SPECIFICATION FOR
TRENCHLESS PIPES INSTALLATION

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1. Pipe Jacking (MTBM) with Slurry Type Machines

1.1 General

This section provides general specification for sewer installation works using slurry type micro tunneling methods that may or may not require casing pipes. The slurry type shall keep earth pressure balance at face and remove only the excavated spoils. The construction method involves jacking of pipe and tunnel boring or micro tunnel boring. Related activities of micro tunneling are site restoration and co-ordination with other works.

Preparatory work consisted of construction of drive shaft and receiving shafts, installation of slurry circulation and recovery system, dewatering arrangement and GWT lowering system. The shafts located within flood plains shall be designed with water retaining liner and shall be extended 600mm above 100 year flood level.

The Contractor shall make adequate preparatory work before commencing tunneling.

The jacking pipe shall be able to withstand high jacking force, the deflection of pipe joint shall not exceed 0.5 degrees and the length of jacking pipes shall comply with the standard lengths given in table below. Pipe joints shall flush with outer diameter of pipe. And outer surface of pipes shall be designed to exert minimum friction to earth pressure.

Pipe Material	Diameter range	Pipe length
Reinforce concrete- RCP	1000 – 3600mm	0.9 – 3.0m
Glass-fiber reinforced-GRP	300 – 2700mm	3 – 6m
Extra Strength Clay - VCP	150 – 1200mm	0.9 – 3.0m
Ductile Iron - DIP	100 – 600mm	Up to 6m

A Steel casing pipe shall be jacked into position first when thermoplastic piped to be installed instead of above type of pipes.

1.2 Direction Control

Generally laser guided control system is acceptable for pipe installation works, The laser instrument installed in entry/ drive shaft is the reference point and reference point should not be effected by the vibration due to operations of machine. The laser guided control system of tunnel boring shall be able to relay (as minimum) target position, inclination (grade), rate of advance, altitude, installed length; thrust force and cutter head torque. The Engineer should approve specifications for other type of direction control systems, tolerances, and technical details provided by the machine manufacturers.

1.3 Reference standards for MTB

Reference standard shall be following or equivalent standards

BSEN 12336:2005 - Tunneling machines, Shield machines, thrust boring machines, auger boring machines, lining erection equipment. Safety requirements

OSHA - Occupational Safety and Health Administration

1.4 Submittals for Micro Tunneling

The Contractor shall submit followings to the Engineer, IN ADDITION to details requested in section 8.4.4 (1&2) for MTB works.

a) Submittals –

1. Detail layout plans, shop drawings, design of the temporary drive and receiving shafts, stamped by a professional civil engineer, and description of sequence of drilling operation.
2. Method of construction and type of face support,
3. Capacity of equipment and type of cushioning proposed at joints,
4. Geotechnical profile along sewer.
5. Details of critical utility crossings and special precautions,
6. Supply full details of resources that will be employed to carryout work.
7. Structural Assessment report: The structural assessment report provide pre and post construction assessment of critical structures located within active excavation from proposed tunnel centre line. Include photo of all existing cracks before and after construction.
8. Submit description of grout mix, equipment and operational procedure to accomplish grouting operation

1.5 Expertise-

The Contractor should employ operators who have trained by the jacking machine manufacturers and have experience in installation of minimum of three 3km of VC, RCC and/or DI sewers using same type of machine. The copies of training certificate from machine manufacturers or micro tunneling institutes acceptable to the Engineer shall be submitted to prove the qualification of personnel employed by the Contractor, for the micro tunneling work. The work supervisors shall have at least experience on one similar micro tunneling project.

The Contractor shall hold the Employer and Engineer harmless and not responsible in any legal action resulting from patent infringement of technologies or plants.

1.6 Grouting Materials

The material used for grout mix shall comply with references standards given below.

ASTM C 150 Type II, BS 4027 : Cement for concrete in contact with the sewage,
ASTM C 94 : Clean water free from harmful concentration of oils, acids, alkalis etc
ASTM C33, BS 812: fine aggregate
ASTM C 937 : fluidifier that holds the solids of the grout in colloidal suspension,
ASTM C 494 and 1017: Admixtures to improve permeability to control setting time.

Grout type application

1. Grout for pressure grouting - Sand cement mortar mix,
2. Grout for annular grouting – low density cellular grout or sand cement mortar mix
3. Grout for ground stabilization – Sand cement mortar mix or cement bentonite clay mix,
4. Grout for spot repair of sewer- chemical grout

1.7 Execution of Grouting

i) Preparation

- Notify the Engineer at least 24 hours in advance of grouting operation,
- Select and operate equipment to avoid damage to existing and new underground utilities.
- In selection of grouting placement consider pipe flotation, length of pipe, length of tunnel, depth from surface, and type of sewer pipe, type of pipe blocking and bulk heading, grout volume and length of pipe to be grouted between bulkheads.
- The Contractor is to ensure there is no water in the annular space between the carrier pipe and the tunnel liner prior to pumping the cellular grout in to the annular space.
- Operate any dewatering systems until the grouting operations are complete

ii) Equipment

- Batch and mix grout in equipment of sufficient size and capacity to provide the necessary quality and quantity of grout for each placement stage.

- Use equipment for grouting of a type and size generally used for the work, capable of mixing grout to a homogeneous consistency, and providing means of accurately measuring grout component quantities and accurately measuring pumping pressures. Use pressure grout equipment, which delivers grout to the injection point at a steady pressure.

iii) Pressure Grouting for Jacked or Pulled Pipe

- For jacked pipe 1500mm in diameter or greater, pressure grout the annulus after installation, displacing the bentonite lubrication. Jacked or pulled pipes less than 1500mm diameter may be left ungrouted unless the excavated diameter exceeds the external pipe diameter by more than 25mm.
- Inject grout through grout holes in the sewer pipe. Drilling holes from the surface or through the carrier pipe walls is not allowed. Perform grouting by injecting it at the pipe invert with bentonite displacement occurring through a high point tap or vent.
- Control ground water as necessary to permit completion of grouting without separation of the grout materials.
- Limit pressures to prevent damage or distortion to the pipe or to keep flexible pipe within acceptable tolerances.
- Pump grout until material discharging is similar in consistency to that at point of injection.

iv) Pressure Grouting for Shaft Liner

- If required, perform grouting operations to fill voids outside of the shaft liner.
- For none expandable primary liners installed by hand mining or in shafts, grout once every 1200mm or more frequently if conditions dictate.
- Control grout pressures so that shaft liner is not overstressed, and ground heave is avoided.
- For liner requiring grout, perform back grouting once each shift, or more often if required to ensure that all voids are filled.

v) Ground Stabilization Grouting:

- Completely fill voids outside the limits of excavation caused by caving or collapse of ground. Fill with gravity or pressure injected sand-cement grout as necessary to fill the void.
- Take care in grouting operations to prevent damage to adjacent utilities or public or private property. Grout at a pressure that not distort or imperial any portion of the work or existing installations or structures.
- Verify that the void has been filled by volumetric comparison and visual inspection. In the case of settlement under existing slabs, take core samples as directed by the Engineer, at no additional cost to the Employer, to demonstrate that the void has been filled.

1.8 Field Quality Control

- Pressure grouting for Shaft Liners. For each shaft, make one set of four compressive test specimens for each 9m depth and one set for any remaining portion less than a 9m increment.

- Pressure grouting for jacked Pipe. Make one set of four compressive test specimens of every 120m of jacked pipe pressure grouting.
- Pressure grouting for Pulled Pipe. Make one set of four compressive test specimens for every 120m of pulled pipe pressure grouting.
- Ground Stabilization Grouting. Make one set of four compressive test specimens for every location where ground stabilization grouting is performed.

1.9 Settlement / Monitoring

Monitoring points to measure ground elevation are required at a distance of 0 m, 3m and 6m from the perimeter of the shaft on each of four radial lines, the radial lines being at 90 degrees to each other.

Monitor ground settlement of track sub base at centerline of each Railroads track.

Monitor ground settlement directly above and 3m offset of the utility or pipeline, before and after installation of pipes.

The contractor shall cease operation immediately when the monitoring points observe surface disruption. The Contractor shall propose immediate action for review and approval by the Engineer to remedy problem.

i) Frequency and Reporting:

The Contractor shall submit to the Engineer, records of readings from the various instruments and survey points.

1. Instrumentation monitoring results to be read at the frequency specified and unless otherwise specified, shall be started prior to the zone of active excavation has passed and until no further detectable movement occurs.
2. Surface settlement monitoring readings shall be taken:
    a. Prior to the zone of active excavation reaching that point,
    b. When the tunnel face reaches the monitoring point (in plan), and
    c. When the zone of active excavation has passed and no further movement is detected.
3. All monitoring readings shall be submitted promptly to the engineer.
4. Immediately report to the Engineer any movement, cracking, or settlement which is detected.
5. Following completion but prior to the final acceptance, make a final survey of all monitoring points.

2. Horizontal Directional Drilling (HDD)

2.1 General

The specifications for installation of pipelines using horizontal directional drilling (HDD) includes minimum requirements for design, materials and equipment used for the HDD works. It also includes materials, dimensions and other pertinent properties of pipe and accessories required for minimum performance standards. The installation of gravity sewers by HDD shall conform to requirements of line and grade specified in ERQ.

2.2 Description of system.

Installation of sewers shall be carried out according to drawings, specifications and by approval of the Engineer. The bore path shall be designed by the Contractor to ensure that pipe joints do not deflect more that 50% of manufacturer's recommended maximum deflection.

2.3 Expertise and experience

The Contractor's shall employ personnel trained or certified by HDD machine manufacturers. The contractor should have at least 5km of HDD sewer installation experience in similar topographic and soil conditions. This includes the preparation and maintenance of the bore path using drilling fluids appropriate for the geology of the soils. The Contractor shall also have experience in safety and dependability installing, in similar geology, and similar size of piping involved.

All personnel shall be fully trained in their respective duties as part of the directional drilling crew and in safety. The Supervisor must have at least two years directional drilling experience. A competent and experienced supervisor representing the Drilling Contractor shall be present at all times during the actual drilling operations. A responsible representative who is thoroughly familiar with the equipment and type work to be performed, must be in direct charge and control of the operation at all times.

The bidder shall submit documentary evidences of his sub contractors to prove the expertise and experience. The information of previous HDD works includes but not limited to following shall be submitted. (Project details, location and previous client's contact details, copy of completion certificate, etc;)

(N.B- The bidder is allowed to propose a new specialized subcontractor who has experience to meets with the revised trenchless experience and capabilities; if the pre qualified specialized subcontractor is unable to meet with the revised requirements.)

2.4 Submittals

Additional to submittals given in section 9.7.2 the contractor shall submit following for HDD method.

Prior to beginning of work, the Contractor shall submit to the Engineer working drawings, method statement and schedule to be used to execute the project. The work plan shall include descriptions of the size, capacity & setup requirement of equipment, location, sites of drilling and receiving pits, monitoring and controlling of line and grade, down-hole tools, a list of personnel and their qualifications and experience (including back-up personnel in the event that an individual is unavailable), a schedule of work activity, a safety plan, traffic control plan, an environmental protection plan comply with EMP and contingency plans for possible problems. Work plan shall be comprehensive, realistic and based on actual working conditions for this particular project. Plan shall document the thoughtful planning required to complete the project.

The Contractor shall submit drilling operations records and a guidance system log of all pipes installed by HDD method to the Engineer. The drilling operation must not interrupt or endanger either surface or subsurface developments.

Specifications on material to be used shall be submitted to Engineer and material shall include the pipe, fittings, drilling mud, drilling additives and any other item, which is to be an installed component of the project or used during construction.

The Contractor shall submit Technical literature and catalogue of HDD equipment and instruction manuals for equipment and pipe installation to the Engineer.

2.5 Products

a) General

The bore path alignment and design for HDD shall be based on the ERQ, Engineer's instructions and other factors. Some of these factors are the pipe bell and barrel diameters, the optimum individual pipe length (6m- nominal), bore path inside diameter and maximum deflection capabilities of the joint.

Prior to the start of drilling, reaming and pipe placement operations, the Contractor shall properly locate and identify all existing utilities in proximity to the pipeline alignment.

b) Pipes and joints

Either high density polyethylene pipe (HDPE PE100) or restrained joint PVC or FPVC pipes or Class 350 DI pipes shall be used for HDD unless otherwise stated specifically in ERQ. Pipe materials shall conform to pipe specification in section-9 Joints with bulky glands or flanges that may prevent the smooth flow of drilling fluid/soil slurry over the joint shall not be acceptable.

Joints used for directional drilling shall be boltless, flexible, restrained and shall be approved by the Engineer.

c) Drilling fluid

Drilling fluid shall be a mixture of clean water and bentonite clay with or without appropriate additives. The drilling fluid return caused by fracturing of formation at locations other than entry and exit points shall be minimized. Excess drilling fluid and spoils shall be disposed of at sites approved by the Engineer. The excess drilling fluid, slurry and spoils shall be transported in a manner that prevents accidental spillage on to roads. No drilling fluid or slurry or spoils shall be discharged into the sanitary or storm drains of the city.

The information of other drilling fluid proposed shall be submitted with the bid to the Engineer for approval.

The drilling fluid reservoir tank shall be a minimum of 500 gallons. Mixing system shall continually agitate the drilling fluid during drilling operations.

Additives to drilling fluid such as drill soap, polymers, etc. shall be "environmentally safe" and be recommended for such usage and approved by the Engineer.
The contractor will be responsible for making provisions for clean water supply.

d) Drilling System

The directional drilling machine shall consist of a hydraulically powered system to rotate, push and pull hollow drill pipe into the ground at variable angles down to 8 degrees above horizontal, while delivering a pressurized fluid mixture to a guidable drill (bore) head. The machine shall have a capacity to adequately complete the drilling and piping installation. The machine shall be anchored to the ground to withstand the pulling, pushing and rotating forces required to complete the works. Rig shall have a system to monitor the maximum pull-back pressure during the pull-back operation. The rig shall be grounded during drilling and pull-back operations. An automatic sounding system to detect electrical current and presence of electric cables near and across drill path shall be available in drilling machines

e) Guidance System

A conventional electromagnetic sound walkover system, Magnetic Guidance System (MGS) probe or proven gyroscopic probe and interface shall be used to provide a continuous and accurate determination of the location of the drill head under drilling operation. The guidance shall be capable of tracking at the maximum depth required and in any soil condition, including hard rock. It shall enable the driller to guide the drill head by providing immediate information to the tool face, azimuth (horizontal direction), and inclination (vertical direction). The guidance system shall be accurate to ± 2% of the vertical depth of the borehole at sensing position at depths up to one hundred feed and accurate within 1.5 meters horizontally.

The Guidance System shall be of a proven type and shall be setup and operated by personnel trained and experienced with this system. The Operator shall be aware of any

geo-magnetic anomalies and shall consider such influences in the operation of the guidance system if using a magnetic system.

f) Other Equipment

Pipe rollers shall be of sufficient size to fully support the weight of the pipe while being hydro-tested and during pull-back operations. Sufficient number of rollers shall be used to prevent excess sagging of pipe. Rollers shall be used as necessary to assist in pull back operations and in layout/jointing of piping.

Hydraulic or pneumatic pipe rammers may only be used if necessary and with the approval of the Engineer.

Other devices or utility placement systems require the Engineer's consent prior to commencement of work.

g) Polyethylene Encasement

If the drill area has a history of corrosive soil or a soil survey determines the soil to be corrosive, the ductile iron pipe to be installed by horizontal directional drilling shall be installed with a single or double polyethylene encasement (PE) per ANSI/AWWA C105/A21.5. Any damage that occurs to the polyethylene wrap during pipe handling and throughout the construction process shall be repaired prior to pulling the pipe string into the bore path.

2.6 Execution

a) General

The Engineer must be notified 48 hours in advance of starting work. The Directional Bore shall not begin until the Engineer is present at the job site and agrees with preparations made for the HDD operation. The Engineer's approval for beginning the installation shall in no way relieve the Contractor of the ultimate responsibility for the satisfactory completion of the work as per the Contract.

The drawings showing approximate locations of existing utilities are available with the Engineer. There is no guarantee that these utilities are located as shown or that the other utilities may not be present. The Contractor is to field locate existing utilities in advance of the work so as not to delay work and avoid conflict or disruption of utility services.

b) Drilling Procedure

Work site(s) within right-of-way, will be graded or filled with the Engineer's approval to provide a level working area for HDD equipment. No alterations beyond what is required for operations are to be made. Contractor shall confine all activities to designated work areas.

Entire drill path shall be accurately surveyed with entry and exit stakes placed in the appropriate locations approved by the Engineer. Approximate locations of entry and exit points are shown on drawings. If Contractor is using a magnetic guidance system, drill path shall be surveyed for any surface geomagnetic variations or anomalies.

Contractor shall adhere to all applicable safety regulations of KMC and safety requirements of his HSE plan and all operations shall be conducted in a safe manner acceptable to the Engineer.

Pipes shall be connected together to form a single length, if space permits. Pipe shall be placed on pipe rollers before pulling into bore hole with rollers spaced close enough to prevent excessive sagging of pipe.

Pilot hole shall be drilled on bore path with no deviations greater that 5% of depth over a length of 30m. In the event that pilot does deviate from bore path more than 5% of depth in 30m, Contractor shall notify Engineer and Engineer may require Contractor to pull-back and re-drill from the location along bore path before the deviation.

Upon successful completion of pilot hole, Contractor shall ream bore hole to a minimum of 25% greater than outside diameter of pipe bell for straight pulls and 50% greater for curved or radius pulls using the appropriate tools. Contractor shall have the option to pre-ream or ream and pull back pipe in one operation if conditions allow. Contractor shall not attempt to ream at one time more than the drilling equipment and mud system are designed to safely handle.

After successfully reaming bore hole to the required diameter, Contractor shall pull the pipe through the bore hole. In front of the pipe shall be a swivel. Once pull-back operations have commenced, operations must continue without interruption until pipe is completely pulled into bore hole. During pull-back operations Contractor shall not apply more than the maximum safe pipe pull force at any time. In the event that pipe becomes stuck, Contractor shall notify Engineer. Engineer, Contractor, and/or the maintaining agency shall discuss options and then work shall proceed accordingly.

Excess pipe shall be removed and the bore hole associated with this excess pipe shall be filled with flowable fill or grout unless the area of the excess pipe is excavated and backfilled as part of the tie-in operations. In the event that a drilling fluid fracture, inadvertent returns or returns loss occurs during drilling operations, Contractor shall cease operations and shall discuss corrective options with the Engineer and/or maintaining agency, and then work shall proceed accordingly.

c) Assembly and Pulling Methods

i) Cartridge Assembly (Option 1)

Cartridge assembly option is defined as the assembling of individual sections of flexible restrained joint pipe in a secured entry and assembly pit. The pipe sections are assembled individually and then progressively pulled into the bore path a distance equivalent to a single pipe section. This assembly-pull process is repeated for each pipe length until the entire line is pulled trough the bore path to the exit point.

ii) Assembly-Line or Ramp Method (Option 2)

Assembly-line option is defined by the pre-assembly of multiple lengths of flexible restrained joint pipe, with subsequent pulling installation into the bore path as a long pipe string. With this option the Contractor shall provide an entry ramp to the entrance of the bore path. The ramp shall be of sufficient length and grade such that any one pipe joint does not exceed the allowable joint deflection at any point prior to the pipe string entering the bore path. The Contractor shall be responsible for providing the necessary equipment or ground surface preparation to allow the pipe to be pulled back along the surface prior to the entry ramp and bore path without damaging the PE encasement. The Contractor shall repair any damage to the wrap prior to the pipe section entering the bore path.

d) Joint Cleaning / Assemblies in HDD

The Contractor shall be responsible for the proper assembly of all pipe and appurtenances in accordance with the Manufacturers written installation procedure and as supplemented by these guidelines. Prior to joint assembly all joints and joint components shall be thoroughly cleaned and examined to ensure proper assembly and performance. In the event

that the Contractor is not experienced with the assembly of the type of flexible restrained joint being used, it shall be the responsibility of the Contractor to get manufacturer's field service for recommendations on the proper and efficient installation of the joint and pipes. Two copies of manufacturer's field service report shall be submitted to the Engineer immediately for review.

e) Record Keeping

Contractor shall maintain a daily record of the drilling operations and a guidance system log with a copy given to Engineer at completion of boring.

2.7 Testing of Sewers

Following successful pullback of pipe, the Contractor shall test sewers according to specifications of ERQ.

2.8 Restoration of Worksites

Following drilling operations, the Contractor shall de-mobilize equipment and restore the work-site to original condition. Any noticeable surface defects, due to the drilling operation, shall be repaired by the Contractor. The structural defects observed due to drilling and pipe installation shall be repaired to the original condition and to the satisfaction of the Engineer.

3. Pilot tube Micro tunneling

3.1 General

3.1.1 Definition

Pilot Tube Micro Tunneling shall be defined as an alternate Micro Tunneling system for sizes 200mm through 450mm and larger nominal internal diameter pipe. This system is a two or three stage system, which allows both trenchless guided installations of house connection sewers as well as accurate direct jacking of mainline collection sewer pipes without use of casing a permanently installed casing. The Pilot Tube Micro Tunneling boring machine uses a remote controlled, laser or theodolite guidance system to maintain specified line and grade, a jacking system is used for thrust and mechanical drive which creates torque to both the pilot tube and the augers used for spoil removal.

3.1.2 Major Components

The system utilized shall be either a two phase system or a three phase system and shall consist but not be limited to the major components listed below.

a. Line and grade control – laser , lighted target, theodolite, etc
b. Jacking frame - The frame shall develop a uniform distribution of jacking forces on the end of the pipe. The auger motor shall possess adequate torque to steer the pilot tube and adequate torque and speed to effectively auger the excavated material from the face of the bore to the drive shaft.
c. Pilot tube – rigid steel tube in short sections and connects rigidly to each other
d. Enlargement casing- steel sections
e. Soil transport system – auger train
f. Soil remover- removal of soil collected to shaft from tunnel
g. Hydraulic power unit-
h. Lubrication system-
i. Monitoring equipment – jacking pressure, deviation from line and grade

3.1.3 Drive and receiving shafts

Shafts diameter shall be minimized however shall be commensurate with safe working practices. Shafts shall be located at manhole locations and elsewhere as approved by the Engineer. The Contractor shall provide equipment as required to keep the shafts free of flowing or standing water while in use. The groundwater control system shall not result in a loss of fines for the soil surrounding the shaft. The Contractor shall assess during the design phase if the lowering of the groundwater in the vicinity of the shafts will have unacceptable impacts and if so shall preclude the lowering of the groundwater table. Groundwater may be disposed of into the combined sewer or as directed by the Engineer. Design and

construction technique for drive and receiving shafts shall be the responsibility of the Contractor and, shall be in compliance with all applicable requirements. The Engineer shall assume no responsibility for shaft design and or construction. Shaft design shall include all devices required for safe working conditions shall be in compliance with OSHA and regulations of the country. The Contractor shall make provisions to prevent groundwater, if present, from flowing along the pipe into the shaft and prevent pipe lubricant from escaping into the shaft.

3.1.4 Ground Movement -

1 The machine shall provide full support to the tunnel without use of ground stabilization or other ground support techniques to allow the installation of the sewer line.

2 Drive and receiving shafts shall be designed in a manner to preclude settlement of the adjacent areas.

3 Settlement of the ground surface along the centerline of the gravity sewer during and after construction shall not exceed 12mm.

4 Repair of ground losses and or damage to structures due to ground losses that are a result of the pilot tube Micro Tunneling operation shall be the responsibility of the Contractor.

5 Repair of voids created during the pilot tube Micro Tunneling operation shall be the responsibility of the Contractor. A plan of repair shall be prepared by the Contractor for review and approval by the Engineer.

6 Voids greater than 12mm beneath pavement shall be filled with a soil slurry mix approved by the Engineer.

3.1.5 Thrust Block-

Thrust blocks design including the establishment of allowable thrust load is the responsibility of the Contractor and shall provide a minimum factor of safety of three. Thrust blocks shall be designed to distribute loads into the ground in a uniform manner and shall not impart excessive loads on the shaft itself or cause the jacking frame to become misaligned. Special requirements to achieve general thrust block requirements shall be the responsibility of the Contractor.

3.2 Expertise and Experience

a. The contractor shall have experience in installation of sewer by pilot tube method at least 3km.

b. The contractor's operators shall be trained personnel from the machine manufacturers. The copies of training certificate shall be produced to the Engineer for approval. Additionally they should have work experience of 1km pipe installation using similar machines and/ or ground condition.

3.3 Submittals

Submit for the Engineer's review a complete work plan including drawings showing details of the proposed method of construction. Include written descriptions as necessary to clearly indicate the manner in which the sewer installation will be performed including the sequence of work. Show the location of working shafts, including method of excavation, shoring and bracing, and dewatering techniques that are proposed to be used.

Structural designs and other engineered components shall be signed and sealed by a Professional engineer.

Such other information as the Engineer may request.

3.4 Products

Pipe - The sewer pipe and pipe joints to be used on this project shall be designed and selected by the Contractor's according to ERQ and to satisfaction of the Engineer

Lubricant shall be selected by the Contractor to achieve successful installation of the pipe system. Any additives used should meet relevant BSEN or ASTM Standard.

Packing rings (cushion and or gasket buffer) shall be as recommended by the pipe manufacturer.

3.5 Execution

Methods of construction for the shafts, jacking pits, or other components of the construction shall be such as to ensure the safety of the work, Contractor's employees, the public and adjacent property, whether public or private. All

damage to property shall be restored to equal or better condition than prior to construction.

Selection of an excavation technique, excavation support system, and dewatering system is the contractor's responsibility. The Contractor is responsible to ensure all excavations are in compliance with all Federal State and Local regulations.

All excavations shall be adequately ventilated. Air monitoring of the shafts or pits shall be conducted on a continuous basis.

All work of excavation, shoring and bracing and tunneling shall be executed in such a way that settlement effect is not noticeable.

Before beginning construction at any location, the contractor must adequately protect existing structures, utilities, trees, shrubs and other permanent objects.

The repair of or compensation for damage to permanent facilities due to negligence for lack of adequate protection on the part of the Contractor will be at no cost to the Employer.

The Contractor shall provide surface drainage during the period of construction to protect the work and to avoid nuisance to adjoining property and to assure that surface runoff does not enter the entrance or exit shafts.

The Contractor shall conduct his operations is such a fashion that trucks and other equipment does not create a dirt nuisance in the streets. The Contractor shall immediately remove and dispose of any spillage or excess dirt on the roadway.

Blasting will not be permitted.

The machine shall be operated so as to prevent either surface heave or loss of ground during tunneling and shall be steerable to maintain line and grade within the tolerances specified.

The thrust reaction backstop shall be properly designed and constructed. The backstop shall be normal to the proposed pipe alignment. The thrust wall shall be designed to support the maximum obtainable jacking pressure developed by the main jacking system and shall include a safety factor. Failure of the thrust block system and any corrective action required shall be the responsibility of the Contractor.

The pipe shall be jacked in place without damaging the pipe joints or completed pipe section. Any pipe, which has been damaged during installation, shall. be replace by the Contractor at no additional cost to the Engineer.

All excavated material from the tunnel and shaft construction shall be disposed of away from the construction site. No stockpiling of material on the job-site will be permitted. Material shall be removed at regular intervals not exceeding 48 hours.

The Contractor shall monitor all ground movements associated with the work and maintain these within permissible tolerances. A baseline survey shall be prepared by the Contractor prior to commencement of the tunneling work.

3.6 Testing

After the completion of each line segment, before the jacking frame has been removed, each completed drive section shall be tested in accordance with section 9.2.3.8. In addition, Contractor shall televise all lines and a copy of the videotape (DVD) shall be provided to the Engineer. All acceptance testing shall be completed prior to the removal of the jacking frame.

3.7 Restoration of Worksites

Following drilling operations, the Contractor shall de-mobilize equipment and restore the work-site to original condition. Any noticeable surface defects, due to the drilling operation, shall be repaired by the Contractor. The structural defects observed due to drilling and pipe installation shall be repaired to the original condition and to the satisfaction of the Engineer.