
Incorrect heating temperature can result in bad fusion joints. Check heater plate surface temperature periodically with a pyrometer, and make necessary adjustments. The thermometer on heaters indicates internal temperature, and should be used as a reference only.

Do Not Tow Fusion Machine At Speeds Greater Than 8 KM (5 MPH)

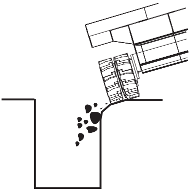


⚠WARNING The chassis is not designed for over-road towing. Towing at speeds greater than five miles per hour can result in machine damage as well as injury. Always transport the machine by flat bed truck or similar means, and make sure that unit is properly secured.

Positioning Fusion Machine

Place fusion machine on as level ground as possible, and set the brake on the rear wheel. If it is necessary to operate machine on unlevel grade, chock the wheels and block the unit to make it as stable as possible.

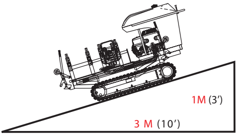
Keep Machine Away From Edge Of Ditch



⚠WARNING Heavy equipment too close to a ditch can cause the walls of the ditch to cave-in. Keep the machine far enough away from the edge of the ditch to prevent injury to personnel and equipment from a cave-in.

Fusion Equipment Safety Information

Operating TracStar Fusion Machines

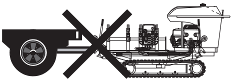


Place fusion machine on as level ground as possible.

If it is necessary to operate machine on unlevel grade, make sure that the ground is stable. Some unstable conditions maybe ice, snow, mud, and loose gravel.

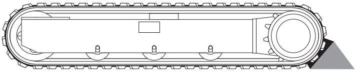
⚠WARNING For operation safety, never operate machine on a grade steeper than 30%. A 1 M (3') elevation change in 3 M (10').

Do Not Attempt to Tow A TracStar Fusion Machine



⚠CAUTION The machine is not designed for towing. Attempting to tow the machine can result in machine damage. Always transport the machine by flat bed truck or similar means, and make sure that unit is properly secured.

Positioning Fusion Machine



Place fusion machine on as level ground as possible. If it is necessary to operate machine on unlevel grade, chock the tracks and block the unit to make it as stable as possible.

Hearing Protection Required For TracStar 412 and TracStar 618.

When operating machine for more than four hours per day, wear hearing protection.

Fusion Equipment Safety Information

Safety Precautions For Guarding Against Static Electricity And Gaseous Ignition

⚠ DANGER Polyethylene plastic pipe does not readily conduct electricity. A static electricity charge can buildup on inside and outside surfaces and stay on the pipe surface until some grounding device, such as a tool or a person comes close enough for the static electricity to discharge to the grounding device.

⚠WARNING Discharging one part of the pipe surface will not affect other charged areas because static electricity does not flow readily from one area to another. Polyethylene pipe cannot be discharged by attaching grounding wires to the pipe.

Heaters, electric facers and electric power tools are NOT explosion proof. Static electricity discharge can ignite a flammable gas or combustible dust atmosphere.

A static electricity discharge to a person, a tool, or a grounded object close to the pipe surface can cause an electric shock or a spark that can ignite a flammable gas or combustible dust atmosphere causing fire or explosion.

In gas utility applications, static electricity can be a potential safety hazard. Where a flammable gas-air mixture may be encountered and static charges may be present, such as when repairing a leak, squeezing-off an open pipe, purging, making a connection, etc., arc preventing safety precautions are necessary. Observe all procedures for static electricity safety and control, including procedures for discharging static electricity and requirements for personal protection.

Take steps to discharge static electricity from the surface of the polyethylene gas pipe. Such steps include wetting the entire exposed pipe surface with a conductive anti-static liquid or a dilute soap and water solution, then covering or wrapping the entire wetted, exposed pipe surface with grounded wet burlap, conductive poly film, or wet tape conductor. The external covering should be kept wet by occasional re-wetting with anti-static solution. The covering or tape should be suitably grounded such as to a metal pin driven into the ground.

Steps that discharge the outer surface do not discharge the inner surface of the pipe. Squeeze-off purging, venting, cutting, etc., can still result in a static electricity discharge. When appropriate, ground tools and remove all potential sources of ignition.

Fusion Equipment Safety Information

Safety Precautions For Guarding Against Static Electricity And Gaseous Ignition (Continued)

Key items:

Do not put a butt fusion machine chassis in a hazardous environment. Set the chassis up out of harms way and use extension hoses to operate upper works in hazardous area.

Do not use a butt fusion machine with an electric facer in a gaseous environment. Use a machine equipped with a hydraulic facer or convert the electric facer to a manual by removing the brushes and turning facer manually.

When making butt fusions, saddle fusions and socket fusions in a hazardous environment, set the generator up out of harms way and have the heater plugged into it there. Set the heater temperature at the maximum allowed for the application. Use 232° C (450° F) for butt fusion and 266°C (510° F) for saddle fusion and socket fusion. These are surface temperatures. The high side temperatures are used to compensate for the drop in temperature experienced when heater is unplugged from the power source to make fusion in hazardous area. Unplug heater prior to using in a hazardous environment.

Do not drill hole first prior to making a saddle fusion.

When prepping the main pipe for a saddle fusion, **do not** use an electric grinding tool. Prepare main pipe manually by use of 50-60 grit utility cloth.

Do not use an electric drill for punching hole through after saddle fusion has been made.

Use your senses and good judgment: Listen, Smell, Feel, See and Report any unsafe situations you see or see coming to your onsite contact, if corrective action is not taken in your opinion, **Do not** enter into the situation.

Tips For Success

Tips for Success

- Use Personal Safety Equipment. Always wear a hard hat and protective boots. Gloves protect hands from heater burns and sharp blades on the facer. Protective Eye Glasses are also a good idea.
- Make sure all equipment is in good working order and power cords are free of cuts with grounding blade on receptacle in tack.
- Position fusion equipment on level ground whenever possible.
- If the fusion equipment has wheels, set the wheel lock or block them.
- Position pipe support stands on either side of the fusion equipment approximately 6 M (20') from ends of the fusion equipment. Adjust stands so that pipes are level to reduce drag.
- When working with McElroy Self-Contained fusion units excluding the T-500 and T-900, make sure to open the facer valve prior to starting the unit and keep it open until started. Close valve once unit is running. This will save the battery and keep you from burning up the starter.
- Plug heater in on self-contained fusion units only after unit has been started and warmed up. Unplug heater before turning fusion unit off. This will keep you from having heater element and circuitry problems with your heater.
- Load loose pipe joints into movable side of the fusion equipment and pull joints already fused through non-movable side.
- Check your pipe before you fuse it. Look for deep scratches, cuts and gouges. Use the 10 percent rule: Any imperfection affecting more than 10 percent of the pipe wall being worked with should not be used.
- When rough cutting pipe, use a pipe wrap to mark the pipe with a reference line, this will aid you in making a square and even cut. In general, tooling that works with wood works well with HDPE pipe. For cutting pipe, skill saws and chain saws work well. When using chain saws, the cut ends MUST be cleaned with isopropyl alcohol to remove BAR Oil Splash or any other contaminants. For cutting holes in pipe, drills with hole saws and reciprocating saws work well.
- When making fusions that involve pipe to fittings, special care should be taken. The necking down or toe in at the pipe ends, which is normal, needs to be completely removed in the facing process. This is seen primarily in working with the larger pipe diameters.
- Do not abuse the facer when facing pipes by using too much pressure.
- When pulling pipe through the fusion equipment, elevate pipe in the machine using the pipe lifts so the fusion bead clears all obstructions as it is pulled through.

Tips for Success (Continued)

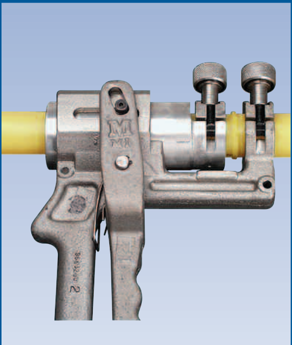
- If a fusion weld does not come out exactly as you like or you question the quality of the fusion weld, then cut it out and re-fuse. Always remember – IF IN DOUBT, CUT IT OUT and redo.
- Fusion beads can be removed by means of external and internal bead removers without effecting the integrity of the fusion joint.
- In inclement weather and especially in windy conditions, the fusion operation should be shielded to avoid precipitation or blowing snow and excessive heat loss from wind chill. Capping ends of pipe that are being fused aides heater from being chilled as fusion joint is being made.
- The joint area and its parts that are being fused must be completely dry. No liquid of any kind running through the pipe or fittings is permissible.
- When fusion is done in cold weather, DO NOT INCREASE HEATING TOOL SURFACE TEMPERATURE.
- Do not try to shorten cooling times of fusions by applying wet cloths, water or the like.
- When removing pipe from the fusing unit and pulling into place, use proper lifting slings and pulling heads in good condition. Chains and rope can slip and cause injury/damage to personnel and pipe.
- When working with coiled pipe 63 mm-160 mm (2" - 6"), a McElroy LineTamer™ should be used to straighten and reround coiled pipe to meet or exceed ASTM D-2513 Quality Requirements.
- Squeeze tools can be used on HDPE Pipe to stop flow in a pipeline while a tie in or repair is made. Follow manufacturer's squeeze-off tool instructions.
- A common obstacle when working with HDPE pipe in the field is understanding the thermal expansion and contraction.
  Rule of thumb - 2 cm/10 M/10°C (1.4"/ 100'/ 10ºF.)

Butt Fusion Joining Rates

Pipe Sizes IPS/DIPS	Approx. Fusions per 8-10 Hr. Day
20 mm - 90 mm (3/4" - 3")	30 - 60
110 mm - 200 mm (4" - 8")	24 - 48
250 mm - 450 mm (10" - 18")	12 - 24
500 mm - 630 mm (20" - 24")	10 - 16
710 mm- 800 mm (28" - 31.5")	8 - 12
900 mm- 1200mm (36" - 48")	6 - 10
1400 mm - 1600mm (55" - 63")	4 - 8

Important:
Fusions per day are dependent upon pipe wall thickness, equipment to move and handle pipe, manpower, site conditions and weather. Use lower number for estimation and planning.

Manual Butt Fusion Machine Procedure



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Manual Butt Fusion Machine Procedure

The principle of heat fusion is to heat two surfaces to a designated temperature, and then fuse them together by application of force. This pressure causes flow of the melted materials, which causes mixing and thus fusion. When the polyethylene material is heated, the molecular structure is transformed from a crystalline state into an amorphous condition. When fusion pressure is applied, the molecules from each polyethylene part mix. As the joint cools, the molecules return to their crystalline form, the original interfaces are gone, and the two pipes become one homogeneous unit.

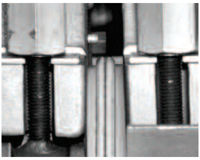
The principle operations include:

Cleaning	The pipe ends must be clean and free of any dirt, debris or other contaminants
Clamping	The pipe pieces held axially to allow all subsequent operations to take place.
Facing	The pipe ends must be faced to establish clean, parallel mating surfaces perpendicular to the centerline of the pipes.
Alignment	The pipe ends must be aligned with each other to minimize mismatch or high-low of the pipe wall.
Heating	A melt pattern that penetrates into the pipe must be formed around both pipe ends.
Joining	The melt patterns must be joined with a specified force. The force must be constant around the interface area.
Holding	The molten joint must be held immobile with a specified force until adequately cooled.

BUTT FUSION OF PIPES AND COMPONENTS WITH DIFFERENT WALL THICKNESSES

When Butt Fusion is used to join pipes and other components together they must have the same outside diameter and the difference between minimum wall thickness dimensions for the two components being joined should not exceed 26%.

Example: You have a pipe or fitting that has a wall thickness of 25 mm (1”). You can weld that pipe to pipes or fittings that have a wall thickness of 20 mm (3/4”) min. or 32 mm (1-1/4”) max.



Important:
- The pipe line is only as strong as its weakest link.
- The fusion pressure used to join two different wall thicknesses is always that of the thinner.

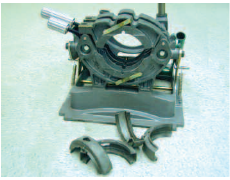
Manual Butt Fusion Machine Procedure

Install Clamping Inserts

Select and install appropriate clamping inserts for the pipe that is being fused.

No. 2LC & No. 2CU machines

20mm - 50mm (1/2" CTS - 2" IPS Pipe)
40 mm (1-1/2") and smaller inserts are fitted to jaw castings using flat head fasteners.



No. 14 Pitbull Machines

32 mm - 110 mm (1" IPS - 4" DIPS Pipe)
2" IPS Master, 90 mm (3") & 110 mm (4") inserts are held in place by spring pins located on upper and lower jaws.
40 mm (1-1/2") and smaller inserts are fitted to 2" IPS Master inserts using flat head fasteners.

Loading Pipe Into Machine
(No. 14 Pitbull Used In the Following Illustrations)

Clean the inside and outside of the pipe ends that are to be fused.

Open the upper jaws and insert pipe in each pair of jaws with applicable inserts installed.

Let the ends of the pipe protrude about 25 mm (1") past the face of the jaws.

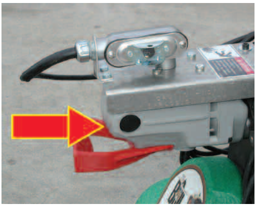
Close upper jaws but do not overtighten.

Manual Butt Fusion Machine Procedure

Electric Facer

The facer is a McElroy Rotating Planer Block Design. The blade holders each contain two cutter blades. The Block rotates on ball bearings and is chain driven (enclosed in lubricant) by a heavy duty electric motor. When operating in a hazardous environment, operate the facer manually.

⚠ DANGER Electric motors are not explosion proof. Operation of these components in a hazardous environment will result in explosion and death.



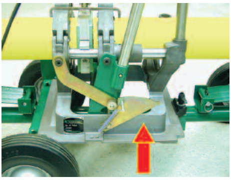
The armature brushes must be removed from the electric motor when manually operating in a hazardous condition. Unscrew the brush covers from both sides of the motor. (Both brushes must be removed). A 22 mm (7/8") hex shaft allows for manual operation in hazardous conditions.

The facer has a handle that latches into place on a guide bar. The handle must be pulled out to unlatch and remove facer.

Manual Facer for No. 2LC and No. 2CU

The manually operated facer has a hand powered crank. Turn the crank counterclockwise for facing.

Cam Lock

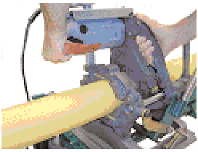


A semi-automatic cam locking system locks the movable jaw during the cooling cycle.

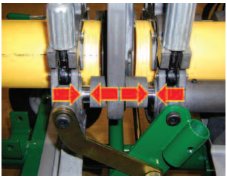
Manual Butt Fusion Machine Procedure

Inserting Facer

Place the end opposite the handle onto the far guide rod, then lower the facer handle end down onto the near guide rod and latch.



Positioning Pipe In Machine

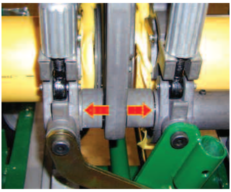


With facer in position use lever handle to bring pipe ends together against the facer, watching the gap between the facer stops and the pipe clamping jaws. Leave enough gap so that proper face-off will be achieved when the facer stops are bottomed out against the clamps. Tighten the pipe clamp knobs by hand until firm resistance is felt. Do not over-tighten.

Important:
Thoroughly clean all dirt and debris from pipe ends before facing.

Facing The Pipe Manually

Turn facer handle counterclockwise and apply firm pressure on lever handle. Continue facing until facer stops have bottomed out against the clamping jaws. Stop rotation of facer. Move jaws apart.



Unlatch and remove facer. Remove shavings from pipe ends and machine. Do not touch faced pipe ends.

Inspect both pipe ends for complete face off. If the face off is incomplete, return to Loading Pipe Into Machine on page 20.

Manual Butt Fusion Machine Procedure

Electric Facer

The electric facer should be started before the pipe is pushed into contact with the blades.

Continue facing until the facer stops are against the jaws.

Turn off the facer while continuing to hold pressure closed on the lever until the facer stops completely.

Reverse force to the lever handle to move the pipe ends away from the facer.

Unlatch and remove the facer taking care not to touch the pipe ends.

Remove shavings from pipe ends and machine.

Do not touch faced pipe ends as this may contaminate them.

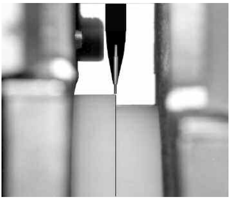
If faced pipe ends are touched, use a clean non-synthetic cloth to clean affected area before proceeding.

If after facing, any imperfections are visible, return to Loading Pipe Into Machine on page 20.

Any time clamp knobs are tightened, pipe ends should be refaced.

Manual Butt Fusion Machine Procedure

Check Alignment Of Pipe

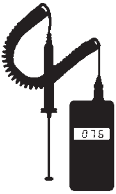


Bring the pipe ends together under sufficient force to overcome any pipe drag or friction in the system.

Check for alignment and proper face off. If high/low (misalignment) exists, adjust by tightening the clamp on the high side and reface the pipes. Their should be no more than 10% of the wall thickness in misalignment to maintain full joint strength.

Notice:
When clamping, do not over-tighten the clamp knobs because machine damage can result. Check to see if there is space between the upper and lower jaws. If the two jaws are touching, do not continue to tighten. Bring the pipe ends together under fusion pressure to check for slippage. If slippage occurs, return to Loading Pipe Into Machine section on page 20.

Check Heater Temperature



⚠CAUTION Incorrect heating temperature can result in questionable fusion joints. Check heater plates periodically in multiple locations with a pyrometer and make necessary adjustments.

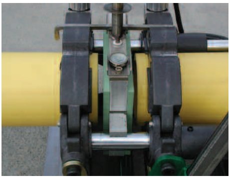
For butt fusion heater surface temperature should be Minimum 205°C (400° F), **Optimum 218°C (425° F)**, Maximum 230°C (450° F).

Important:
The dial thermometer on the heater indicates internal temperature which varies from the actual surface temperature.

The dial thermometer can be used as reference once the surface temperature has been verified.

Manual Butt Fusion Machine Procedure

Inserting Heater



⚠ DANGER Heater Is Not Explosion Proof. Operation of heater in a hazardous environment without necessary safety precautions will result in explosion and death.

If operating in a hazardous environment, heater should be brought up to temperature in a safe environment, then unplugged before entering the hazardous atmosphere for fusion.

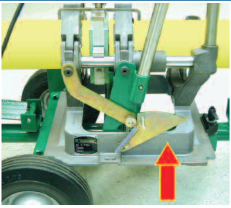
Use a clean non-synthetic cloth to clean butt fusion heater adapter surfaces.

Check heater adapters for coating damage, plastic buildup rings and surface imperfections. These conditions could cause a poor fusion. Replace them if conditions exist.

Verify heater temperature by referencing the reading on the dial thermometer.

Insert heater between the pipe ends. The stripper bar downward legs should be outside of the jaws. (not on top)

Heating The Pipe



With heater in position between the pipe ends, snap pipe ends sharply against the heater to ensure proper seating. Raise the locking cam into the engaged position while in the heating cycle. ***Do not heat under pressure.***

Notice:
The heating of the pipe ends is strictly a manual and visual process that is done with only contact pressure. The time it takes for the melt beads to reach their proper size and heating cycle is dependent on the working environment. The heating cycle is complete when the melt beads are the following sizes depending on the pipe OD.

(See **Approximate Melt Bead Size Chart** on page 26).

Manual Butt Fusion Machine Procedure

Approximate Melt Bead Size (Pipe Ends):

Pipe Size	Approximate Melt Bead
40 mm (1-1/4") and smaller	1mm - 2 mm (1/32" – 1/16")
50 mm (1-1/2") through 90 mm (3")	2 mm - 3 mm (1/16" – 1/8")
110 mm (4")	3 mm - 5 mm (1/8" – 3/16")

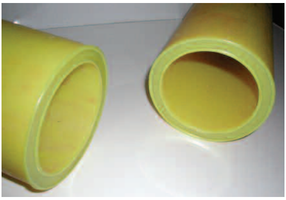
Fusing the Pipe

Once melt beads are of proper size, remove the heater, QUICKLY inspect the melted ends, which should be flat, smooth, and completely melted. If the melted surfaces are acceptable, immediately and in a continuous motion, bring the ends together and apply enough joining force for the beads to touch, flare up and roll back till they come in FULL contact with the pipe surfaces being fused. Do not slam.

A concave melt surface is unacceptable; it indicates pressure during heating. Do not continue. Allow the melted ends to cool and start over.

The locking cams will assist by holding force during the cooling cycle.

Unacceptable Concave Melt Appearance



What Causes This?

Answer - Heating under pressure.

Notice:
A concave melt surface is unacceptable; it indicates pressure during heating. Do not continue. Allow the melted ends to cool and start over.

Manual Butt Fusion Machine Procedure

Optional Use Of Torque Wrench

After the heating cycle is completed, remove the heater and quickly apply fusion force with the lever handle. To use a torque wrench with the No. 14 Pitbull, place an adapter in the lever socket.

P/N 410802

The locking cams will assist by holding force during the cooling cycle.

CAUTION Failure to follow the proper heating time, pressure and cooling time may result in a bad joint.

Approximate Values		
Torque Wrench Reading	No. 2LC	No. 14 Pitbull
Nm (Ft.Lb.)	N (Lbs.Force)	N (Lbs. Force)
15 (10)	320 (70)	520 (115)
30 (20)	600 (135)	960 (215)
45 (30)	890 (200)	1470 (330)
60 (40)	1160 (260)	1935 (435)
75 (50)	1425 (320)	2425 (545)
90 (60)	1780 (400)	2935 (660)
105 (70)	2135 (480)	3470 (780)
120 (80)	2450 (550)	4070 (915)
135 (90)	2825 (635)	4560 (1025)
150 (100)	3070 (690)	5070 (1140)

Interfacial Pressure (IFP)
Minimum
4.1 Bar (60 psi)
Optimum
5.2 Bar (75 psi)
Maximum
6.2 Bar (90 psi)

To determine the amount of force required:
(OD-t) x t x 3.1416 x 5.2 Bar (IFP) = Force

This value is then read on chart to determine how much torque is needed to apply the force.

Manual Butt Fusion Machine Procedure

Cooling Of The Fusion Joint

The fusion joint must be kept under pressure until the joint is cool. This time will vary with pipe size, wall thickness, heater temperature setting and environmental conditions.

There are three acceptable methods that can be used individually or combined.

1) Cool to the touch.

2) Timing "Guidelines Only" Chart.

Timing "Guidelines Only" Chart

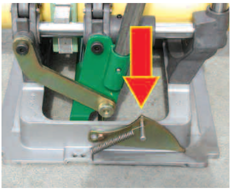
Wall Thickness of Pipe being Fused	Cooling Time 23°C (74 º F)
Up to 5 mm (0.2")	5 min.
5 mm (0.2") to 10 mm (0.4")	5 to 10 min.
10 mm (0.4") to 15 mm (0.6")	10 to 15 min.
15mm (0.6") to 20 mm (0.8")	15 to 20 min.

3) Use pyrometer to measure temperature of the weld bead and compare it to the temperature of the pipe and or fittings being fused. If the temperatures are the same, the cooling requirement has been met.

Notice: Heavier wall thickness pipes require longer cooling times.

Allow the joint to cool an additional thirty (30) minutes minimum outside of the fusion machine before subjecting the fusion joint to any rough handling or severe bending.

Remove Pipe and Inspect



After pipe has cooled sufficiently, apply closing force on the lever handle and push the locking cams down into the unlocked position. Unscrew the clamp knobs enough that they can be swiveled outward.

Pull pipe through machine, and prepare for making next fusion. Inspect joint and if it has to be redone, use Trouble Shooting Guides to determine problem and make adjustments before next fusion. (See pages 29 and 30)

Manual Butt Fusion Machine Procedure

Butt Fusion Joint Troubleshooting Guide

The Inspection Of The Fusion Joint

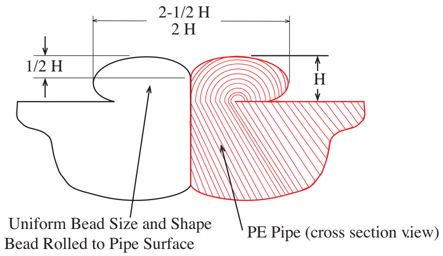
Golden Rule: If in doubt, cut it out and redo.

The double bead should be rolled over onto the adjacent surfaces, and be uniformly rounded and consistent in size all around the joint. As illustrated in the Figure below, the double bead width should be 2 to 2-1/2 times its height above the surface, and the v-groove depth between the beads should not be more than half the bead height.

When butt fusing to molded fittings, the fitting side bead may have an irregular appearance. This is acceptable provided the pipe side bead is correct.

It is not necessary for the internal bead to roll over to the inside surface of the pipe.

Butt Fusion Bead Proportions



Note: This is a “guideline” only and should not be taken solely as pass or fail. The bead may be in various configurations but they must satisfy the following requirements:

- There shall be no evidence of cracks or incomplete fusion.
- Joints shall not be visually mitered (angled, offset). The ovality offset shall be less than 10% of the minimum wall thickness of the fused components.
- The cleavage between fusion beads shall not extend to or below the outside pipe diameter pipe surface.

Manual Butt Fusion Machine Procedure

Butt Fusion Joint Troubleshooting Guide

Observed Condition	Possible Cause
Excessive double bead width	Overheating; Excessive joining force
Double bead v-groove too deep	Excessive joining force; Insufficient heating; Pressure during heating
Flat top on bead	Excessive joining force; Overheating
Non-uniform bead size around pipe	Misalignment; Defective heating tool; Worn equipment; Incomplete facing
One bead larger than the other	Misalignment; Component slipped in clamp; worn equipment; defective heating tool; incomplete facing
Beads too small	Insufficient heating; Insufficient joining force
Bead not rolled over to surface	Shallow v-groove - Insufficient heating & insufficient joining force; Deep v-groove - Insufficient heating & excessive joining force
Beads too large	Excessive heating time
Squarish outer bead edge	Pressure during heating
Rough, sandpaper-like, bubbly, or pockmarked melt bead surface	Hydrocarbon contamination

Hydraulic Butt Fusion Machine Procedure

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Hydraulic Butt Fusion Machine Procedure

The principle of heat fusion is to heat two surfaces to a designated temperature, and then fuse them together by application of force. This pressure causes flow of the melted materials, which causes mixing and thus fusion. When the polyethylene material is heated, the molecular structure is transformed from a crystalline state into an amorphous condition. When fusion pressure is applied, the molecules from each polyethylene part mix. As the joint cools, the molecules return to their crystalline form, the original interfaces are gone, and the two pipes have become one homogeneous unit.

The principle operations include:

Cleaning	The pipe ends must be clean and free of any dirt, debris or other contaminants
Clamping	The pipe pieces held axially to allow all subsequent operations to take place.
Facing	The pipe ends must be faced to establish clean, parallel mating surfaces perpendicular to the centerline of the pipes.
Alignment	The pipe ends must be aligned with each other to minimize mismatch or high-low of the pipe wall.
Heating	A melt pattern that penetrates into the pipe must be formed around both pipe ends.
Joining	The melt patterns must be joined with a specified force. The force must be constant around the interface area.
Holding	The molten joint must be held immobile with a specified force until adequately cooled.

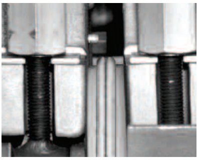
BUTT FUSION OF PIPES AND COMPONENTS WITH DIFFERENT WALL THICKNESSES

When Butt Fusion is used to join pipes and other components together they must have the same outside diameter and the difference between minimum wall thickness dimensions for the two components being joined should not exceed 26%.

Example: You have a pipe or fitting that has a wall thickness of 25 mm (1”). You can weld that pipe to pipes or fittings that have a wall thickness of 20 mm (3/4”) min. or 32 mm (1-1/4”) max.

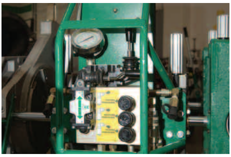
Important:

- The pipe line is only as strong as its weakest link.
- The fusion pressure used to join two different wall thicknesses is always that of the thinner.



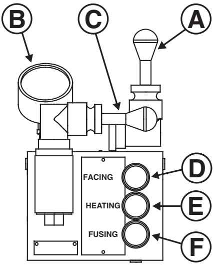
Hydraulic Butt Fusion Machine Procedure

Hydraulic Manifold Block



Mounted on this block are a carriage directional control valve, a selector valve, three pressure reducing valves, and a pressure gauge.

A) The carriage control value, mounted on the top of the manifold, determines whether the carriage is moving left, right, or in neutral.



B) A pressure gauge is mounted on top of the manifold.

C) The selector valve, mounted on the front of the manifold, selects a pressure from one of the pressure reducing valves. Each pressure reducing valve is labeled with a different function.

D) The top valve adjusts facing pressure, normally 3 to 7 Bar (50-100 psi) gauge pressure.

E) The middle valve adjusts heating pressure, always 0 Bar (0 psi) or backed all the way out turning knob counterclockwise. The drag pressure may have to be compensated for when working with more than one joint of pipe on the movable side or with tie-ins.

F) The bottom valve adjusts fusion pressure, this pressure must be determined.

Install Clamping Inserts

Select and install appropriate clamping inserts for the pipe that is being fused.

Hydraulic Butt Fusion Machine Procedure

Check Hydraulic Pressure

The pressure gauge on the manifold block indicates the pressure of the carriage valve. How much pressure depends on the position of the selector valve and the pressure set on the specific pressure reducing valve. With the selector valve up, the facing pressure can be set. It may be necessary to adjust the carriage speed, while facing, with the top pressure-reducing valve to control facing speed.

Shift the selector valve to the center position, heating, and set the pressure reducing valve at its lowest setting, or the drag pressure, whichever is higher.

With the selector valve in the down position, the fusion pressure can be set.

The fusion pressure can be calculated using the Fusion Pressure Calculator (shown on the next page or by using the formula on the next page, or they can be found in the reference section.)

An approximate 2 Bar (30 psi) drag factor should compensate for seal, and pipe drag with one joint of pipe on a pipe stand. If additional lengths of pipe are being moved by the movable jaws, the actual drag pressure should be determined using the following procedure:

After facing the pipe, move the carriage so that the pipe ends are approximately 50 mm (2") apart.

Shift the carriage control valve to the middle (neutral) position, select the heating mode, and adjust the middle pressure reducing valve to its lowest pressure by turning the valve counterclockwise.

Shift the carriage control valve to the left.

Gradually increase the pressure by turning the heating valve clockwise. Increase the pressure until the carriage moves.

Quickly reduce the heating pressure valve counterclockwise until the carriage is just barely moving.

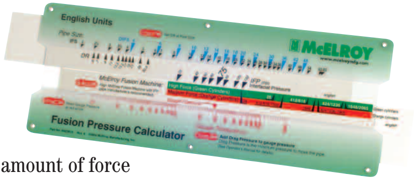
Record this actual drag pressure.

Take the pressure, determined from the Fusion Pressure Calculator, and add the actual measured drag pressure. This will be the actual fusion pressure to set with the bottom pressure reducing valve. If fusion pressures are used from the reference section, you must subtract 2 Bar (30 psi) drag, which is already figured in and then add the actual drag pressure back.

Adjust the middle heating valve to show recorded drag so that pipe ends will stay in contact with heater during heating phase.

Hydraulic Butt Fusion Machine Procedure

Fusion Pressure Calculator



Interfacial Pressure (IFP)
Minimum 4.1 Bar (60 psi)
Optimum 5.2 Bar (75 psi)
Maximum 6.2 Bar (90 psi)

Interfacial Pressure (IFP) = amount of force per sq. inch of the surface area of the pipe end. Interfacial Pressure (IFP) and Fusion machine gauge pressure are not the same.

How to Use the Fusion Pressure Calculator

Step 1: Set DR at Pipe Size.
Step 2: Align McElroy Fusion Machine with IFP.
Step 3: Read Gauge Pressure at red arrow.
Step 4: Add Drag Pressure to gauge pressure.

Determining Fusion Pressure

Variable Definitions
OD = Outside Diameter
t = Wall Thickness
π = 3.1416
DR = Dimensional Ratio
IFP = Recommended Interfacial Pressure (Shown Above)
TEPA = Total Effective Piston Area
DRAG = Force Required to Move Pipe

Example:
Using a McElroy No. 250 Standard Fusion Machine (Low Force, Yellow Cyl.)
OD of Pipe = 200 mm
DR of Pipe = 11
Recommended Interfacial Pressure = 5.2 Bar (75 PSI)
Measured Drag 2 Bar (30 PSI)

Formula: Wall Thickness

$$t = \frac{OD}{DR} = \frac{200\ \text{mm}}{11} = 18.2\ \text{mm}$$

TEPA = 1077 mm² (1.67 in²) (chosen from the table on page 36)

$$\textbf{Gauge Pressure} = \frac{(OD - t) \times t \times \pi \times IFP}{TEPA} + DRAG$$

$$\textbf{Gauge Pressure} = \frac{(200 - 18.2) \times 18.2 \times 3.14 \times 5.2}{1077} + 2 = 52\ \text{Bar}$$

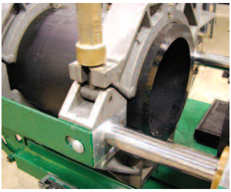
Hydraulic Butt Fusion Machine Procedure

Notice:
See Reference Section, pages 80-85, for fusion pressure charts showing pressures precalculated to include 2 Bar (30 psi) for system drag.

Determining Fusion Pressure (Continued)

	TEPA = Total Effective Piston Area mm^2 (in^2)		
Fusion Machine Model	High Force Standard (Green Cylinders)	Medium Force High Velocity (Orange Cylinders)	Low Force Extra High Velocity (Yellow Cylinders)
250 or T-250	3039 (4.71)	NA	1077 (1.67)
412 or T-412	7600 (11.78)	3877 (6.01)	2026 (3.14)
618 or T-618	7600 (11.78)	3877 (6.01)	2026 (3.14)
T-500 Series I or II	NA	3877 (6.01)	NA
824	19000 (29.44)	9885 (15.32)	6097 (9.45)
1236	19000 (29.44)	9885 (15.32)	6097 (9.45)
T-900	19000 (29.44)	9885 (15.32)	6097 (9.45)
1648	20272 (31.42)	9123 (14.14)	NA
2065	20272 (31.42)	NA	NA

Loading Pipe Into Machine
(No. 412 and No. 618 Used In the Following Illustrations)



Clean the inside and outside of pipe ends that are to be fused.

Open the upper jaws and insert pipe in each pair of jaws with applicable inserts installed.

Let the ends of the pipe protrude more than 25 mm (1") * past the face of the jaws.

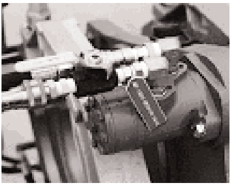
* This distance changes with fusion machine type.

Tighten the clamp knobs on the outer jaws to prevent pipe slippage and lightly tighten inner clamp knobs for possible later alignment adjustments.

Hydraulic Butt Fusion Machine Procedure

Facing The Pipe

Pivot the facer into place and secure.

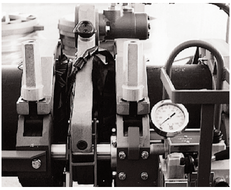


Move the carriage to the right.

Open the ball valve on the facer motor.

Assure the selector valve handle is up in the facing position.

Move the carriage to the left.



If the facer stalls, adjust the facing pressure so the facer continues to cut.

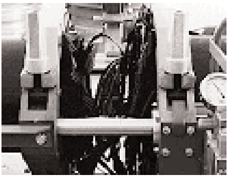
Important:
When facing heavy wall pipe, it may be necessary to increase the system pressure.

Important:
When drag pressure exceeds 20 Bar (300 psi) it is necessary to move the carriage to the left bringing the pipe ends into contact with the facer before opening the facer valve.

Let the carriage bottom out at the facer stops. Turn the facer off. Move the carriage to the right so the facer can be removed.

Hydraulic Butt Fusion Machine Procedure

Remove Facer

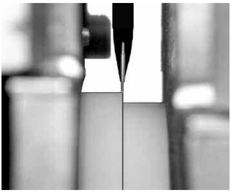


Pivot the facer out to the storage position.

Remove chips from pipe ends, careful not to touch faced pipe ends.

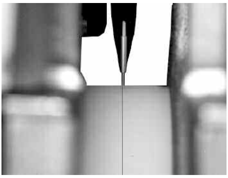
If faced pipe ends are touched, use clean non-synthetic cloth to clean affected area before proceeding.

Move the carriage to the left until ends of pipe butt together. Check pipe joint for proper alignment.



WARNING Do not use finger to check for hi/low (misalignment). The unit is under pressure, and slippage could result in crushed fingers. Always keep hands clear of the jaw area.

If pipe is not lined up, tighten the inner high side jaw to bring into alignment.



Important:
Always tighten the side that is higher, never loosen the low side.

When the pipe is properly aligned tighten outside clamps to insure against slippage.

If clamp knob adjustment has been made, reinstall facer and begin facing procedure again.

Let the carriage bottom out on facer stops. Turn facer off. Move the carriage to the right so the facer can be removed.

Remove chips from pipe ends careful not to touch faced pipe ends.

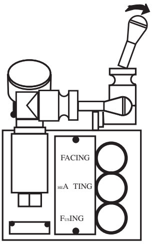
Bring the pipe ends together under fusion pressure to check for slippage. If slippage occurs, return to Loading Pipe Into Machine on page 36.

Notice:
Their should be no more than 10% of the wall thickness in misalignment to maintain full joint strength.

Hydraulic Butt Fusion Machine Procedure

Position Carriage For Heater Insertion

Move carriage to the right to open a gap large enough to insert the heater.



Check Heater Temperature

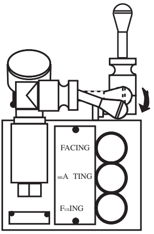
⚠CAUTION Incorrect heating temperature can result in questionable fusion joints. Check heater plates periodically in multiple locations with a pyrometer and make necessary adjustments.

For butt fusion heater surface temperature should be Minimum 205°C (400° F), **Optimum 218°C (425° F)**, Maximum 230°C (450° F).

Important:
The dial thermometer on the heater indicates internal temperature. The dial thermometer can be used as reference once the surface temperature has been verified.

Select the Fusion Position

Move selector valve handle down to the fusing position. Use fusion pressure required from Fusion Pressure Calculator or the formula on page 35 . Also see Reference Section, page 80-85.



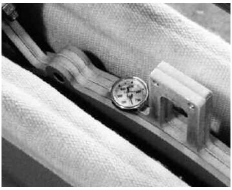
Hydraulic Butt Fusion Machine Procedure

Inserting Heater

⚠ DANGER Heater is Not Explosion Proof. Operation of heater in a hazardous environment without necessary safety precautions could result in explosion and death.

If operating in a hazardous environment, heater should be brought up to temperature in a safe environment,then unplugged before entering the hazardous atmosphere for fusion.

Use a clean non-synthetic cloth to clean the butt fusion heater adapter surfaces.

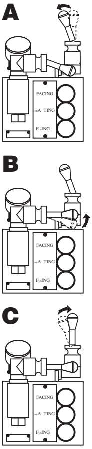


Check heater plates for coating damage, plastic buildup rings and surface imperfections. These conditions could cause a poor fusion. Replace them if conditions exist.

Verify heater temperature noting the reading on the dial thermometer.

Insert heater between the pipe ends.

Heating The Pipe



A) Move the carriage to the left under the fusion pressure, bringing the heater into contact with both pipe ends, seating pipe ends against heater. At first indication of melt around circumference of pipes, move to step B.

B) Move selector valve to center position, allowing pressure to drop and stabilize at lowest setting, in most cases “0”. When fusing more than one pipe length on the movable side of the fusion unit, drag must be compensated for.

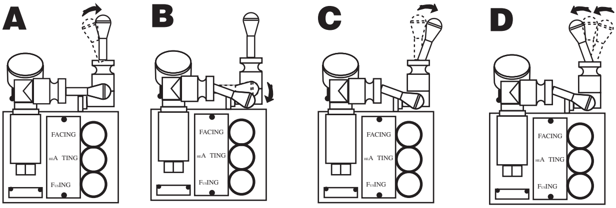
C) Return carriage control valve to neutral (middle) position. The pipe ends are now heating at “0” pressure or the pressure to compensate for drag, allowing the pipe ends to remain in contact with the heater.

Hydraulic Butt Fusion Machine Procedure

Fusing The Pipe

⚠CAUTION Failure to follow the proper shift sequence, verify proper melt pattern and achieve proper cooling time may result in a bad joint.

After proper melt pattern has been established, use the **Approximate Melt Bead Size** chart on page 42 to determine the proper size, then:



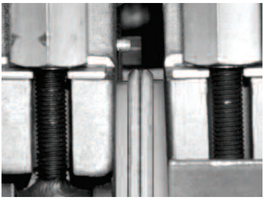
A) Shift carriage control valve to neutral position if not in this position already.

B) Shift the selector valve down to fusion position.

C) Move the carriage to the right just enough to remove the heater. The stripper bar on the heater should help "pop" heater loose. Quickly remove the heater without coming into contact with melted pipe ends.

D) Quickly inspect pipe ends, which should be flat, smooth, and completely melted. Concave pipe ends are unacceptable, see page 42. If acceptable, shift carriage control valve to the left immediately bringing ends together and apply fusion pressure, calculated from page 35 or obtained from fusion pressure charts in Reference Section, pages 80-85.

Notice:
Bring pipe ends together being careful not to exceed the **Approximate Dwell/Transfer Times** shown on page 42.



Hydraulic Butt Fusion Machine Procedure

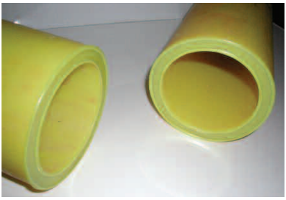
Approximate Melt Bead Size (Pipe Ends)

Pipe Size	Approximate Melt Bead Size
40 mm (1-1/4") - 90 mm (3")	About 2 mm (1/16")
90 mm (3") - 200 mm (8")	3 mm (1/8") - 5 mm (3/16")
200 mm (8") - 315 mm (12")	5 mm (3/16") - 6 mm (1/4")
315 mm (12") - 630 mm (24")	6 mm (1/4") - 11 mm (7/16")
630 mm (24") - 900 mm (36")	About 11 mm (7/16")
900 mm (36") - 1600 mm (63")	About 14 mm (9/16")

Approximate Dwell/Transfer Times

Pipe Size	Max. Transfer Time
90 mm (3") & smaller	4 sec.
110 mm (4") to 315 mm (12")	6 sec.
340 mm (13") to 630 mm (24")	9 sec.
710 mm (28") to 900 mm (36")	12 sec.
1000 mm (40") & Up	15 sec.

Unacceptable Concave Melt Appearance



What Causes This?

Answer - Heating under pressure.

Notice:
A concave melt surface is unacceptable; it indicates pressure during heating. Do not continue. Allow the melted ends to cool and start over.

Hydraulic Butt Fusion Machine Procedure

Cooling Of The Fusion Joint

The fusion joint must be kept under fusion pressure until joint is cool. This time will vary with pipe size, wall thickness, heater plate temperature setting and environmental conditions.

There are three acceptable methods that can be used individually or combined.

1) Cool to the touch.

CAUTION If using this method, do not place hand or fingers in between jaws. The joint has pressure applied and the jaws could still slip at this point. Use a tool like a long handled screwdriver that can be used to probe weld bead. If tool makes an impression in weld bead, the weld bead is soft and has not cooled enough.

2) **Timing "Guidelines Only"**

Wall Thickness	**Cooling Time at 23° C (74° F)**
Up to 5 mm (0.2")	5 minutes
5 mm (0.2") to 10 mm (0.4")	5 to 10 minutes
10 mm (0.4") to 15 mm (0.6")	10 to 15 minutes
15 mm (0.6") to 20 mm (0.8")	15 to 20 minutes
20 mm (0.8") to 30 mm (1.2")	20 to 30 minutes
30 mm (1.2") to 40 mm (1.6")	30 to 40 minutes
40 mm (1.6") to 51 mm (2.0")	40 to 50 minutes
51 mm (2.0") to 61 mm (2.4")	50 to 60 minutes
61 mm (2.4") to 71 mm (2.8")	60 to 70 minutes
71 mm (2.8") to 81 mm (3.2")	70 to 80 minutes

3) Use a pyrometer to measure temperature of the weld bead and compare it to the temperature of the pipes and or the fittings being fused. If the temperatures are the same, the cooling requirement has been met.

Notice:
Heavier wall thickness pipes require longer cooling times.

You must allow the joint to cool an additional thirty minutes minimum outside of the fusion machine before subjecting the fusion joint to any rough handling or severe bending.

Hydraulic Butt Fusion Machine Procedure

Opening Movable Jaws

After the joint has cooled for the recommended time, shift the carriage control valve to the neutral position.

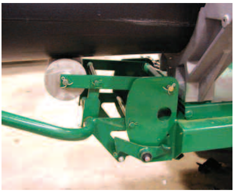
Loosen all clamp knobs, and move carriage to the right far enough to open the jaw nearest the facer.

Open the movable jaws.

Opening Fixed Jaws

Open the fixed jaws

Raise Pipe



Raise the joined pipe using the pipe lift(s).

Pull Pipe through machine, and prepare for making next fusion. Inspect joint and if it has to be redone, use Trouble Shooting Guides on page 45 and 46 to determine problem and make adjustments before next fusion.

Butt Fusion Joint Troubleshooting Guide

The Inspection Of The Fusion Joint

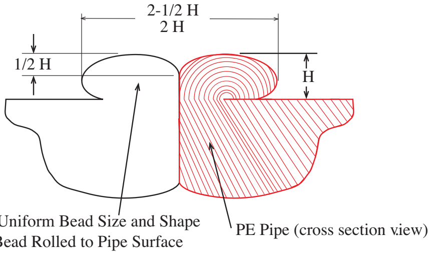
Golden Rule: If in doubt, cut it out and redo.

The double bead should be rolled over onto the adjacent surfaces, and be uniformly rounded and consistent in size all around the joint. As illustrated in the Figure below, the double bead width should be 2 to 2-1/2 times its height above the surface, and the v-groove depth between the beads should not be more than half the bead height.

When butt fusing to molded fittings, the fitting side bead may have an irregular appearance. This is acceptable provided the pipe side bead is correct.

It is not necessary for the internal bead to roll over to the inside surface of the pipe.

Butt Fusion Bead Proportions



Note: This is a “guideline” only and should not be taken solely as pass or fail. The bead may be in various configurations but they must satisfy the following requirements:

- There shall be no evidence of cracks or incomplete fusion.
- Joints shall not be visually mitered (angled, off-set). The ovality offset shall be less than 10% of the minimum wall thickness of the fused components.
- The cleavage between fusion beads shall not extend to or below the outside pipe diameter pipe surface.

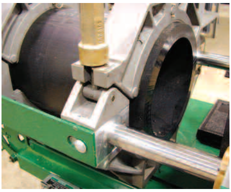
Hydraulic Butt Fusion Machine Procedure

Butt Fusion Joint Troubleshooting Guide

What Is Present	Attributing Factors
One bead larger than the other	Misalignment, component slipped in clamp, worn equipment, incomplete facing
Bead not rolled over to surface	Shallow v-groove - insufficient heating & insufficient joining force, deep v-groove - insufficient heating & excessive joining force
Squarish outer bead edge	Pressure during heating
Excessive double bead width	Overheating, excessive joining force
Flat top on bead	Excessive joining force, overheating
Beads too small	Insufficient heating or joining force
Beads too large	Excessive heating time
Rough, sand-paper like, bubbly, or pockmarked melt bead surface	Hydrocarbon contamination
Double v-groove too deep	Excessive joining force, insufficient heating, pressure during heating
Non-uniform bead size around pipe	Misalignment, defective heating tool, worn equipment, incomplete facing
A third bead	Excessive joining force

Hydraulic Butt Fusion Machine Procedure

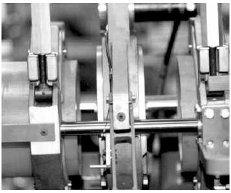
Position Pipe For Next Joint



Move the fusion machine to the end of pipe, or pull the pipe through the jaws until the end of the pipe is protruding more than 25 mm (1") * past the jaw face of the fixed jaw.

* This distance changes with fusion machine type.

Install Next Piece Of Pipe



Insert a new piece of pipe in the movable jaws and repeat all previous procedures.

Saddle Fusion Machine Procedure

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Saddle Fusion Machine Procedure

The theory of heat fusion is to heat two surfaces to a designated temperature, and then fuse them together by application of force. This pressure causes flow of the melted materials, which causes mixing and thus fusion. When the polyethylene material is heated, the molecular structure is transformed from a crystalline state into an amorphous condition. When fusion pressure is applied, the molecule from each polyethylene part mix. As the joint cools, the molecules return to their crystalline form, the original interfaces are gone, and the fitting and pipe have become one homogeneous unit.

The principle operations include:

Clamping	The pipe and fitting must be held firmly to allow all subsequent operations to take place.
Cleaning	The area of pipe that the fitting will come in contact with must be cleaned and roughed up, as well as the base of the fitting.
Alignment	The fitting must be properly seated on the pipe and then clamped in the machine for proper alignment.
Heating	A melt pattern must be formed that penetrates into the pipe and into the fitting.
Joining	The melt patterns must be joined with a specified force. The force must be constant around the interface area.
Holding	The molten joint must be held immobile with a specified force until adequately cooled.

Saddle Fusion Procedures

Definitions

Initial Heat (Bead-up): The heating step used to develop a melt bead on the main pipe.

Initial Heat Force (Bead-up force): The force applied to establish a melt pattern on the main pipe. The Initial Heat Force is determined by multiplying the fitting base area by the initial heat interfacial pressure (Bar per 25.4 mm^2). This force is twice the fusion force.

Heat Soak Force: The force applied after an initial melt pattern is established on the main pipe. The Heat Soak Force is the minimum force (essentially zero Bar) that ensures that the fitting, heater, and main stay in contact with each other.

Fusion Force: The force applied to establish the fusion bond between the fitting and the pipe. The Fusion Force is determined by multiplying the fitting base area by the fusion interfacial pressure (Bar per 25.4 mm^2).

Total Heat Time: A time that starts when the heater is placed on the main pipe and initial heat force is applied and ends when the heater is removed.

Cool Time: The time required to cool the joint to approximately 49°C (120°F). The fusion force must be maintained for five minutes on 40 mm (1-1/4" IPS) or ten minutes for all other main sizes, after which the saddle fusion equipment can be removed. The joint must be allowed to cool undisturbed for an additional thirty minutes before tapping the main or joining to the branch outlet.

Interfacial Area for Rectangular Base Fittings: The major width times the major length of the saddle base, without taking into account the curvature of the base or sides, minus the area of the hole in the center of the base.

Interfacial Area for Round Base Fittings: The radius of the saddle base squared times π (3.1416), without taking into account the curvature of the base or sides, minus the area of the hole in the center of the base.

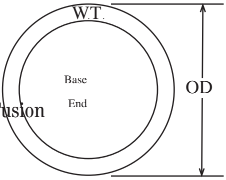
Fitting Label: The Initial Heat Force, Heat Soak Force, and the Fusion Force may be listed in the lower right corner of the fitting label for all saddle fusion fittings. This will eliminate the need to calculate the fusion forces in the field (example 80/0/40). Some manufacturers have this information on fitting labels but not all.

Saddle Fusion Procedures

How To Determine Fusion Pressures

Round Base

$$\frac{(\text{O.D. of Base} - \text{Wall Thickness}) \times \text{Wall Thickness} \times 3.14 \times \text{IFP*}}{\text{TEPA**}}$$



Notes:

*IFP = Interfacial Fusion Pressure is always 2 Bar (30 Psi) for Saddle Fusion

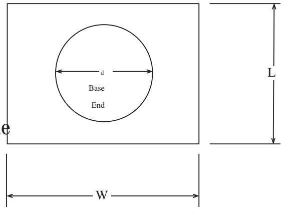
**TEPA = Total Effective Piston Area

*** Add 2 Bar (30 Psi) to your fusion pressure to compensate for drag when using hydraulic pump powered fusion equipment.

Examples: Sidewinders have 1 TEPA
No. 28 Combo has a 4.7 TEPA or 1.67 TEPA for a 250 unit

Rectangular Base

$$\frac{L \times W - (d \times d \times .7854) \times \text{IFP*}}{\text{TEPA**}}$$



Notes:

*IFP = Interfacial Fusion Pressure is always 2 Bar (30 Psi) for Saddle Fusion

**TEPA = Total Effective Piston Area

*** Add 2 Bar (30 Psi) to your fusion pressure to compensate for drag when using hydraulic pump powered fusion equipment.

Examples: Sidewinders have 1 (25.40) TEPA
No. 28 Combo (HF) has a 4.7 (3039) TEPA or 1.67 (1077) TEPA for a 250 (LF) unit

Saddle Fusion Procedures

Prepare Fusion Machine
This procedure requires the use of a Saddle Fusion Tool like the examples shown on the cover page of this procedure. This tool must be capable of holding and supporting the main, rounding the main for good alignment between the pipe and fitting, holding the fitting, applying and indicating the proper force during the fusion process.

Install the Saddle Fusion Tool on the main according to the manufacturer's instructions. The tool should be centered over a clean, dry location where the fitting will be fused. Secure the tool to the main. A main bolster or support is recommended under the pipe on 160 mm (6" IPS) and smaller main pipe sizes.

Abrade the fusion surface of the fitting with 50 to 60 grit utility cloth; to remove oxidation layer and contaminants. After abrading, brush residue away with a clean, dry cloth.

Saddle Fusion Procedures

Insert the fitting in the Saddle Fusion Tool loosely.

Abrade the fusion surface of the main with a 50-60 grit utility cloth to remove oxidation layer and contaminates. The abraded area must be larger than the area covered by the fitting base. After abrading, brush residue away with a clean, dry cloth.

Using the Saddle Fusion Tool, move the fitting base and apply about 7 Bar (100 pounds) force to seat the fitting. Secure the fitting in the Saddle Fusion Tool.

Heating

⚠ DANGER Heater is Not Explosion Proof. If working in a hazardous environment review pages 7, 13 and 14 in Safety Section.

⚠CAUTION Incorrect heating temperature can result in questionable fusion joints. Check heater plates periodically in multiple locations with a pyrometer and make necessary adjustments.

The heater must be fitted with the correct heater adapters. Serrated heater adapters are recommended to allow for maximum heat penetration. The non-stick coating on the heater adapters should be in good condition. The temperature of the heater adapter fusion surfaces must be 255°C - 265°C (490-510° F), with **260°C (500ºF)** being **Optimum.**

Important:
The dial thermometer on the heater indicates internal temperature. The dial thermometer can be used as reference once the surface temperature has been verified.

Saddle Fusion Machine Procedure

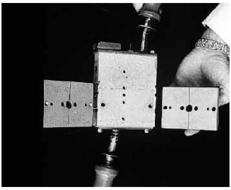
Saddle Fusion Procedures

Installing Fusion Heater Adapters

The heater body of this assembly is not coated. Coated heater adapters are available for all fusion applications.

Heater adapters are installed with Stainless Steel Cap Screws.

Care should be taken to assure that the heater adapters are seated on the heater body, and that there is no foreign matter trapped between these surfaces.



Important: Do not over-tighten the bolts.

The surface of the heater adapters are coated with an anti-stick coating.

Place the heating tool on the main centered beneath the fitting base. Immediately move the fitting against the heater faces, apply the Initial Heat Force, (see fitting label or use twice the calculated fusion pressure), and start the heat time.

Apply the Initial Heat Force until melt is first observed on the crown of the pipe main, (Initial Heat is the term used to describe the initial heating (bead-up) step to develop a melt bead on the main pipe and usually is 3-5 seconds) and then reduce the force to the Heat Soak Force (Bead-up Force) (see fitting label or use "0" psi.)

At the end of the Total Heat Time (See Below), remove the fitting from the heater and the heater from the main with a quick snapping action. Quickly check the melt pattern on the main pipe and fitting base for even melt patterns (no unheated areas).

Total Heat Time ends when: See Page 55.

Saddle Fusion Procedures

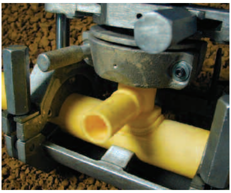
Maximum Heating Time And Minimum Cooling Time

Main Size	**Maximum Heating Time**	**Minimum Cooling Time**
40 mm (1-1/4" IPS) all DR's Pressurized	Stop heating when about 2 mm (1/16") bead is visible all around fitting base. **Do not exceed 15 sec. when hot tapping** (blowout may occur if main line is pressurized.)	5 min. + 30 min.
63 mm (2" IPS) all DR's Pressurized	Stop heating when about 2 mm (1/16") bead is visible all around fitting base. **Do not exceed 35 sec. when hot tapping** (blowout may occur if main line is pressurized.)	10 min. + 30 min.
40 mm - 63 mm (1-1/4 - 2" IPS) all DR's Non-Pressurized	Stop heating when about 2 mm (1/16") bead is visible all around fitting base.	10 min. + 30 min.
90 mm (3" IPS) all DR's Non-Pressurized	Stop heating when about 2 mm (1/16")- 3 mm (1/8") bead is visible all around fitting base.	10 min. + 30 min.
110 mm (4" IPS) and Larger all DR's Non-Pressurized	Stop heating when about 3 mm (1/8") - 6 mm (1/4") bead is visible all around fitting base.	10 min. + 30 min.

Notice:
It is highly recommended that a trained ISCO Field Service Technician support you on projects involving pressurized mains greater than 63 mm (2" IPS) in size and branch saddles greater than 200 mm (8" IPS) in size.

Saddle Fusion Procedures

Fusion and Cooling



Whether or not the melt patterns are satisfactory, press the fitting onto the main pipe very quickly (within 3 seconds) after removing the heater and apply the Fusion Force (See the fitting label or use the formula on page 51 to calculate). Maintain the Fusion Force on the assembly for 5 minutes on 40 mm (1-1/4" IPS) mains and for 10 minutes on all larger sizes , after which the saddle fusion equipment may be removed. (Fusion Force adjustment may be required during Cooling Time, but never reduce the Fusion Force during the cooling).

Important:
Visually check the fusion bead around the entire fitting base at the main pipe. The fusion bead should be uniformly sized all around the fitting base, and should have a characteristic “three-bead” shape. The first bead is the fitting base melt bead. The second or outermost bead is produced by the edge of the heating tool face on the main. The third or center bead is the main pipe melt bead. The first and third beads should be about the same 3 mm (1/8") - 6 mm (1/4") size all around the fitting base. The second bead is usually smaller, but should also be uniformly sized around the fitting base.

The assembly should cool for an additional 30 minutes before rough handling or tapping the main. Inspect fusion using the troubleshooting guide on page 57 for proper melt patterns. If melt patterns are not satisfactory or if the fusion bead is unacceptable, cut off the saddle fitting above the base to prevent use and relocate to a new section of main. Then make a new saddle fusion using a new fitting.

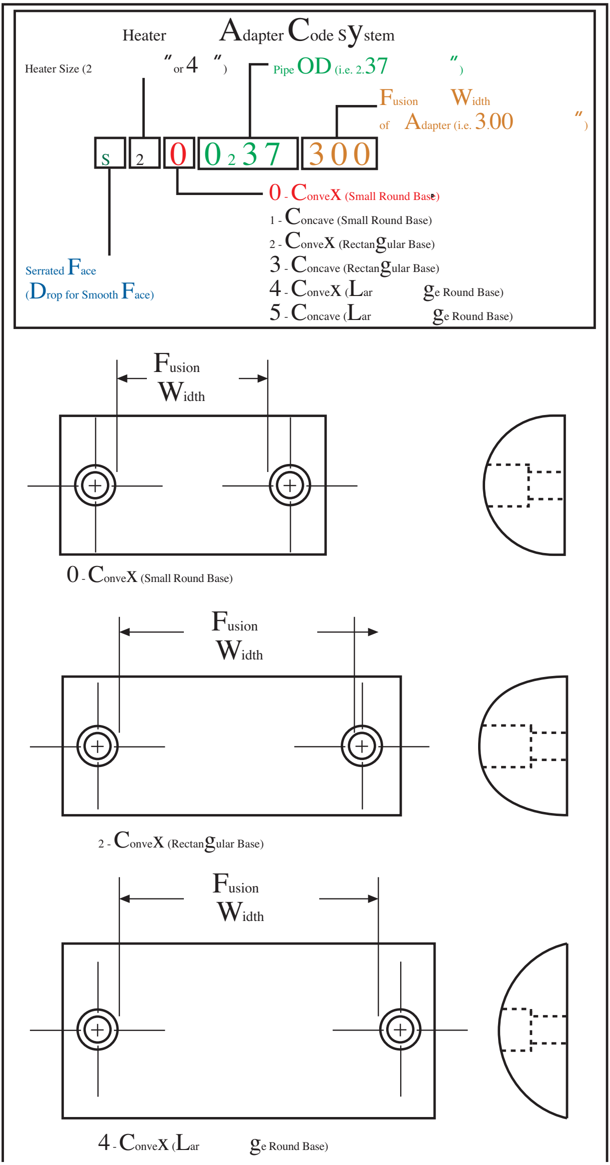
Important:
These procedures are based on tests conducted under controlled ambient temperature conditions. Environmental conditions on a job site could affect heating and cooling times. Regardless of job site conditions or ambient temperature, the prescribed heating tool temperature is required. Do not increase or decrease the heating tool temperature.

Saddle Fusion Procedures

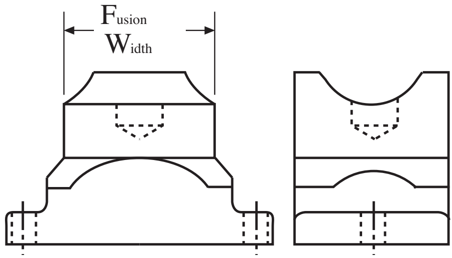
Troubleshooting Guide

Observed Condition	Possible Cause
Non-uniform bead size around fitting base	Misalignment; Defective heating tool; Loose or contaminated heating tool saddle faces; Worn equipment; Fitting not secured in application tool; Heating tool faces not within specified temperature
One bead larger than the other	Misalignment; Component slipped in clamp; Worn equipment; Defective heating tool; Loose or contaminated heating tool saddle faces; Heating tool faces not within specified temperature
Beads too small	Insufficient heating; Insufficient joining force
Beads too large	Excessive heating time; Excessive force
No third bead, or third bead widely separated from center bead	Incorrect pipe main heating tool face or insufficient joining force
Serrated bead appearance	Normal for serrated heating tool faces
Smooth bead appearance	Normal for smooth heating tool faces
Pressurized main pipe blowout (beside base or through fitting center)	Overheating; Incorrect heating tool faces; Heating tool faces not within specified temperature; Taking too much time to start heating or to remove the heating tool and join the fitting to the main pipe
Rough, sandpaper-like, bubbly, or pockmarked melt bead surface	Hydrocarbon contamination

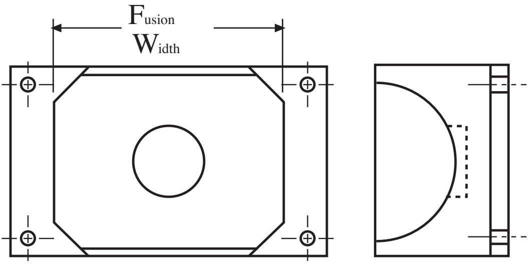
Saddle Fusion Procedures



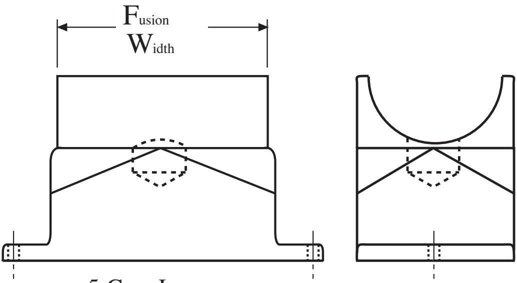
Saddle Fusion Procedures



1 - Concave (Small Round Base)

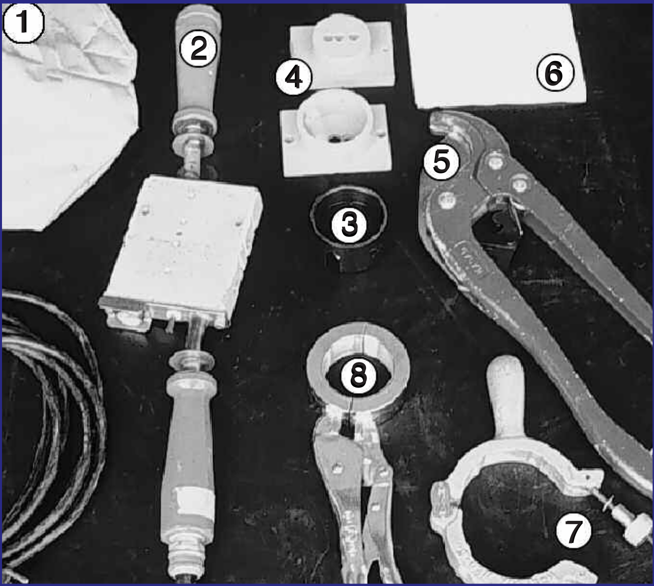


3 - Concave (Rectangular Base)



5 - Concave (Large Round Base)

Socket Tooling and Fusion Procedure



Nomenclature

1) Heater Sling
2) Heater
3) Chamfer Tool/Depth Gauge
4) Heater Adapters
5) Pipe Cutter
6) Clean Cloth
7) Fitting Holder
8) Cold Ring Clamp

Socket Tooling and Fusion Procedure

The theory of heat fusion is to heat two surfaces to a designed temperature, and then fuse them together by application of force. This pressure causes flow of the melted materials, which causes mixing and thus fusion. When the polyethylene material is heated, the molecular structure is transformed from a crystalline state into an amorphous condition. When fusion pressure is applied, the molecule from each polyethylene part mix. As the joint cools, the molecules return to their crystalline form, the original interfaces are gone, and the fitting and pipe have become one homogeneous unit.

The principle operations include:

Clamping	The pipe and fitting must be held firmly to allow all subsequent operations to take place.
Cleaning	The area of pipe that the fitting will come in contact with must be cleaned, as well as the base of the fitting.
Alignment	The fitting must be properly seated on the pipe for proper alignment.
Heating	A melt pattern must be formed that penetrates into the pipe and into the fitting.
Joining	The melt patterns must be joined with pressure. The pressure must be constant around the interface area.
Holding	The molten joint must be held immobile until adequately cooled.

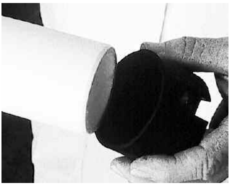
Socket Fusion Tooling and Fusion Procedure

Prepare Pipe End

Cut off damaged or oval ends of pipe squarely with a pipe cutter.

Place the chamfering tool on end of pipe and turn to cut off sharp edge on top end of pipe.

Remove shavings and burrs inside pipe end.



Depth Gauge

The chamfering tool is also a depth gauge for measuring the length of pipe that will go into the fitting.

Place chamfering tool on end of pipe.

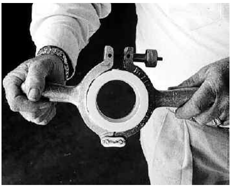
Place cold ring clamp on pipe at the bottom of the chamfering tool.

Remove chamfering tool.

Secure 63 mm (2") And Larger Fittings

Place fitting in socket fitting holder.

Tighten socket fitting holder around fitting.

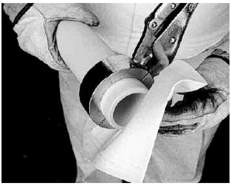


Socket Fusion Tooling and Fusion Procedure

Clean Fitting And Pipe

Fitting and pipe must be clean and dry. Use a clean cloth to wipe the mating surfaces.

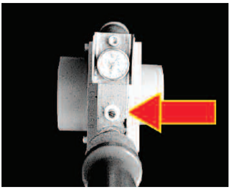
Notice:
Do not touch with hands.



Heater Is Not Explosive Proof

⚠ DANGER This heater is not explosion proof. Operation of heater in a hazardous environment without necessary safety precautions will result in explosion and death. If operating in a hazardous environment the heater should be brought up to temperature in a safe environment, then unplugged before entering the hazardous atmosphere for fusion.

Use a clean non-synthetic cloth to clean the heater adapter surfaces.



Old Style Heater

New Style Heater

Heater Temperature

⚠CAUTION Incorrect heating temperature can result in questionable fusion joints. Check socket faces periodically in multiple locations with a pyrometer and make necessary adjustments.

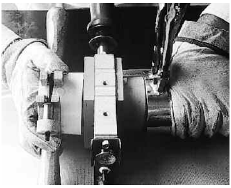
The non-stick coating on the heater adapters should be in good condition.

The socket faces of the heater must be at the correct temperature. Minimum 255° C (490° F), **Optimum 260° C (500°)** Maximum 265° C (510° F).

Important:
The dial thermometer on the heater indicates internal temperature. The dial thermometer can be used as reference once the surface temperature has been verified.

Socket Fusion Tooling and Fusion Procedure

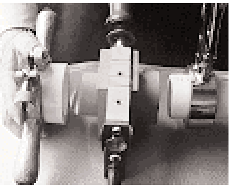
Heating The Pipe And Fittings



Firmly seat the socket fitting on the male adapter on the heater. Place the female adapter of the heater over the end of the pipe, firmly against the cold ring clamp. Heating time starts when the heater is bottomed out on the cold ring clamp. See chart on page 67 for proper heating time.

Notice: Do not twist fitting, pipe or heater.

Remove Heater



Snap the heater and fitting from the pipe by holding upper part of heater handle with one hand and tapping sharply on the handle with the other hand. Immediately remove fitting from heater.

Inspect Melt

Quickly inspect the heated parts to make sure all surfaces have been melted properly.

If melt is not complete, cut off melted pipe end. Use a new fitting and repeat preparation and heating process over again.

Socket Fusion Tooling and Fusion Procedure

Fusion And Cooling

Within 3 seconds after the heater has been removed, firmly push the melted fitting squarely onto the pipe until it makes firm contact with the cold ring clamp.

Notice: Do not twist or rotate the fitting.

Hold the fitting firmly in place for the total cooling time. See chart on page 67 for proper cooling time. ***Pipe and fitting should be aligned straight with each other.***

Inspecting Fusion Joint

After completing the specified cooling and waiting time, remove the cold ring clamp and the socket fitting holder.

Inspect the joint. A good joint will have a uniform melt ring that is flat against the socket fitting and perpendicular to the pipe.

There should be no gaps or voids between the fitting and the pipe. If the joint is questionable refer to the Troubleshooting Guide (page 66) for possible cause and adjustments that can be done before next fusion.

Holding force may be relaxed when the cooling time ends. After an additional 3 minutes undisturbed cooling time, the Cold Ring Clamp can be removed. Allow an additional 10 minutes undisturbed cooling time before testing, backfilling, or stressing the joint.

Total Cooling Time equals time shown on chart (page 67) plus an additional 13 minutes.

Socket Fusion Tooling and Fusion Procedures

Troubleshooting Guide

Observed Condition	Possible Cause
No cold-ring impression in socket fitting melt bead	Depth gauge not used; Cold ring not used, or set at incorrect depth; Insufficient heat time
Gaps or voids around the pipe at socket fitting edge	Pipe or fitting removed straight from heater face (twisting or removing from heater face at an angle); Pipe or fitting not inserted straight into each other when fusing; joining together at an angle; Twisting while joining pipe and fitting together; Cold ring not used or set to deep
(When viewed from inside, or when qualifying lengthwise cut joint) wrinkled or collapsed pipe or tubing end	Incorrect heating sequence-always push the pipe or tubing into the heater after the fitting has been pushed on the heater (inserting the tubing first heats the tubing too long); Cold ring set too deep; Cold ring not used
(When qualifying lengthwise cut joint) voids in fusion bond area	Pipe or fitting not removed straight from heater face (twisting or removing from heater face at an angle); Pipe or fitting not inserted straight into each other when fusing; joining together at an angle; Twisting while joining pipe and fitting together; Cold ring not used or set too deep
(When qualifying lengthwise cut joint) Unbonded area on pipe or tubing at end of pipe or tubing	Cold ring not used or set too deep
(When qualifying lenghtwise cut joint) Socket melt extends past end of pipe or tubing	Cold ring set too shallow
Rough, sandpaper-like, bubbly, or pockmarked melt bead surface	Hydrocarbon contamination

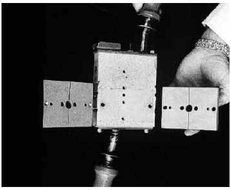
Socket Fusion Tooling and Fusion Procedures

Heating and Cooling Times

Pipe Size	PE 2406 (Yellow Pipe)		PE 80 (PE3408 Black Pipe)	
	Heating Time (Sec.)	Cooling Times (Sec.)*	Heating Time (Sec.)	Cooling Times (Sec.)*
20 mm (1/2" IPS)	6-7	20	9-10	30
25 mm (3/4" IPS)	8-10	20	12-14	30
32 mm (1" IPS)	10-12	30	15-17	40
40 mm (1-1/4" IPS)	12-14	30	18-21	40
50 mm (1-1/2" IPS)	14-17	30	20-23	40
63 mm (2" IPS)	16-19	30	24-28	40
90 mm (3"IPS)	20-24	40	28-32	50
110 mm (4"IPS)	24-29	40	32-37	50

* After an additional 3 minutes of undisturbed cooling time, the Cold Ring Clamp can be removed. After removing the Cold Ring Clamp allow an additional 10 minutes of undisturbed cooling time before testing, backfilling, or stressing the joint.

Installing Socket Fusion Heater Adapters



The heater body of this assembly is not coated. Coated heater adapters are available for all fusion applications.

Heater adapters are installed with Stainless Steel Cap Screws.

Care should be taken to assure that the heater adapters are seated on the heater body, and that there is no foreign matter trapped between these surfaces.

Important: Do not over-tighten the bolts.

The surface of the heater adapters are coated with an anti-stick coating.

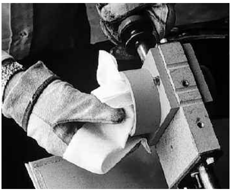
Socket Tooling and Fusion Procedure

Socket Fusion and Tooling Procedures

Clean Heater Surfaces

The heater adapters must be kept clean and free of any plastic build-up or contamination.

CAUTION Before and after each fusion is made, the surface of the heater adapters must be wiped with a clean, non-synthetic cloth.



Adjusting Heater Temperature

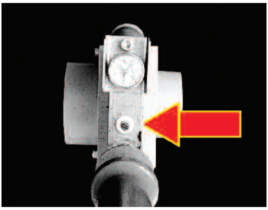
CAUTION Incorrect adjustment can result in injuries as well as machine damage. Follow these instructions carefully.

The heater thermoswitch adjustment shaft protrudes through the heater handle base.

Turn the adjustment shaft clockwise to lower temperature, counter clockwise to raise temperature.

Allow sufficient amount of time for unit to stabilize at the new temperature (5 to 10 minutes) after each adjustment.

One full turn equals approximately 38°C (100° F). (Old Style Heater)



Old Style Heater

New Style Heater

Reference Information: McElroy DataLogger™, Pendant/Coach™ Equipment & Fusion Pressure Charts

Reference

Power Requirements				
Machine	**Heater Power**	**Facer Power**	**Hydraulic**	**Min. Req. at sea Level**
MiniMc	300 Watt @ 120 VAC, 1Ph	Hand Operated	None	0.3 KW @ 120 VAC
No. 2LC	800 Watt @ 120 VAC, 1Ph	Hand Operated	None	0.8 KW @ 120 VAC
No. 2CU	800 Watt @ 120 VAC, 1Ph	Hand Operated	None	0.8 KW @120 VAC
Socket Fusion	2" - 800 Watt @ 120 VAC, 1Ph 4" - 1,200 Watt @ 120 VAC, 1Ph	Not Applicable	None	2" - Heater - 0.8 KW @120 VAC 4" - Heater - 2.5 KW @120 VAC
No. 14	1,200 Watt @ 120 VAC, 1Ph	7 Amps @ 120 VAC (Running) 22 Amps @ 120 VAC (Stall)	None	2.5 KW @120 VAC
Side-winder	2" - 800 Watt @ 120 VAC, 1Ph 4" - 1,200 Watt @ 120 VAC, 1Ph	Not Applicable	None	2" - Heater - 0.8 KW @120 VAC 4" - Heater - 2.5 KW @120 VAC
TracStar No. 28	1,750 Watt @ 120 VAC, 1Ph Saddle- 2,270 Watt @ 240 VAC, 1Ph	Hydraulic	Self-Contained	Self-Contained Gasoline
No. 28	1,750 Watt @ 120 VAC, 1Ph	Hydraulic	1 1/2HP, 1Ph @ 120 VAC	3.5 KW @120 VAC
No. 28 CU	1,750 Watt @ 120 VAC, 1Ph Saddle- 2,270 Watt @ 240 VAC	Hydraulic	1 1/2HP, 1Ph @ 120 VAC	4 KW @120 VAC
Mc. 28 Pitbull	1,750 Watt @ 120 VAC, 1Ph	Hydraulic	1 1/2HP, 1Ph @ 120 VAC	3.5 KW @120 VAC
TracStar No. 412	3,000 Watt @ 240 VAC, 1Ph	Hydraulic	Self-Contained	Self-Contained Diesel
No. 412	3,000 Watt @ 240 VAC, 1Ph	Hydraulic	Self-Contained	Self-Contained Gasoline
No. 412E	3,000 Watt @ 240 VAC, 1Ph	Hydraulic	3 HP, 3Ph @ 240 VAC	5.5 KW / 6.5 KVA @ 240 VAC 60Hz
TracStar No. 618	3,000 Watt @ 240 VAC, 1Ph	Hydraulic	Self-Contained	Self-Contained Diesel
No. 618	3,000 Watt @ 240 VAC, 1Ph	Hydraulic	Self-Contained	Self-Contained Gasoline
No. 618E	3,000 Watt @ 240 VAC, 1Ph	Hydraulic	5 HP, 3Ph @ 240 VAC	6.5 KW / 7.5 KVA @ 240 VAC 60Hz
TracStar 500	4,000 Watt @ 240 VAC, 1Ph	Hydraulic	Self-Contained	Self-Contained Diesel
No. 824	10,950 Watt @ 240 VAC, 3Ph	Hydraulic	7.5 HP, 3Ph @ 240 VAC	17.5 KW / 20 KVA @ 240 VAC 60Hz
TracStar 900	20,461 Watt @ 240 VAC, 3Ph	Hydraulic	Self-Contained	Self-Contained Diesel
No. 1236	20,461 Watt @ 240 VAC, 3Ph	Hydraulic	10 HP, 3Ph @ 240 VAC	30 KW / 30 KVA @ 240 VAC 60Hz
No. 1648	35,000 Watt @ 240 VAC, 3Ph	Hydraulic	10 HP, 3Ph @ 240 VAC	50 KW / 50 KVA @ 240 VAC 60Hz
No. 2065	65"- 38,437 Watt @ 240 VAC, 3Ph 48"- 35,000 Watt @ 240 VAC, 3Ph	Hydraulic	10 HP, 3Ph @ 240 VAC	50 KW / 50 KVA @ 240 VAC 60Hz

Pipe Size Reference Charts

Metric ISO Pipe Sizes		
Pipe	OD	Circumference
20 mm	0.79"	2.48"
25 mm	0.98"	3.09"
32 mm	1.26"	3.96"
50 mm	1.97"	6.18"
63 mm	2.48"	7.79"
75 mm	2.95"	9.28"
90 mm	3.54"	11.13"
100 mm	3.94"	12.37"
110 mm	4.33"	13.61"
125 mm	4.92"	15.46"
150 mm	5.91"	18.55"
160 mm	6.30"	19.79"
180 mm	7.09"	22.26"
200 mm	7.87"	24.74"
225 mm	8.86"	27.83"
250 mm	9.84"	30.92"
280 mm	11.02"	34.63"
315 mm	12.40"	38.96"
340 mm	13.39"	42.05"
355 mm	13.98"	43.91"
400 mm	15.75"	49.47"
450 mm	17.72"	55.66"
500 mm	19.69"	61.84"
560 mm	22.05"	69.26"
630 mm	24.80"	77.92"
710 mm	27.95"	87.82"
800 mm	31.50"	98.95"
900 mm	35.43"	111.32"
1000 mm	39.37"	123.68"
1200 mm	47.24"	148.42"
1400 mm	55.12"	173.16"
1600 mm	62.99"	197.90"

Metric JIS-1, 1U, 2, 3 Pipe Sizes		
Pipe	OD	Circumference
40 mm	1.89"	5.94"
50 mm	2.36"	7.41"
75 mm	3.50"	11.00"
100 mm	4.49"	14.10"
125 mm	5.51"	17.31"
150 mm	6.49"	20.39"
175 mm	7.48"	23.50"
200 mm	8.50"	26.70"
250 mm	10.51"	33.02"
300 mm	12.52"	39.33"
350 mm	14.57"	45.77"
400 mm	16.54"	51.96"

OD Pipe Sizes		
Pipe	OD	Circumference
2 5/8"	2.62"	8.25"
4 1/4"	4.25"	13.35"
6.27"	6.27"	19.70"
7 1/8"	7.12"	22.38"
21 1/2"	21.50"	67.54"

Reference

Pipe Size Reference Charts

IPS Pipe Sizes

Pipe	OD	Circumference
1/2"	0.84"	2.64"
3/4"	1.05"	3.30"
1"	1.32"	4.13"
1 1/4"	1.66"	5.22"
1 1/2"	1.90"	5.97"
2"	2.37"	7.46"
2 1/2"	2.87"	9.03"
3"	3.50"	11.00"
4"	4.50"	14.14"
5"	5.56"	17.47"
6"	6.63"	20.81"
8"	8.63"	27.10"
10"	10.75"	33.77"
12"	12.75"	40.06"
14"	14.00"	43.98"
16"	16.00"	50.27"
18"	18.00"	56.55"
20"	20.00"	62.83"
22"	22.00"	69.12"
24"	24.00"	75.40"
26"	26.00"	81.68"
28"	28.00"	87.96"
30"	30.00"	94.25"
32"	32.00"	100.53"
34"	34.00"	106.81"
36"	36.00"	113.10"
42"	42.00"	131.95"
48"	48.00"	150.80"
52"	52.00"	163.36"
54"	54.00"	169.65"
63"	63.00"	197.92"

DIPS Pipe Sizes

Pipe	OD	Circumference
3"	3.69"	12.44"
4"	4.80"	15.08"
6"	6.90"	21.68"
8"	9.05"	28.43"
10"	11.10"	34.87"
12"	13.20"	41.47"
14"	15.30"	48.07"
16"	17.40"	54.66"
18"	19.50"	61.26"
20"	21.60"	67.86"
24"	25.80"	81.05"
30"	32.00"	100.53"
36"	38.30"	120.32"
42"	44.50"	139.80"
48"	50.80"	159.59"
54"	57.10"	179.38"
60"	61.61"	193.55"
64"	65.64"	206.21"

CTS Pipe Sizes

Pipe	OD	Circumference
1/2"	0.63"	1.98"
3/4"	0.88"	2.75"
1"	1.13"	3.53"
1 1/4"	1.38"	4.32"
1 1/2"	1.63"	5.11"
2"	2.13"	6.68"

ISCO INDUSTRIES

Hydraulic Fluid Characteristic Chart

The use of proper hydraulic oil is mandatory to achieve maximum performance and machine life. Hydraulic oil should have anti-wear and other special additives. The oil must meet 150 SSU at 38° C (100ºF), with the exception of a cold weather operation.

The following table specifies the oil temperature at various viscosities. Temperature rise of the hydraulic oil can vary from 1°C (30ºF) to about 21°C (70ºF) over the ambient temperature depending on the pressure setting, age of the pump, wind, etc. Mobile DTE 15M multi-grade hydraulic oil is installed at the factory. The advantage of this oil is a wider temperature range, however, this oil should not be used for continuous operation below -7°C (20ºF). For use in extremely cold ambient temperatures, we suggest Mobile DTE 11, which can be used to -26°C (-16ºF). This oil should not be used for continuous operation above 38°C (100ºF) (oil temperature).

Note: This chart is based on pump manufacturer recommendations of 100 to 4000 SSU limits.

Note: Temperatures shown are fluid temperatures - Not ambient temperatures.

Reference

Hydraulic Fluid Characteristic Chart				
Manufacturer	**Fluid Name**	**SSU 100F**	**SSU 210F**	**V.I.**
Chevron	Chevron 32 AW	173	45	100
	Chevron 46 AW	238	49	98
	Chervon 68 AW	335	54	99
Phillips	Magnus A32	170	45	101
	Magnus A46	225	48	98
	Magnus A68	350	54	98
Shell	Tellus T32	150	44	102
	Tellus T46	215	48	103
	Tellus T68	315	53	89
Sun	Sunvis 2105	206	52	167
	Sunvis 832	164	44	99
	Sunvis 846	236	49	98
	Sunvis 868	352	55	98
Unocal	Unax AW 32	150	44	107
	Unax AW 46	215	48	107
	Unax AW 68	315	54	107
Mobil	DTE 11M	87	40	145
	DTE 13M	165	48	140
	DTE 15M	225	53	140
	DTE 24	162	44	95
	DTE 25	227	47	95
	DTE 26	335	53	95
Exxon	Univis N-32	177	49	164
	Univis N-46	233	55	163
	Univis N-68	376	68	160

Reference

Hydraulic Fluid Characteristic Chart

-20ºF	-10ºF	0ºF	10ºF	30ºF	50ºF	70ºF	90ºF	110ºF	130ºF	150ºF	Range Fahrenheit
											15-125
											25-142
											34-155
											15-123
											24-136
											37-151
											-2-124
											7-135
											20-152
											5-140
											12-121
											23-136
											34-152
											12-125
											20-137
											30-152
											-27-87
											5-130
											5-140
											23-120
											37-137
											47-150
											5-140
											25-142
											34-155

Reference

TracStar® Pendant/ Coach Setup

To turn pendant on, turn key to right.
To turn pendant off, turn key to off.

Navigate using numeric keys, <+> and <-> keys, <=> key, and <c> key.

Password as shipped from McElroy, **123**.

Setup Fusion Parameters
When starting a job the screen should read time in upper left hand corner. 1 Setup, 2 Pressure, 3 Menu on left side of screen and Face, Soak, Fuse with pressure in center of screen.

Follow instructions on each screen for navigation instructions.
Select setup, press 1 on the keyboard.
C092 Parameters Screen
  Press + use parameters on screen
  Press - enter new parameters
  If selected, then screen below will appear.
D112 Select Pipe Material
  List of pipe manufacturers in programmed into Coach, Scroll through list using + or - key, make selection and press = key
S030 Heater Temperature
  Use Pipe manufacturers recommend temperature, type in temperature and press =
  Heater off set (-10 for T500, -60, for T900)
  Enter -, enter password, and enter 10 for T500 or 60 for T900
D140 Piston Area
  Press = to default to 6.010, or enter 4.71 for Pit Bull carriage, 15.32 (Orange Cylinders) or 29.44 (Green Cylinders) for T900
S014 Pipe Size
  Select IPS, DIPS, OD, mmOD using + or - to scroll up or down
  Type in pipe size press =
S018 Pipe Wall Thickness
  Select DR, WT, mmWT using + or - key to scroll
  Type in parameter selected, press =
D122 Heat (IFP)
  Type in 0, then press =, or enter pipe manufacturers IFP if required
D124 Soak (IFP)
  Press - to skip
D126 Fuse (IFP)
  Type in pipe manufacturers recommended IFP usually 75 and press =
D128 Cool (IFP)
  Press - to skip
C092 Parameter Screen
  To allow you to review parameters entered, press + if ok or - to change
S010 Drag (All pendant/coach units use 70 instead of 30)
  Press + to default to 70 (machine drag) or shift carriage selector valve to close and raise pressure. Using facer pressure valve, raise pressure until carriage starts to move slowly, shift carriage to neutral, let pressure stabilized
  press + and then = to set drag pressure
NOTE: Drag automatically added to Heat and Fuse pressure

Reference

TracStar® Pendant/Coach DataLogger Operation

DataLogger Operation
1ST Screen press 3 for Menu
M001 Main Menu
Press 2 for Datalogger mode
D001 Datalogger Menu
Press 1 to Log Data
C090 Identifications
+ To use data recorded on screen or - to enter new data
C100 Machine ID (if - pressed above)
Type in machine ID press =
C102 Employees No.
Type in employee ID press =
C104 Job No.
Type in Job No. press =
C106 Joint No.
Type in joint No. press =
C090 Indentifications
Press + if correct data or - to change
C092 Pipe Parameters
+ to use data or - to enter new data
(Refer to Setup Fusion Parameters if - selected)
D134 Drag Pressure
Refer to Drag Pressure Setup in Setup Fusion Parameters

Fusion Operation

D Screen
Press 4 to start Logging - Logging will flash on screen during fusion operation
D Screen
Press 6 to stop Datalogging - Stop logging before opening carriage or unclamping pipe
D150 Datalogging Stopped
Press + to view report or - to continue
D160 Print Report
Press + to print or - to continue
D170 Log another joint
Press + to Log another joint or - to stop
*** If + pressed then refer to C090, C092, and C134 above.

Reference

DataLogger™ Operation

Note: The use of a DataLogger™ **Will Not** stop you from using an improper joining procedure. The DataLogger™ merely logs data pertaining to the fusion(s). The DataLogger™ is an excellent QA/QC Tool. A stamping system should be used to tie the fusion bead to the DataLogger.™

Operation

To turn the unit On, press the F1 key.

To turn the unit Off, press the blue key once and then press F1 within 2 seconds.

Note: The Unit stays On as long as it is connected to the charger.

Connect to the Fusion Machine

The fusion machine must have the proper hydraulic quick disconnect for connecting the DataLogger™ pressure transducer.

Note: Make sure the hydraulic pump is turned off and the pressure is at 0 before connecting or disconnecting the DataLogger™.

Navigate using the Arrows Keys, BKSP Key, <Y> and <N> keys, Numeric Keys and the Enter Key.

Logging a fusion joint

When starting a job the screen should read 000 in the upper left corner. If it does not, press the <BKSP> key until it does. Press number selection to select language (i.e. (1) = English). Press <1> to Log Data.

Follow instructions on each screen for the machine and job data.

A list of machines is programmed into the DataLogger™; scroll down the list through the units and make your selection.

Select pipe wall

Select DR, or if unknown, measure the actual wall thickness (WT).

Calculate gauge pressure Press <Y>

Interfacial heat pressure	Usually enter <0> or Press <N> to skip.
Interfacial soak pressure	Usually enter <0> or Press <N> to skip.
Interfacial fusion pressure	Enter the Pipe Manufacturer's recommended interfacial pressure (i.e.) then press **Enter.**
Interfacial cool pressure	Usually the same as the fusion pressure or press <N> to skip this entry.
Verify Data	Screen #1 and #2 Verify Data entered is correct on Screen and press <Y>

Reference

DataLogger™ Operation

Drag Pressure

A drag value must be entered for each fusion. See fusion machine's operations manual, or the DataLogger™ manual for measuring drag. Enter the measured drag pressure and press **Enter.** If you just press **Enter**, a default drag value of 2 Bar (30 Psi) will be added to the DataLogger™.

Heater Temperature

Hold the infrared temperature probe against the coated area of the heater that the pipe will contact, and press **Enter** when the temperature stabilizes.

Prepare to Log Data

The pipe should be faced off and misalignment adjust ments should be made at this point.

Verify the correct fusion pressure has been set on the fusion machine. This is done by shifting the fusion unit into the fuse position on the hydraulic manifold block and bringing the faced pipe ends together. With fusion pressure still applied, check the calculated fusion pressure against the carriage pressure. Adjust the fusion pressure control valve on the hydraulic manifold block, as necessary, to achieve the same reading as the calculated fusion pressure shown on the DataLogger™.

Open the carriage enough to allow the heater to be placed on the guide rods, between the faced pipe ends, install heater and press <4> on the DataLogger™. Quickly bring the pipe endds agains the heater and follow the proper shift sequence on the fusion unit and the Pipe Manufacturer's recommendations for fusing pipe.

At the end of the cooling cycle press <6>, on the DataLogger™, before opening the fusion unit or shifting to a different pressure setting.
Important: follow the directions on the DataLogger™ screen to view the graph to ensure proper procedures were followed.

Recommended Precautions

Fully charge the DataLogger™ before each use for optimal battery performance.

Download the reports daily to a PC or printer to prevent data loss.
For more complete details of the DataLogger™ see the Instruction manual or call ISCO Industries, LLC

Reference

If your cylinders are yellow

Machines:
McElroy 250 and McElroy T-250
Cylinders: Yellow (Low Force) - 1077 mm² (1.67 in²) Piston Area
Heater Surface Temperature: 220°C Interfacial pressure: 5.2 bar
Note: Fusion pressure shown includes 2 Bar (30 psi) for system drag.

METRIC

Pipe Size	SDR 7.4	9	11	13.6	17	21	26	33	41
63	9.0	7.9	6.9	6.1	5.3	4.7	4.2	3.8	3.4
75	11.9	10.4	9.0	7.8	6.7	5.8	5.1	4.5	4.0
90	16.3	14.1	12.1	10.3	8.8	7.5	6.5	5.6	4.9
110	23.3	20.0	17.1	14.4	12.1	10.3	8.7	7.4	6.3
125	29.5	25.3	21.5	18.1	15.0	12.7	10.7	8.9	7.6
140	36.5	31.2	26.4	22.1	18.4	15.4	12.9	10.7	9.0
160	47.1	40.1	33.9	28.3	23.4	19.5	16.3	13.3	11.2
180	59.1	50.3	42.4	35.3	29.1	24.2	20.1	16.4	13.6
200	72.5	61.6	51.9	43.1	35.4	29.4	24.3	19.7	16.4
225	91.2	77.4	65.1	54.0	44.3	36.6	30.2	24.4	20.2
250	112.2	95.1	79.9	66.2	54.2	44.7	36.9	29.7	24.4

Reference

If your cylinders are green

Machines:
McElroy No. 412, McElroy No. 618, McElroy T-412, McElroy T-618 TracStar No.412, McElroy TracStar No. 618
Cylinders: Green (High Force) - 7600 mm² (11.78 in²) Piston Area
Heater Surface Temperature: 220ºC Interfacial pressure: 5.2 bar
Note: Fusion pressure shown includes 2 Bar (30 psi) for system drag.

METRIC

Pipe Size	SDR								
	7.4	9	11	13.6	17	21	26	33	41
110	5.0	4.6	4.1	3.8	3.4	3.2	3.0	2.8	2.6
125	5.9	5.3	4.8	4.3	3.8	3.5	3.2	3.0	2.8
140	6.9	6.1	5.5	4.9	4.3	3.9	3.5	3.2	3.0
160	8.4	7.4	6.5	5.7	5.0	4.5	4.0	3.6	3.3
180	10.1	8.8	7.7	6.7	5.8	5.1	4.6	4.0	3.6
200	12.0	10.4	9.1	7.8	6.7	5.9	5.2	4.5	4.0
225	14.7	12.7	10.9	9.4	8.0	6.9	6.0	5.2	4.6
250	17.6	15.2	13.0	11.1	9.4	8.1	6.9	5.9	5.2
280	21.6	18.6	15.9	13.4	11.3	9.6	8.2	6.9	6.0
315	26.8	23.0	19.5	16.5	13.7	11.6	9.8	8.2	7.0
355	33.5	28.6	24.3	20.4	16.9	14.2	12.0	9.9	8.4
400	42.0	35.8	30.3	25.3	20.9	17.5	14.7	12.1	10.1
450	52.6	44.8	37.8	31.5	26.0	21.6	18.0	14.7	12.3

Reference

If your cylinders are orange

Machines: McElroy No. 412, McElroy No. 618,
McElroy T-412, McElroy T-618,
McElroy T-500 Series II (Manifold Equipped)
Cylinders: Orange (Medium Force) - 3877 mm² (6.00 in²) Piston Area
Heater Surface Temperature: 220°C Interfacial pressure: 5.2 bar
Note: Fusion pressure shown includes 2 Bar (30 psi) for system drag.

METRIC

Pipe Size	SDR								
	7.4	9	11	13.6	17	21	26	33	41
110	7.9	7.0	6.2	5.5	4.8	4.3	3.9	3.5	3.2
125	9.7	8.5	7.4	6.5	5.6	5.0	4.4	3.9	3.6
140	11.6	10.1	8.8	7.6	6.5	5.7	5.0	4.4	4.0
160	14.5	12.6	10.9	9.3	7.9	6.9	6.0	5.2	4.6
180	17.9	15.4	13.2	11.2	9.5	8.2	7.0	6.0	5.2
200	21.6	18.6	15.9	13.4	11.3	9.6	8.2	6.9	6.0
225	26.8	23.0	19.5	16.5	13.7	11.6	9.8	8.2	7.0
250	32.6	27.9	23.6	19.8	16.5	13.9	11.7	9.7	8.2
280	40.4	34.5	29.2	24.4	20.2	16.9	14.2	11.7	9.8
315	50.6	43.1	36.4	30.3	25.0	20.9	17.4	14.2	11.9
355	63.7	54.2	45.6	38.0	31.2	26.0	21.5	17.5	14.6
400	80.4	68.2	57.4	47.7	39.1	32.4	26.8	21.7	18.0
450	101.2	85.8	72.1	59.8	49.0	40.5	33.4	26.9	22.2
500	124.4	105.5	88.6	73.4	60.0	49.5	40.7	32.8	26.9

Reference

If your cylinders are green

Machines: McElroy No. 824, McElroy No. 1236,
McElroy T-900 (Manifold Equipped)
Cylinders: Green (High Force) - 19000 mm² (29.44 in²)Piston Area
Heater Surface Temperature: 220°C Interfacial pressure: 5.2 bar
Note: Fusion pressure shown includes 2 Bar (30 psi) for system drag.

METRIC

Pipe Size	SDR								
	7.4	9	11	13.6	17	21	26	33	41
225	7.1	6.3	5.6	5.0	4.4	4.0	3.6	3.3	3.0
250	8.2	7.3	6.4	5.6	5.0	4.4	4.0	3.6	3.3
280	9.8	8.6	7.5	6.6	5.7	5.0	4.5	4.0	3.6
315	11.9	10.4	9.0	7.8	6.7	5.8	5.1	4.5	4.0
355	14.6	12.6	10.9	9.3	8.0	6.9	6.0	5.2	4.6
400	18.0	15.5	13.3	11.3	9.6	8.2	7.1	6.0	5.3
450	22.2	19.1	16.3	13.8	11.6	9.9	8.4	7.1	6.1
500		23.1	19.7	16.6	13.8	11.7	9.9	8.3	7.1
560			24.2	20.3	16.9	14.2	11.9	9.9	8.4
630			30.1	25.1	20.8	17.4	14.6	12.0	10.1
710				31.4	25.9	21.6	17.9	14.7	12.3
800					32.3	26.8	22.2	18.1	15.0
900					40.4	33.4	27.6	22.4	18.5

Reference

If your cylinders are orange

Machines: McElroy No. 824, McElroy No. 1236,
McElroy T-900 (Manifold Equipped)
Cylinders: Orange (Medium Force) - 9885 mm² (15.32 in²)Piston Area
Heater Surface Temperature: 220°C Interfacial pressure: 5.2 bar
Note: Fusion pressure shown includes 2 Bar (30 psi) for system drag.

METRIC

Pipe Size	SDR 7.4	9	11	13.6	17	21	26	33	41
225	11.7	10.2	8.9	7.7	6.6	5.8	5.1	4.4	4.0
250	14.0	12.1	10.5	9.0	7.7	6.7	5.8	5.0	4.4
280	17.1	14.7	12.7	10.8	9.1	7.8	6.8	5.8	5.1
315	21.1	18.1	15.5	13.1	11.0	9.4	8.0	6.8	5.9
355	26.2	22.5	19.1	16.1	13.5	11.4	9.7	8.1	6.9
400	32.7	28.0	23.7	19.9	16.6	13.9	11.7	9.7	8.3
450	40.9	34.9	29.5	24.7	20.4	17.1	14.3	11.8	9.9
500		42.6	36.0	30.0	24.8	20.6	17.2	14.1	11.8
560			44.6	37.1	30.5	25.4	21.1	17.2	14.3
630			55.9	46.5	38.1	31.6	26.1	21.2	17.5
710				58.5	47.9	39.6	32.6	26.4	21.7
800					60.3	49.7	40.9	32.9	27.0
900					75.7	62.4	51.2	41.1	33.7

Reference

If your cylinders are orange

Machines: McElroy No. 1648
Cylinders: Orange (Medium Force) - 9123 mm² (14.14 in²)Piston Area
Heater Surface Temperature: 220ºC Interfacial pressure: 5.2 bar
Note: Fusion pressure shown includes 2 Bar (30 psi) for system drag.

METRIC

Pipe Size	SDR 7.4	9	11	13.6	17	21	26	33	41
450	44.2	37.6	31.8	26.6	22.0	18.4	15.3	12.6	10.6
500		46.0	38.8	32.3	26.7	22.2	18.5	15.1	12.6
560			48.2	40.1	32.9	27.3	22.7	18.4	15.3
630			60.4	50.2	41.1	34.1	28.1	22.8	18.8
710				63.2	51.7	42.7	35.2	28.4	23.4
800					65.1	53.7	44.2	35.5	29.1
900					81.9	67.4	55.4	44.4	36.3
1000					100.6	82.8	67.9	54.3	44.4
1200					144.0	118.3	96.9	77.4	63.0

Reference

If your cylinders are green

Machines: McElroy No. 1648, McElroy No. 2065
Cylinders: Green (High Force) - 20272 mm² (31.42 in²)iston Area
Heater Surface Temperature: 220ºC Interfacial pressure: 5.2 bar
Note: Fusion pressure shown includes 2 Bar (30 psi) for system drag.

METRIC

Pipe Size	SDR 7.4	9	11	13.6	17	21	26	33	41
450	21.0	18.0	15.4	13.1	11.0	9.4	8.0	6.8	5.9
500		21.8	18.6	15.7	13.1	11.1	9.4	7.9	6.8
560			22.8	19.1	15.9	13.4	11.3	9.4	8.0
630			28.3	23.7	19.6	16.4	13.8	11.3	9.6
710				29.5	24.4	20.3	16.9	13.9	11.6
800					30.4	25.3	21.0	17.1	14.2
900					37.9	31.4	26.0	21.1	17.5
1000					46.4	38.4	31.6	25.6	21.1
1200					65.9	54.4	44.7	35.9	29.5
1600						95.1	77.9	62.3	50.8

Reference

Temperature Conversions

Fahrenheit	Celsius	Fahrenheit	Celsius
0	-18	260	127
10	-12	270	132
20	-7	280	138
30	-1	290	143
40	4	300	149
50	10	310	154
60	16	320	160
70	21	330	165
80	27	340	171
90	32	350	176
100	38	360	182
110	43	370	188
120	49	380	193
130	54	390	199
140	60	400	204
150	65	410	210
160	71	420	215
170	77	430	221
180	82	440	226
190	88	450	232
200	93	460	238
210	99	470	243
220	104	480	249
230	110	490	254
240	115	500	260
250	121	510	265

Conversion Formulas

Inches	X	25.40	=	Millimeters
Millimeters	X	0.03937	=	Inches
Feet	X	304.8	=	Millimeters
Millimeters	X	.003280839	=	Feet
SQ. Inches	X	645.16	=	SQ. Millimeters
SQ. Millimeters	X	.00155	=	SQ. Inches
Ounces(fluid) US	X	0.02957	=	Liters
Quarts	X	0.9463	=	Liters
Liters	X	1.057	=	Quarts
Gallons	X	3.785	=	Liters
Liters	X	0.2642	=	Gallons(fluid) US
Pounds	X	0.4536	=	Kilograms
Kilograms	X	2.205	=	Pounds
Bar	X	14.503	=	Psi
mPa	X	145.03	=	Psi
Kg/cm^2	X	14.223	=	Psi

Reference

References

1. Plastics Pipe Institute Technical Report-33. Generic Butt Fusion Joining Procedure for Polyethylene Gas Pipe, 2001

2. Plastics Pipe Institute Technical Report-41. Generic Saddle Fusion Joining Procedure for Polyethylene Gas Pipe, 2002

3. Plastics Pipe Institute. Polyethylene Joining Procedures, March 1998.

4. ASTM D2657-97. Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings. Volume 8.04. American Society of Testing and Materials. Baltimore, 2002.

5. ASTM F1056-97. Standard Specification for Socket Fusion Tools for Use in Socket Fusion Joining Polyethylene Pipe or Tubing and Fittings. Volume 8.04. American Society of Testing and Materials. Baltimore, 2002.

6. Pipeline Safety Regulations. U.S. Department of Transportation. CFR 49. Washington, 2002.

Notes

Notes

Acknowledgements

KWH Pipe

McElroy Manufacturing, Inc.

Performance Pipe™

Plastic Pipe Institute

Rinker Materials™

WL Plastics

Brand Names and product names are trademarks of their respective owners.

APPENDIX I

Ballast Depth Localisation As-built

Ballast Blocks Position in Meliadine Lake Survey conducted on August 6, 2017			
Block	Feet dept	Feet clearance	Axe
1	2	0,5	Ouest
2	3	0	Ouest
3	7	1	Ouest
4	11	0	Ouest
5	12	0	Ouest
6	15	0	Ouest
7	16	0	Ouest
8	18	0	Ouest
9	18	0	Ouest
10	20	0	Ouest
11	20	0	Ouest
12	21	0	Ouest
13	21	0	Ouest
14	21	0	Ouest
15	21	0	Ouest
16	21	0	Ouest
17	21	0	Ouest
18	22	0	Ouest
19	22	0	Ouest
20	22	0	Ouest
21	23	0	Ouest
22	23	0	Ouest
23	23	0	Ouest
24	22	0	Ouest
25	22	0	Ouest
26	21	0	Ouest
27	21	0	Ouest
28	21	0	Ouest
29	21	0	Ouest
30	21	0	Ouest
31	21	0	Ouest
32	21	0	Ouest
33	22	0	Ouest
34	24	0	Ouest
35	25	0	Ouest
36	26	0	Ouest
37	30	0	Ouest
38	33	0	Ouest
39	34	0	Ouest
40	36	0	Ouest
41	31	0	Ouest
42	37	0	Ouest
43	37	0	Ouest
44	36	0	Ouest
45	36	0	Ouest
46	35	0	Sud
47	35	0	Sud
48	35	0	Nord
49	34	0	Nord

APPENDIX J
Diffuser Tideflex Valve Specifications

Red Valve Company, Inc.

700 N. Bell Avenue
Carnegie, PA 15106

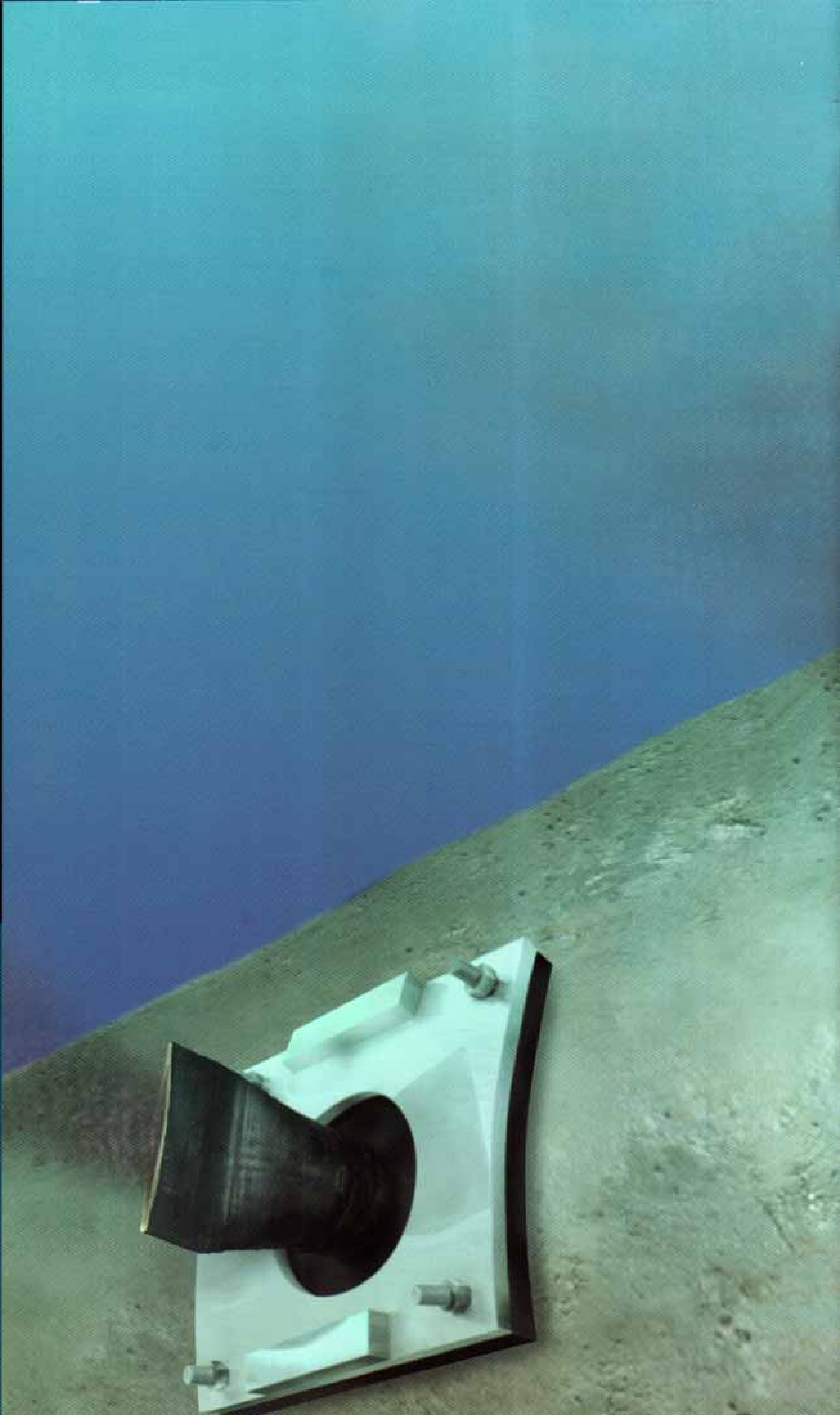
PHONE:
412/279-0044

FAX:
412/279-7878

www.redvalve.com

The information presented in this catalog is provided in good faith. Red Valve Company, Inc. reserves the right to modify or improve its design specifications without notice, and does not imply any guarantee or warranty for any of its products from reliance upon the information contained herein. All orders are subject to Red Valve's standard terms and warranty and are subject to final acceptance by Red Valve.

RVM 2/98 10M



300mm rubber risers with two 200mm Tideflex diffuser valves. Multiport risers achieve dilution while minimizing the number of risers.

Eighteen 8" series 35D valves with integral 90° elbows for effluent diffuser in Georgia.

RED VALVE
HYDRAULIC DIFFUSER ANALYSIS

Your Partner in Engineering Design and Technical Analysis for Effluent Diffuser Systems.

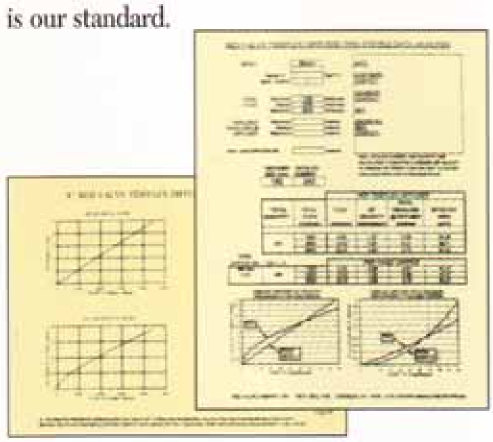
Each diffuser system is unique. Red Valve Company has conducted extensive hydraulic tests on Tideflex diffuser valves from 2" (50 mm) to 48" (1200 mm) and has developed an exclusive computer program to assist engineers in designing multiport diffusers. The program includes data analysis on headloss, total headloss, jet velocity and effective open area. This data can be compared to conventional fixed-orifice diffuser designs to illustrate the hydraulic advantages of Tideflex valves (I).

Also available for individual Tideflex valves are graphs of headloss, total headloss, jet velocity and effective open area organized in a "4-pack" format (II).

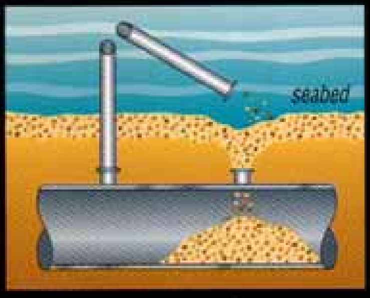
For a diffuser nozzle hydraulics analysis, please contact our engineering department.

Your special diffuser valve design is our standard.

35 SQ square flange

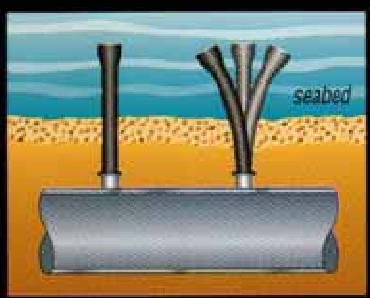


PROBLEM



Plastic and metal risers are rigid and are prone to being broken from diffuser pipeline.

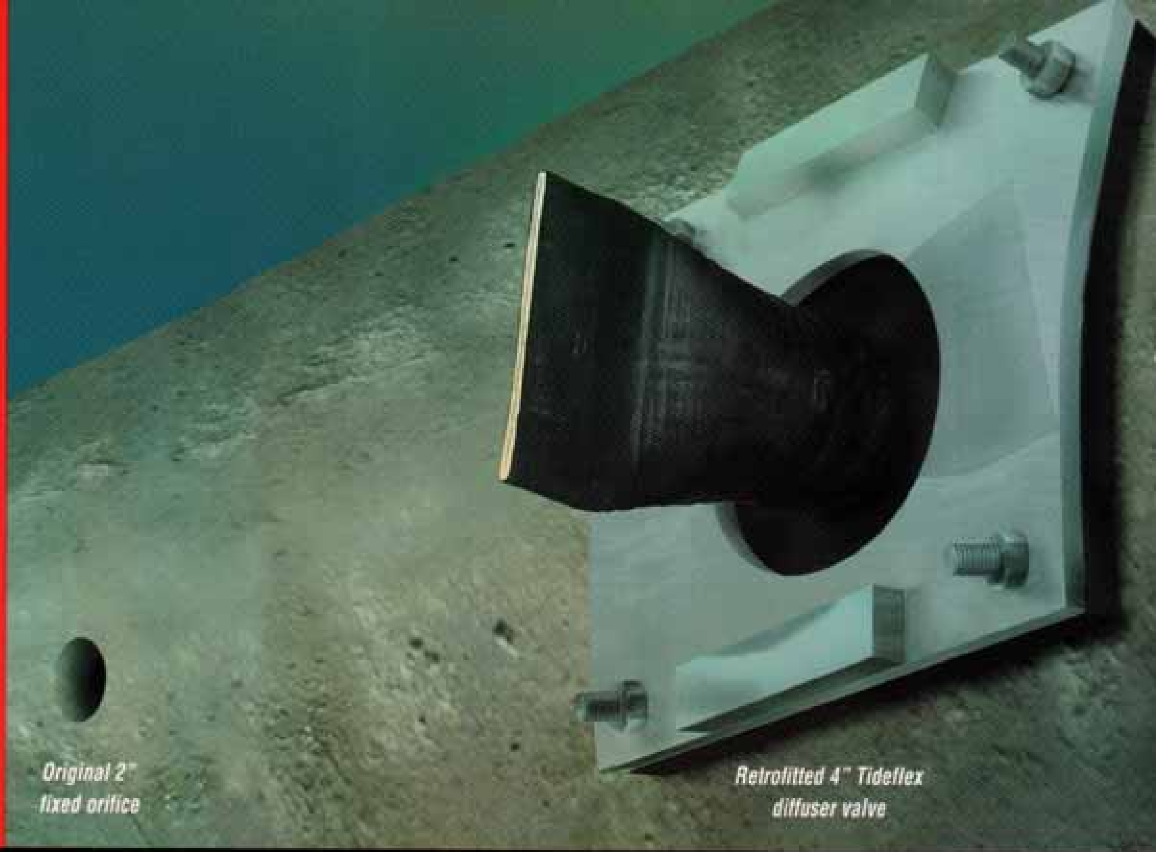
SOLUTION



Tideflex check valves with integral rubber risers and elbows are flexible, eliminating damage from boat anchors, nets and debris.

129 four-inch Tideflex valves with 16" square flanges were retrofitted over original 2" fixed-orifice ports on a reinforced concrete outfall in California.

The four-hole, square-flanged 35-SQ Tideflex reduces installation costs and minimizes stress on the outfall pipe.



RETROFITTING EXISTING DIFFUSER PIPELINES

Available with slip-on, circular-flanged and square-flanged fabricated connections, Tideflex diffuser valves can accommodate almost any effluent diffuser system.

The slip-on valves can be clamped to the outside diameter of riser pipes, and circular-flanged valves can be fastened to any flange, including ANSI and DIN drillings. The square-flanged valves can be fastened directly to the outside diameter of an outfall pipe.

Common for outfalls that rest on the riverbed or seabed unburied, the square-flanged valves have a four-hole arrangement, compared to an eight- or twelve-hole pattern, that minimizes localized stress and makes installation easier.

FLEXIBLE RISERS AND ELBOWS

The risers incorporated in buried diffusers are usually metal or plastic and, therefore, prone to being sheared from the outfall by impacting debris, anchors, nets, etc. These breaks allow considerable amounts of riverbed or seabed bottom material to backflow into the outfall.

Tideflex diffuser valves can be integrally fabricated with all-rubber risers and/or elbows. They are flexible, durable and designed to deflect and return when subjected to impact loads such as those from anchors and nets. Having Tideflex diffuser valves fabricated with rubber risers and elbows ensures only flexible components are above the seabed or riverbed, eliminating physical damage to the diffuser.

Tideflex diffuser valves can be retrofitted to any diffuser system operating at a reduced efficiency. They prevent backflow of sediment and salt water and optimize the hydraulics by generating higher jet velocity at low flow and providing a more uniform flow distribution. Tideflex diffuser valves are especially suited for emergency overflow outfalls or decommissioned outfalls since they are susceptible to severe intrusion and marine fouling.

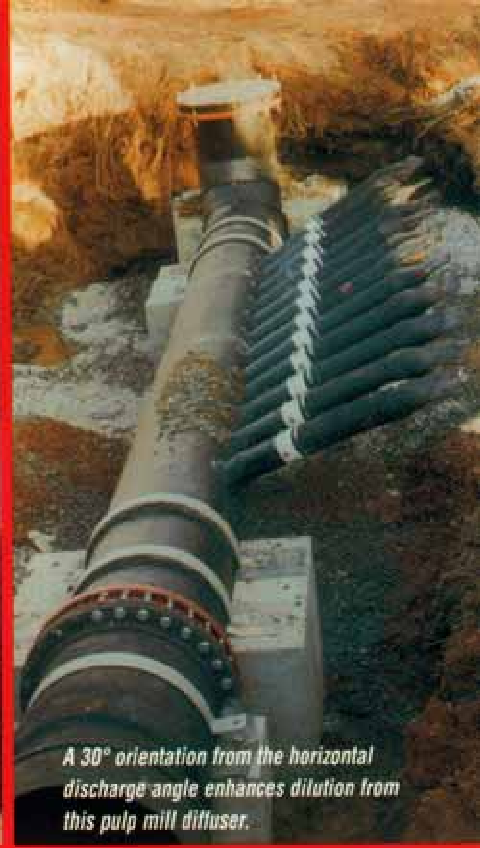

TF-D


35D with 90° elbow


35D with 45° elbow


35D with rubber riser

12 six-inch Tideflex diffuser valves with integral three-foot- long rubber risers discharging to a shallow river.



A 30° orientation from the horizontal discharge angle enhances dilution from this pulp mill diffuser.

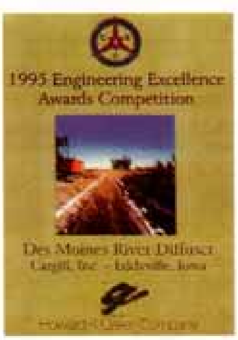
INLAND OUTFALLS

Outfalls that discharge to inland waters, such as rivers, streams and lakes, often exhibit problems with intrusion of sediment and debris into the diffuser. Incorporating Tideflex diffuser valves on new diffusers or retrofitting existing diffusers, prevents backflow and ensures the outfall will operate as initially designed.

In addition, the effluent typically is the same density as the receiving water body, meaning there is no buoyancy difference to assist in increasing dilution. The receiving body in inland outfalls often has a limited assimilative capacity and a limited depth. Jet velocity, therefore, is critical, since it alone can optimize initial dilution.

The Tideflex diffuser valve's variable orifice enhances jet velocity throughout the range of flows. This, along with the elliptical plume of the Tideflex diffuser valve, improves overall dilution.

Tideflex diffuser valves assist municipal and industrial dischargers in meeting stringent typical water quality standards established by regulatory agencies. This not only includes bacterial standards for municipal wastewater, but toxic standards for industrial discharges as well. In addition, diffusers with Tideflex diffuser valves have also been installed at textile, pulp and paper, and dye plants specifically to disperse colored effluent to eliminate unsightly "slicks."



44 four-inch Tideflex diffuser valves installed on this award-winning diffuser system for a food processing plant discharging to the Des Moines River.

Twenty 250mm Tideflex diffuser valves on a 1.5 km outfall in Viña Del Mar, Chile.

Eighty 200mm Tideflex diffuser valves installed on multiport riser caps in Hong Kong.

MARINE OUTFALLS

Effluent diffusers that discharge to oceans, estuaries and bays are faced with challenges of strong currents, waves, tides, sediment transport and boat traffic.

These conditions can result in intrusion of sediment and salt water into the outfall, which reduces the hydraulic capacity and dilution efficiency of the diffuser. Since salt water is usually heavier than effluent, it can intrude through the ports even while effluent is discharging.

Once salt water has entered the outfall, it can block numerous ports, imbalance the hydraulics, introduce sediment into the diffuser, promote marine fouling and cause effluent particles to floc and deposit on the bottom of the pipe.

Evacuating sediment from an outfall and rehabilitating the diffuser pipeline typically costs thousands, or even millions, of dollars for large ocean outfalls. Even more of a problem, however, than the expensive repairs is that, with conventional fixed-orifice diffusers, intrusion can recur, requiring continual, costly service.

Tideflex diffuser valves, however, with an all-elastomer "duckbill" design, prevent intrusion of salt water, sediment and debris and keep the outfall operating at peak hydraulic capacity and dilution efficiency. In addition, independent tests in Hong Kong have established that diffusers fitted with Tideflex diffuser valves purge salt water even at extremely low plant flow, allowing all ports to consistently flow. This is beneficial both for the commissioning of a new outfall and for an outfall that has been retrofitted with Tideflex diffuser valves.

Series 35-D

Industrial Discharge

- Pulp & Paper Mills
- Textile Mills
- Chemical Plants
- Dye Plants
- Food Processing Plants
- Power Plants

Tideflex Diffuser Valves:

- **Prevent intrusion of debris, sediment, saltwater and aquatic life**
- **Provide proven long-term, maintenance-free service life**
- **Enhance jet velocity**
- **Improve initial dilution**
- **Provide a more uniform flow distribution across ports**

Photo taken from Red Valve's effluent diffuser video, which reviews actual diver inspections of numerous worldwide outfalls.

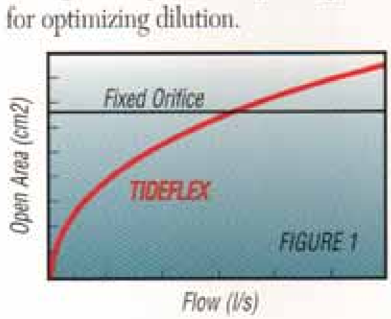
THE TIDEFLEX VARIABLE ORIFICE VS. FIXED-DIAMETER ORIFICE

VARIABLE AREA

In addition to preventing intrusion, backflow and clogging, Tideflex diffuser valves also enhance the hydraulics of multiport diffusers. Unlike fixed-diameter ports, in which the open area remains constant, Tideflex diffuser valves are inherently variable orifice by design. As Figure 1 illustrates, the open area increases as flow increases, and decreases as flow decreases.

ENHANCED JET VELOCITY

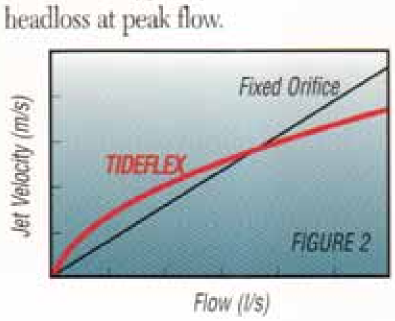
As Figure 2 illustrates, the Tideflex diffuser valve's variable orifice improves jet velocity, or momentum, providing as much as three times the jet velocity of fixed orifices at low flow. This is important because the jet velocity of the flow through each port is a key component for optimizing dilution.



REDUCED HEADLOSS

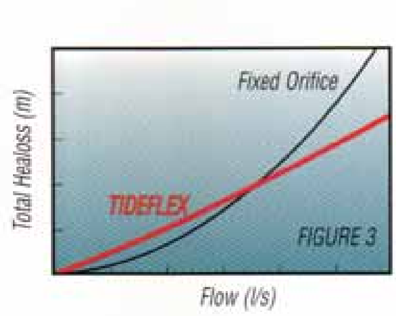
Figure 3 shows the headloss comparison of a fixed-diameter port and the Tideflex diffuser valve. The headloss of a fixed orifice is a function of the flow rate squared. The Tideflex diffuser valve's variable orifice generates less headloss at peak flow, increasing the peak capacity of the outfall, reducing the number of overflows and minimizing energy costs associated with pumps.

Able to meet jet velocity requirements often mandated by environmental agencies, Tideflex diffuser valves still generate an acceptable headloss at peak flow. Sizing fixed-orifice ports to generate a similar jet velocity at low plant flow, on the other hand, typically results in excessive headloss at peak flow.



ELLIPTICAL PLUME

Another advantage the Tideflex diffuser valve offers is its elliptical rather than circular-shaped plume. Independent testing in Oregon and Hong Kong found that this slot-type geometry is proven to provide superior dilution because the receiving water body can disperse the elliptical plume much more quickly than the circular plume. This benefit may be especially desirable for diffusers with stringent water quality standards at the Zone of Initial Dilution (ZID) or other mixing zone boundary.



Red Valve

Your Partner in Engineering, Design and Technical Analysis for Effluent Diffuser Systems

TIDEFLEX® DIFFUSER VALVES

Consulting engineers worldwide specify Red Valve Tideflex diffuser valves for superior performance on effluent diffuser applications.

Effluent outfalls typically incorporate multiport diffusers that discharge effluent over a wide area through numerous ports, rather than through one large open-ended pipe. Providing a cost-effective means of achieving high initial dilution, multiport diffusers minimize the impact of municipal and industrial discharges on the environment.

The most important item on an effluent diffuser system for controlling initial dilution is its port size. A diffuser system's ports ensure that peak flows can be discharged with a limited amount of driving head, ensuring that ports are the correct size and have the proper configuration is critical.

LIMITATIONS OF CONVENTIONAL MULTIPORT DIFFUSERS

The ports of conventional diffusers are holes that were cast or drilled into the outfall pipe, or risers extending from the crown. Referred to as "fixed-orifice" ports, these holes cannot prevent the intrusion of sand, mud, debris and saltwater into the diffuser pipe.

Sediment that enters the diffuser pipe reduces the hydraulic capacity of the outfall, leading to the need for additional pumping operations or causing overflows to bypass outfalls. Additionally, if the ports become blocked—even partially—by accumulating sediment, the diffuser will operate at a reduced dilution efficiency, creating a risk for permit noncompliance and higher bacterial or constituent concentrations on the shore.

TIDEFLEX MULTIPORT DIFFUSERS

Tideflex diffuser valves overcome the challenges associated with conventional multiport diffusers, enabling diffusers to operate at peak performance. Tideflex diffuser valves prevent intrusion of sediment and salt water and optimize diffuser hydraulics and, therefore, eliminate concerns of clogging. In addition, because the valves feature a non-mechanical, all-rubber construction, they will not corrode and remain unaffected by marine growth. Tideflex diffuser valves, virtually maintenance-free, have revolutionized effluent technology for marine and inland outfall lines in municipal and industrial applications.

Red Valve

TIDEFLEX® EFFLUENT DIFFUSER VALVES

APPENDIX K
Technical Memo
Effluent Discharge Modelling for the As-built Diffuser

TECHNICAL MEMO

ISSUED FOR USE

To:	Blandine Arseneault	**Date:**	May 25, 2018
c:	Nigel Goldup, Josee Alarie	**Memo No.:**	01
From:	Aurelien Hospital and Jim Stronach	**File:**	ENG.EARC03076
Subject:	Effluent Discharge Modelling for the As-Built Diffuser at the Meliadine Gold Project, Nunavut.		

1.0 INTRODUCTION

Agnico Eagle Mines Limited (AEM) retained the services of Tetra Tech to carry out the planning and design works associated with the Water and Environment and the Civil Works components of the Meliadine Project, a gold mine located approximately 25 km north of Rankin Inlet, and 80 km southwest of Chesterfield Inlet in the Kivalliq Region of Nunavut.

This technical memo focuses on the as-built diffuser system that will discharge effluent into Meliadine Lake, as part of the effluent water outfall system. Tetra Tech previously prepared the design report (AEM N° 6515-E-132-005-132-REP-009) for the proposed diffuser system.

Construction and installation of the diffuser system occurred during the summer of 2017 during the first week of August. It was discovered after the installation that the bathymetry at the diffuser location is shallower than the original bathymetry provided by AEM at the diffuser design stage. AEM's field personnel supervised and managed the diffuser construction and installation.

Upon AEM discovering that the diffusor was installed within a shallower bathymetric regime than original design, Tetra Tech was requested to review and assess the anticipated performance of the as-built diffusor system on the potential changes of dilutions at the edge of the mixing zone. Accordingly, this technical memo summarises the results of the analytical work undertaken to assess these potential changes.

2.0 SUMMARY OF PROPOSED SYSTEM (DESIGN REPORT)

Methodology, numerical model and performance of the proposed system were presented in the design report (AEM N° 6515-E-132-005-132-REP-009). Key items are repeated here in this section to facilitate the reading of this technical memo.

Water directed to the collection pond 1 (CP-1) is treated in the Water Treatment Plant prior to being discharged into Meliadine Lake sub-basin through the diffuser system. The water management plan (AEM, Meliadine Gold Project Water Management Plan April 2015 Version 1, 6513-MPS-11) was approved by the Nunavut Water Board as part of the water licensing process. Configuration of the proposed diffuser was the following:

- Diffuser connecting with the outfall through a Tee connection (diffuser oriented NE-SW)
- Coordinates of the Tee: 6,898,150 N / 542,756 E (UTM Zone 15 V)
- Length of diffuser: 30 m;

Tetra Tech Canada Inc.
Suite 1000 – 10th Floor, 885 Dunsmuir Street
Vancouver, BC V6C 1N5 CANADA
Tel 604.685.0275 Fax 604.684.6241

- Diameter of the diffuser: 400 mm OD / 355 mm ID
- Water depth at diffuser location: approximately 14.6 m
- Number of ports: 10 ports;
- Port diameter: 51 mm;
- Port spacing: 3 m;
- Tideflex valve mounted on top of diffuser pipe on each port to eliminate fish access;
- Vertical angle of valve: 45 degrees, pointing toward the southeast;
- Port height from lake bed: 1 m, corresponding to the approximate effluent exit height from lake bed.

Numerical modelling was conducted to assess dilutions of conventional constituents at the edge of the mixing zone. The 3D hydrodynamic model H3D was coupled with the US EPA Visual Plumes model. Visual Plumes simulated the behavior of the plume in the near field and passed conventional constituent concentration to the 3D H3D model, which then advects conventional constituents in the far field. This modelling framework involved a multi-year long simulation spanning 14 years: three years of pre-production, eight years of operation and three years of post-production.

The domain of the model is shown in Figure 1 below.

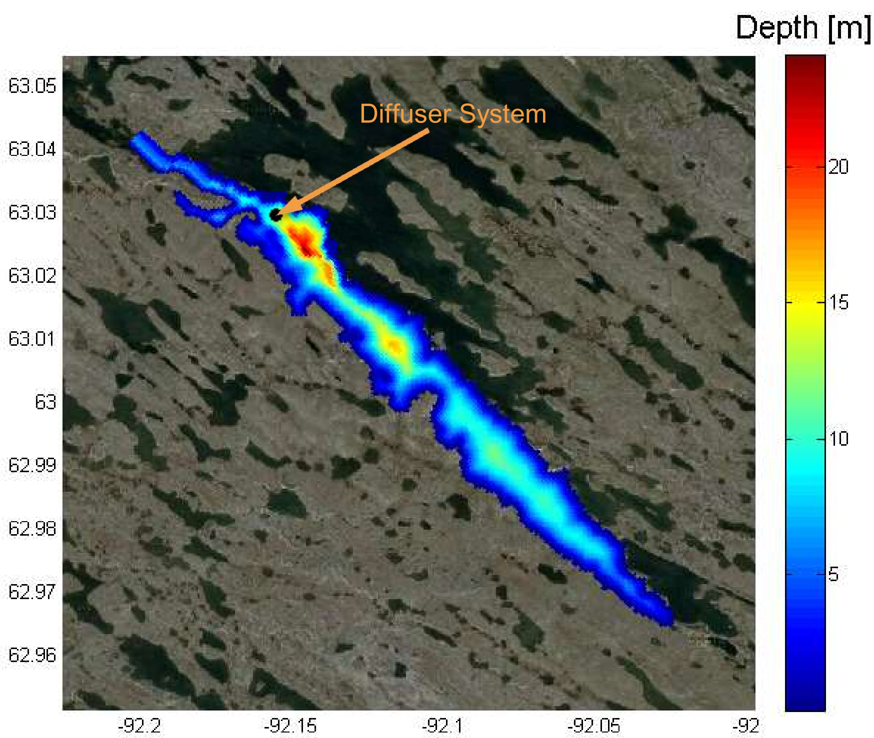


Figure 1: Meliadine Lake Model Domain

Monthly average concentrations for each constituent in the outfall stream were used to assess the build-up of conventional constituents in the Meliadine Lake sub-basin. Total conventional constituent concentrations were used (instead of just dissolved concentrations), which include both dissolved and particulate forms carried in the estimated TSS of 15 mg/L. The estimated monthly volumes of effluent released through the diffuser in Meliadine Lake for the base case scenario, i.e. mean precipitation years, are indicated in Table 1.

Table 1: Estimated Monthly Effluent Released for Simulated Base Case (Mean Precipitation Years)

Year	Volume of Effluent Released Over the Course of the Month [m^3 / calendar month]				
	June	July	August	September	October
Year -3	175,320	233,760	70,128	70,128	23,376
Year -2	175,320	163,632	81,816	70,128	23,376
Year -1	175,320	151,944	93,504	58,440	23,376
Year 1	175,320	268,824	116,880	93,504	35,064
Year 2	175,320	303,888	105,192	93,504	35,064
Year 3	175,320	292,200	105,192	163,632	70,128
Year 4	175,320	350,640	128,568	105,192	35,064
Year 5	175,320	350,640	128,568	93,504	35,064
Year 6	175,320	350,640	128,568	93,504	35,064
Year 7	175,320	350,640	128,568	93,504	35,064
Year 8	175,320	280,512	105,192	81,816	35,064
Year 9	175,320	292,200	116,880	93,504	35,064
Year 10	175,320	292,200	116,880	93,504	35,064
Year 11	175,320	280,512	116,880	93,504	35,064

Following the 14-year long simulation, results showed that the proposed diffuser would achieve dilutions that fall within the Site Specific Water Quality Objectives (SSWQO) and the Canadian Council of Ministers of the Environment guidelines (CCME) guidelines for all of the constituents. On this basis it was concluded that the proposed diffuser would allow AEM to meet water quality guidelines.

3.0 DEVIATIONS DURING CONSTRUCTION

Construction and installation were supervised by the AEM field engineer. Two deviations from the design were observed and recorded during the construction and outlined in Table 2. The two deviations associated with the as-built system represent a 42 m horizontal shift and a 3.2 m shallower depth.

Table 2: Effluent Water Outfall System Characteristics

Item	Proposed	Actual	Deviation
1) Location of Tee Connector for Diffuser System	(6,989,149.90N / 542,755.74E)	(6,989,147.41N / 542,797.91E)	42 m, mainly eastward
2) Depth of the Diffuser System at Tee Connector	14.60 m	11.39 m	3.21 m shallower

Deviation 2) indicated that the bathymetry used in the design report was erroneous near the diffuser. As a result, a new bathymetric survey was conducted in February 2018, but was restricted to the area around the diffuser, due to ice conditions. Results of this survey were the following:

Table 3: February 2018 Bathymetry Survey

Position	Coordinates	Bathymetry in Design Report (Model Cell)	Updated Bathymetry (Survey February 2018)	Difference between Design / New Survey
Tee-Connector Position in Design Report	6,989,149.90 N 542,755.74 E	14.60 m	11.95 m	-2.65 m
As-Built Tee-Connector Position	6,989,147.41 N 542,797.91 E	14.97 m	11.39 m	-3.58 m
As-Built North End of Diffuser	6,989,162.43 N 542,799.07 E	14.39 m	11.18 m	-3.21 m
As-Built South End of Diffuser	6,989,135.52 N 542,796.80 E	15.00 m	11.49 m	-3.51 m
East of As-Built Diffuser	6,989,143.08 N 542,844.80 E	15.18 m	10.95 m	-4.23 m

4.0 AS-BUILT SYSTEM PERFORMANCE

To assess the impact of these two deviations, the numerical modelling framework used in the design report (and summarized in Section 2.0) was used. This modelling framework incorporated the two deviations corresponding to the as-built system, to assess conventional constituent concentrations at the edge of the mixing zone as well as potential concentration build-up over time.

The model bathymetry was based on the original bathymetric survey, i.e. used in the design phase, but was updated at locations where new data was available. Hence, each relevant model grid cell indicated in Table 2 was updated with the February 2018 bathymetry survey. The method to assess conventional constituent concentrations at the edge of the mixing zone was the same as presented in the design report.

- A three-dimensional multi-year simulation covering a total period of 14 years of discharge through the diffuser (Year -3 to Year 11) was set up to assess conventional constituent build-up in the lake.
- Monthly average concentrations for each constituent in the outfall stream were used to assess the build-up of conventional constituents in the Meliadine Lake sub-basin. Total conventional constituent concentrations were used (instead of just dissolved concentrations), which include both dissolved and particulate forms carried in the estimated TSS of 15 mg/L.
- Scenario 1 (Base Case Scenario) was re-run, looking at the accumulation of conventional constituents over time for mean (i.e. normal) precipitations years. The inputs for Scenario 1 (environmental conditions, amount of effluent released…) are the same as in the design report, with the exception of the updated bathymetry.

Results of this simulation, which incorporates the two deviations of the as-built system, are as follows:

By the end of Year 11, concentrations of the conventional constituent, which entered at a concentration of 1 (unit-less), vary between 0.03 and 0.04 at the edge of the mixing zone, corresponding to a dilution of about 23:1 to 32:1. Minimum dilution, representing the maximum concentration, reached over the multi-year simulation was a 23:1 dilution, similar to the proposed system in the design report (23:1 in the design report).

Table 4 presents minimum dilutions obtained at the end of the first year of discharge and through the 14-year long simulation. The following can be noted:

- The smallest dilution obtained through the multi-year simulation is 23:1.
- No difference in the system performance between proposed and as-built system can be noted for the most stringent criterion, i.e. minimum dilution obtained over the multi-year simulation.
- However, because the water depth was reduced in the vicinity of the diffuser, the mixing of effluent with lake water was slightly affected on the short term and results in a 72:1 dilution obtained at the edge of the mixing zone after the first year in the as-built system, compared to a 73:1 dilution in the originally designed system. This slight change does not materially impact water quality, since constituent concentrations are below the CCME and SSWQO.

Conventional constituent concentrations corresponding to the most stringent dilution obtained through the multi-year simulation are shown in Table 5. Similar to the proposed system described in the design report, water quality guidelines are met with the modelled as-built diffuser system, even when including the effects of conventional constituent build-up due to lower flushing rates in the receiving environment compared to the design case.

Table 4: Dilutions for Proposed and As-Built System

	Scenario 1 Results for Proposed System (Design Report)	Scenario 1 Results for As-Built System
Minimum Dilution at the Edge of the Mixing Zone at the End of the First Year of Discharge	73:1	72:1
Minimum Dilution Obtained through the Multi-Year Simulation	23:1	23:1

Table 5: Simulated Conventional Constituent Levels for Proposed and As-Built – Base Case (Mean Precipitation Years)

			Monthly Average Constituent Concentration		
	CCME Guidelines [mg/L]	SSWQO Guidelines [mg/L]	Proposed System (Design Report) Dilution of 23:1	As-Built System Dilution of 23:1	As-Built System Conformity
Conventional Constituents					
Total Dissolved Solids	-		41.8	41.8	Yes

			Monthly Average Constituent Concentration		
	CCME Guidelines [mg/L]	**SSWQO Guidelines [mg/L]**	**Proposed System (Design Report) Dilution of 23:1**	**As-Built System Dilution of 23:1**	**As-Built System Conformity**
Total Suspended Solids	8		2.0	2.0	Yes
pH	-				Yes
Major Ions					
Chloride	120		6.9	6.9	Yes
Fluoride	0.12	2.8	0.03	0.03	Yes
Sodium	-		3.3	3.3	Yes
Sulphate	-		4.2	4.2	Yes
Nutrients					
Total Ammonia as Nitrogen	3.33		0.21	0.21	Yes
Nitrate Ion	13		0.34	0.34	Yes
Phosphorus (total)	0.03		0.02	0.02	Yes
Cyanides					
Total cyanide	-		0.0012	0.0012	Yes
Free cyanide	0.005		-	-	Yes
Metals					
Aluminum	0.1		0.05065	0.05065	Yes
Antimony	-		0.00021	0.00021	Yes
Arsenic	0.005	0.025	0.00799	0.00799	Yes
Barium	-		0.00766	0.00766	Yes
Cadmium	0.00005		0.00003	0.00003	Yes
Chromium	0.0089		0.00031	0.00031	Yes
Copper	0.002		0.00121	0.00121	Yes
Iron	0.3	1.06	0.09107	0.09107	Yes
Lead	0.001		0.00023	0.00023	Yes
Manganese	-		0.00796	0.00796	Yes
Mercury	0.000026		0.00001	0.00001	Yes
Molybdenum	0.073		0.00031	0.00031	Yes
Nickel	0.025		0.00070	0.00070	Yes
Selenium	0.001		0.00006	0.00006	Yes
Silver	0.00025		0.00005	0.00005	Yes
Thallium	0.0008		0.00002	0.00002	Yes
Uranium	0.015		0.00005	0.00005	Yes
Zinc	0.03		0.00184	0.00184	Yes

5.0 RECOMMENDATION AND CONCLUSION

As confirmed with the numerical simulation described above, both deviations in the as-built diffuser (horizontal shift and system in shallower water depth) result in water quality guidelines being met for all conventional constituents.

- Deviation #1: The shift of 42 m in the east direction does not impact the operation of the system. This deviation is very minimal. The most important design criteria was the orientation of the diffuser normal to the main axis of the lake. This configuration was kept. The 42 m shift still results in the system being in the same general area of Meliadine Lake sub-basin.
- Deviation #2: A 3.2 m depth difference was observed between the proposed and the actual diffuser depth. As described above, a recent depth sounding survey was conducted by Hamel Arpentage (February 2018) at five points in the vicinity of the diffuser (proposed and actual) to confirm the depth of the system. Following these depth soundings, an update of the model bathymetry, which was used during the design phase to assess concentrations of conventional constituents at the edge of the mixing zone, was conducted. To summarize, the model bathymetry was based on the original bathymetric survey, i.e. used in the design phase, but was updated at locations where new data was available. As confirmed with the numerical simulation described above, this vertical shift (reduction in water depth) still results in water quality guidelines being met for all conventional constituents, as summarized in Table 6 below.

Table 6: Comparison of Diffuser System Dilution Performance

Item	Minimum Dilution at the Edge of the Mixing Zone Obtained over 14-Years Simulation	
	Designed	**As-Built**
Base Case Scenario	23:1	23:1
Water Quality Guidelines	Met for all conventional constituents	Met for all conventional constituents

In light of the discrepancies between the original and new set of bathymetric data in the vicinity of the diffuser, it is recommended that AEM resurveys the entire Meliadine Lake sub-basin shown in Figure 1 to confirm bathymetry in the area of study.

6.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Agnico Eagle Mines Limited and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Agnico Eagle Mines Limited, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on the Use of this Document attached in the Appendix or Contractual Terms and Conditions executed by both parties.

7.0 CLOSURE

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

Respectfully submitted,
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