Technical Specification

Transport and Main Roads Specifications MRTS140 Horizontal Directional Drilling (HDD)

July 2017

Queensland Government

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Contents

1 Introduction

This Technical Specification applies to the installation of pipelines, public utilities and plant underground structures using Horizontal Directional Drilling (HDD) within State-Controlled Road Corridors.

This Technical Specification shall be read in conjunction with MRTS01 *Introduction to Technical Specifications*, MRTS50 *Specific Quality System Requirements*, TN163 *Third Party Utility Infrastructure Installation in State Controlled Roads Technical Guidelines*, and other Technical Specifications and standards as appropriate.

This Technical Specification forms part of the Transport and Main Roads Specifications Manual.

Throughout this Technical Specification imperial units of measurement are used where referring to drilling equipment parameters. This is in accordance with the Horizontal Directional Drilling industry standard practice.

2 Definition of terms

The terms used in this Technical Specification shall be as defined in Clause 2 of MRTS01 *Introduction to Technical Specifications*. Additional terms used in this Technical Specification shall be as defined in Table 2.

Table 2 – Definition of terms

Term	Definition
3 & 10 joint checks	Method to calculate a measurement for Dog Leg Severity (DLS). DLS is a measure of the amount of change in the inclination, and/or azimuth of the borehole, usually expressed in degrees per 30 m (3 Joints) or 100 m (10 Joints). If DLS is high this can affect the pull loads required to pull the product pipe into the borehole and in a severe case result in the product pipe getting stuck during the pipe pullback operation.
carrier pipe	The permanent pipeline, either installed directly into the borehole or within a casing pipe, if a casing is deemed to be required.
conductor casing	A large casing usually installed at the entry or exit points of the HDD alignment to provide borehole support in weak or granular geological strata.
critical HDD crossing	A crossing where the risks associated with the proposed crossing are deemed to be higher and therefore there is a requirement for more detailed analysis during design, certification of the design and a heightened level of documentation and record keeping during construction.
enveloper pipe	Pipe installed by horizontal directional drilling to house the carrier pipe. Usually employed where the HDD process will risk damage to the carrier pipe due to the friction or pulling loads.
Horizontal Directional Drilling (HDD)	HDD is a trenchless method for installing a product that serves as a conduit for liquids, gasses, or as a duct for pipe, cable, or wire line products. It is a multi-stage process consisting of site preparation, equipment setup, drilling a pilot bore along a predetermined path, pulling the product back through the drilled space and then remediating the Site. When necessary, enlargement of the pilot bore hole may be necessary to accommodate a product larger than the pilot bore diameter. This process is referred to as reaming.

Term	Definition
hydrofracture	Inadvertent drilling fluid release through the geological strata. May or may not be to the surface.
instrumentation and monitoring	Process of gathering, reducing, interpreting and reporting of data obtained from the installed instrumentation system as specified on the Standard Drawings, design documents, and Technical Specifications.
natural ground surface	The ground surface which exists prior to any work being carried out under the Contract.
over bend	A series of back to back radii calculated to bring the prefabricated carrier pipe string from its stationary position on the ground to the required angle to enable insertion in the drilled borehole without exceeding the bend limits of the carrier pipe material.
P_{actual}	The actual downhole drilling mud pressure measured during the drilling process. P_{actual} must be < P_{max} at all times.
pilot casing pipe	Pipe installed by horizontal directional drilling to maintain the integrity of the pilot hole bore in difficult geologies during hole boring.
P_{max}	The maximum downhole drilling mud pressure allowable before hydrofracture may occur. A factor of safety > two is generally applied to the theoretical maximum allowable pressure to determine P_{max}.
P_{min}	The minimum downhole mud pressure required to ensure adequate bore hole cleaning is achieved during drilling. If P_{min} is > P_{max} then further assessment of the borehole design suitability shall be undertaken.
separation plant	An integrated system for the separation of excavated ground from the transportation fluid. Such a plant would employ shakers, screens, hydrocyclones or centrifuges to achieve this solid / fluid separation.
spoil	Material surplus to the Contract requirements which shall be disposed of on or off the Site.

3 Referenced documents

Table 3 lists documents referenced in this Technical Specification.

Table 3 – Referenced documents

Reference	Title
AS 1477	*PVC pipes and fittings for pressure applications*
AS 2033	*Installation of Polyethylene Pipelines*
AS 2885	*Gas and Liquid petroleum*
AS 4130	*Polyethylene pipes (PE) for pressure applications*
AS 4765	*Modified PVC (PVC-M) for pressure applications*
ASME B36	*Welded and seamless wrought steel pipe*
MRTS01	*Introduction to Technical Specifications*
MRTS03	*Drainage, Retaining Structures and Protective Treatments*
MRTS04	*General Earthworks*
MRTS16	*General Requirements Landscape and Revegetation Works*
MRTS50	*Specific Quality System Requirements*
MRTS78	*Fabrication of Structural Steelwork*

Reference	Title
MRTS91	*Conduits and Pits*
MUTCD	Queensland *Manual of Uniform Traffic Control Devices*
NASTT	HDD Good Practices Guidelines
Standard Drawing 1178	*Diversion of Water – Diversion of Water from Roadway and Table Drains*
TN163	*Third Party Infrastructure Installation in State Controlled Roads Technical Guidelines*

4 Quality system requirements

4.1 Hold Points, Witness Points and Milestones

General requirements for Hold Points, Witness Points and Milestones are specified in Clause 5.2 of MRTS01 *Introduction to Technical Specifications*.

The Hold Points, Witness Points and Milestones applicable to this Technical Specification are summarised in Table 4.1.

Table 4.1 – Hold Points, Witness Points and Milestones

Clause	Hold Point	Witness Point	Milestone
4.2			Submission of Construction Procedures (14 days)
4.3	1. Risk and Contingency Plan		
5.1	2. Acceptance of Approvals to undertake proposed work		
5.2 & 10.5	3. Acceptance of HDD Design		
5.2.4		1. Inspection of the approvals from the relevant utility owners	
5.2.5	4. Acceptance of ground monitoring procedure		
5.3	5. Acceptance of construction Procedures		
5.5	6. Pre-Construction Dilapidation Report		Post-Construction Dilapidation Report
6	7. Selection of materials and equipment		
6.1	8. Acceptance of pipe welding and jointing		
7.2	9. Acceptance of nominated HDD personnel		
7.3	10. Acceptance of existing utilities location		

Clause	Hold Point	Witness Point	Milestone
7.4		2. Notification of deviations from original design	
7.6 & 7.7		3. Confirmation of the hole condition before pipe pull and submission of records	
7.7			Monitoring and Reporting Records (including Pilot, Reaming and Conditioning) (seven days)
9			Submission of as constructed records (10 days)
10.2			Submission of settlement management plan for critical HDD crossings (four weeks)

4.2 Construction procedures

The Contractor shall prepare documented procedures for all construction processes in accordance with Clause 5 of MRTS50 *Specific Quality System Requirements.*

Those construction procedures which are required to be submitted by the Contractor to the Administrator in accordance with Clause 5 of MRTS50 *Specific Quality System Requirements* include those listed in Table 4.2, and further defined in Clause 5.3.

Construction procedures shall be submitted at least 14 days prior to works commencing. No works shall proceed until approved by the Administrator. **Milestone**

Table 4.2 – Construction procedures

Clause	Procedure
4.3	Risk and contingency plan
5.2 and 5.3	HDD construction procedures
7.7 and 7.8	HDD monitoring and quality control plan
10	HDD critical crossing (additional requirements)

4.3 Risk assessment and control

The Contractor shall prepare a risk and contingency plan dealing with the key HDD risks.

All contingency plans must be submitted to the Administrator for approval. **Hold Point 1**

As a minimum, the Contractor is to have documented procedures complete with equipment and materials on standby to mitigate the following HDD risks:

a) drill fluid loss

b) a hydrofracture event

c) hydro-lock (loss of fluid circulation)

d) hole collapse

e) fluid pit overflow

f) hydrocarbon spill

g) drill pipe or bottom hole assembly (BHA) failure

h) workplace safety incidents, and

i) any other environmental incidents not mentioned above.

5 Project Preliminaries

5.1 Approvals

The Works shall not commence until all relevant permits and approvals have been gained and signed off by the relevant authority. **Hold Point 2**

5.2 Design requirements

The HDD crossing shall be designed in accordance with this Technical Specification and the referenced documents by a person suitably qualified and having experience with the design considerations required for this type of work.

Prior to any approval being granted, or any Works commencing, the following aspects of the design (as a minimum) shall be submitted to the Administrator: **Hold Point 3**

a) concept development and detailed design for:
   i. HDD bore alignment, identifying existing utility services in close proximity
   ii. entry and exit points, identifying existing utility services in close proximity
   iii. any required temporary or permanent excavations
   iv. conductor casing works (if required) and casing pipe works (if required)
   v. pilot hole size and final borehole size, and
   vi. annulus grouting requirement and procedures.

b) use of the guidance and steering system to achieve the design alignment

c) details of any drilling fluids or other consumables required

d) potential for hydrofracture

e) summary of product pipe selection:
   i. submit standard drawings identifying the individual pipe length and joint design details
   ii. tensile loads (expected and maximum allowable)
   iii. pipe welding procedures for the selected material, and
   iv. the Contractor shall submit QA/QC records indicating pipe material has been manufactured in accordance with the requirements of Clause 6.

f) details of any geotechnical data relied upon in the design of the works. Geotechnical investigation must be undertaken in accordance with AS 1726. As a minimum, boreholes must

be drilled at the entry and exit locations. Boreholes or test pits must be at least 2 m below the proposed invert level of the lowest point of the crossing. Where crossing a dual carriage way, or greater than 60 m in length then an additional borehole shall be drilled at approximately the mid-point of the HDD crossing.

additional holes shall be drilled if deemed necessary. The Administrator shall approve the extent of geotechnical testing carried out within a State-Controlled Road Corridor.

g) instrumentation and monitoring plan

h) details of potential impacts due to contaminated land, acid sulfate soils, fire ants, groundwater and any other environmental considerations specific to the Site

i) drawings confirming the location of and impact on any existing utility services and structures

j) documentation clearly identifying the impacts on but not limited to: natural water courses, table drains, drainage structures, vegetation, overland flow paths, structures, utilities and roadways, and

k) traffic management plan.

No standard design details, or historic as built information provided by Transport and Main Roads shall be relied up on in the design of the works unless approved by the Administrator.

The minimum design Standard Drawings to be submitted are described in Table 5.2.

Table 5.2 – Design drawing requirements

Drawing Description	Drawing Detail	Comments
Borehole details	Elevation	Clearly identify location and any conductor casing proposed, including strata cross sections if applicable.
Entry and exit pit construction	Plan and elevations (cross sections if appropriate)	Include details of drill fluid management, groundwater control and rainfall / runoff management.
HDD alignment and profile	Plan and elevation	Clearly identify dimensions including bore length, depth of the bore below the existing surface, and proximity public utilities and plant. Positions of investigation boreholes shall be indicated in relation to the proposed HDD alignment.
HDD general arrangement	Cross section	Clearly identify dimensions including, excavation diameter, outer / inner diameter of the casing pipe (if any) and outer / inner diameter of the carrier pipe.
Site layout(s)	Plan	Include all existing structures, roads, public utilities and plant, paths and vegetation. Identify any vegetation to be removed, and public utilities and plant or existing structures to be removed or relocated.

5.2.1 HDD bore alignment

The bore shall pass under roads in a straight line and within 5° of perpendicular to the road centreline, unless otherwise approved by the Administrator.

5.2.2 Minimum depth below roads

The minimum depth of cover required for a HDD drive within a state road corridor shall be in accordance with TN163 *Third Party Utility Infrastructure Installation in State Controlled Roads Technical Guidelines*. Refer to Figure 5.2.2(a) and Figure 5.2.2(b) below for an indication of cover requirements.

Figure 5.2.2(a) – Minimum depth below single carriageway

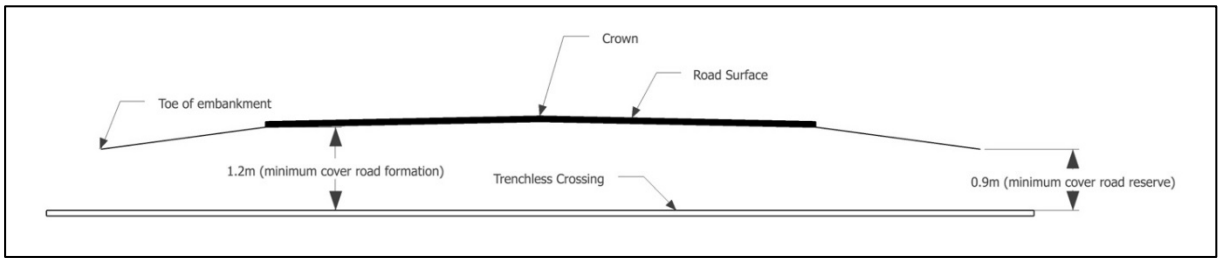
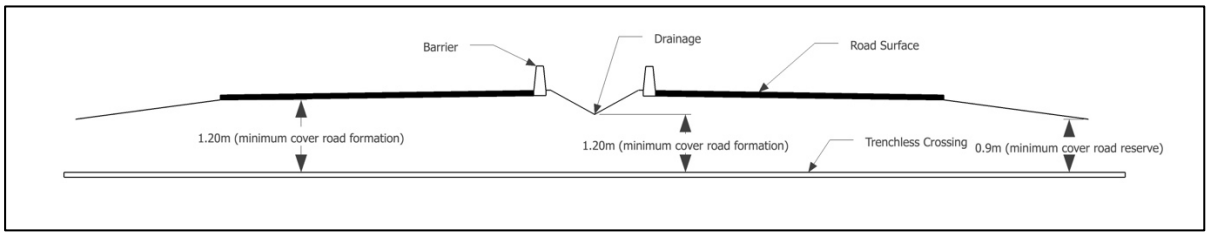


Figure 5.2.2(b) – Minimum depth below dual carriageway



5.2.3 Minimum distance from structures

The HDD drive shall be located according to the requirements of TN163 *Third Party Utility Infrastructure Installation in State Controlled Roads Technical Guidelines*.

5.2.4 Minimum distance from other utilities

The distance between the bore and any existing utility service shall be as approved by the relevant utility owner. This approval shall be provided to the Administrator prior to commencing works. **Witness Point 1**

5.2.5 Settlement and heave

Permissible deformations will depend on the sensitivity of the Transport and Main Roads asset, and will be subject to approval by the Administrator on a case by case basis. The total ground surface and differential settlement limits shall be agreed upon by the Administrator before commencement of the Works. The Contractor shall also submit a ground deformation monitoring procedure to the Administrator prior to commencing works. **Hold Point 4**

5.3 Construction procedures

The construction procedures must document at least the following critical aspects of the works as relevant to the specific project:

a) Site establishment (provision of access and working platform if required)

b) drilling equipment selection and operating methods

   i. the Contractor must submit information detailing the proposed drilling methods for the works. This shall include but not be limited to, drilling equipment size and capacity, tooling selection and method of monitoring and controlling alignment

c) welding/jointing of pipes (enveloper and/or carrier pipe)

d) lifting plan

e) equipment operation and removal of spoil

f) monitoring of the HDD alignment (see Clauses 5.4 and 7.7)

g) operation of a steering system to achieve the design alignment

h) use and management of drilling fluids, lubricants, cementitious grouts or other consumables, including relevant environmental and disposal information

i) annulus grouting procedures

j) demobilisation of the equipment, and

k) landscaping, revegetation and reinstatement of the site following completion of the works.

All construction procedures must be approved by the Administrator in conjunction with MRTS50 *Specific Quality System Requirements*. **Hold Point 5**

The Contractor must also provide a risk and contingency plan to address the risk of failure of any part of the works, and have appropriate materials, equipment and plans available to mitigate against the risks identified.

5.4 Construction risk assessment

The Contractor shall provide the Administrator a comprehensive risk assessment addressing the entire scope of work proposed. This risk assessment must at least address the following:

a) Site establishment, access, and traffic control

b) excavation of trenches and pits

c) design and installation of shoring or other temporary ground support, or drill rig thrust restraint anchor

d) operation of the HDD equipment

e) operation of separation plant

f) work at heights and work in confined spaces

g) potential for damage to infrastructure including structures, public utilities, services and plant

h) immediate and long term settlement and heave resulting from the works

i) flooding and alteration of existing drainage paths

j) interaction with the public, and

k) potential damage to the environment including areas of cultural significance.

5.5 Dilapidation reports

The Contractor is responsible for all pre-construction and post-construction property and infrastructure assessments. These assessments shall be carried out in the presence of the Administrator and certified by RPEQ engineer. Pre-construction assessments shall be submitted to the Administrator for review and acceptance at least 14 days prior to works commencing. **Hold Point 6** Post-construction assessments shall be submitted to the Administrator for review. **Milestone** These assessments shall be a means of determining whether, and to what extent, damage has resulted from the Contractor's operations during the Works. Any damage identified shall be reinstated on a 'like for like' basis at the Contractor's expense.

As a minimum the dilapidation reports shall capture:

a) all work sites and any surrounding area likely to be impacted by the construction activities, including heavy vehicle traffic associated with the works

b) any area within the settlement trough or zone of influence as defined by the Contractors prediction of ground settlement

c) the report must capture the condition of all aspects of the natural and built environment within the nominated areas, including but not limited to building interior and exterior, public utilities and plant, roadways and landscaping, and

d) The condition of any Transport and Main Roads structure shall be recorded according to a Level 2 Bridge Condition Inspection as defined in the department's *Structures Inspection Manual*.

6 Materials and Equipment

Permanent materials are to fully comply with this Technical Specification and the documents referenced herein. The Contractor shall prepare and submit Suppliers Certificates for all permanent materials to be included in the works. **Hold Point 7**

The Contractor shall choose the appropriate pipe material that will fulfil the engineering functionality of the bore. The available pipe materials with respective specifications are outlined in Table 6.

Table 6 – Available HDD pipe materials

Material	Standard/Specification
Fusible Polyvinyl Chloride (F-PVC)	AS 1477, AS 4765
High-density Polyethylene (HDPE)	AS 4130
Steel	ASME B36, AS 2885 (Gas or Petroleum), or equivalent.

Materials for Transport and Main Roads electrical or communications assets shall be in accordance with MRTS91 *Conduits and Pits*.

As per Clause 8.1 of MRTS50 *Specific Quality System Requirements*, no material shall be supplied to or used in the Works until written approval is given by the Administrator.

6.1 Pipe welding and jointing

Steel, High-Density Polyethylene (HDPE) or Fusible Polyvinyl Chloride (PVC) are frequently selected materials for HDD pipeline materials. The Contractor must submit any operational requirements for selected pipe materials, including but not limited to pipe lifespan and allowed loads.

Pipe specifications, weld procedures and welder qualifications are to be provided to the Administrator's Representative for approval prior to procurement of any materials, or commencement of the works. **Hold Point 8**

6.1.1 HDPE pipe

HDPE welding is to be conducted only by pre-qualified welders. HDPE butt welding quality checks are to be completed in accordance with the pipe specification documents referenced in this document, Quality Assurance systems and AS 2033 Installation of Polyethylene Pipelines.

6.1.2 PVC pipe

PVC pipe is to meet the material specifications required by the referenced standards and be of the fusible type, supplied with a manufacturer's recommendation for butt fusion welding.

6.1.3 Steel pipe

Steel pipe is to meet the material specifications required by the referenced standards.

The steel pipe is to be welded by certified welders pre-qualified to undertake the weld procedure and be in accordance with MRTS78 *Fabrication of Steelwork Structures*.

The yield strength and wall thickness of steel pipe is to be selected by the Contractor to take into account the buckling, bending and tensile forces that it will be subjected to in the casing pipe pull.

6.1.4 Steel casing

To provide extra stability to the borehole, or as a requirement of a third party, steel casing may be used.

The steel pipe is to be welded by certified welders pre-qualified to undertake the weld procedure and be in accordance with MRTS78 *Fabrication of Steelwork Structures*.

The yield strength and wall thickness of steel casing is to be selected by the Contractor to take into account the buckling, bending and tensile forces that it will be subjected to in the casing pipe pull.

The Contractor is to verify that there are no weld defects left internally at the joints or misalignment that may cause damage to the carrier pipes or cause issues during installation.

6.2 Pipe stringing

The carrier and / or casing pipes, if possible, shall be strung out and welded in one long string at a location to facilitate ease of insertion into the borehole. All precautions shall be taken to ensure the pipe string is protected from damage.

6.3 Tensile stress

The induced pipe stress shall not exceed the designed tolerances as submitted by the Contractor.

6.4 Pipe thickness

The Contractor shall select a pipe thickness so that the design yield parameters as supplied by the manufacturer are not exceeded in any loading conditions possible during the HDD operation.

6.5 Equipment

All equipment, such as: drilling rig, mud pump, mud mixing, recycling and spoil handling plant must be fit for purpose.

Equipment selection criteria shall be detailed and submitted to the Administrator for approval.

6.6 Drilling Fluids

The Contractor is to use drilling fluid to efficiently support the borehole and carry the cuttings away in suspension to the surface. The drilling fluid is to be water soluble bentonite or polymer that is environmentally safe, biodegradable and conforms to the relevant legislation.

The Contractor must select the appropriate fluid separation system to adequately handle the volume of the drilling fluid.

Spoil disposal methodologies must be submitted to the Administrator for approval.

In the event of a drilling hydrofracture occurrence the Contractor shall employ the approved contingency plan as outlined in Clause 4.3.

7 Construction

7.1 General

A Site supervisor who has experience with and is knowledgeable in the use of the equipment and procedures proposed for the works must be present at the work site at all times whilst the HDD operation is underway.

Protection of the public and worksite shall be established utilising temporary fencing and traffic control devices in accordance with the Queensland *Manual of Uniform Traffic Control Devices* (MUTCD).

All earthworks shall comply with the requirements of MRTS04 *General Earthworks*.

All excavated material is to be disposed of in accordance with MRTS04 and the relevant environmental requirements.

All temporary works are to be demolished and removed from the site following completion of the works, unless otherwise approved by the Administrator.

7.2 Personnel requirements

The Contractor must ensure appropriately trained and experienced personnel are engaged for the delivery of the works. All contractors must hold current licences and qualifications where required. Details of key personal experience and copies of relevant licenses and qualifications shall be provided to the Administrator's Representative for approval before the works commence. **Hold Point 9**

7.3 Utility location

Prior to commencing any excavation or HDD, dial-before-you-dig (DBYD) searches shall be carried out to locate any underground utilities (i.e. gas, sewer, water, fuel, electrical, etc.) in the work area. Once the utilities have been located the Contractor shall engage a licensed service locator to identify the exact location of the utilities by vacuum or hand excavation, when possible, in order to determine the actual location and path of any underground utilities which might be within the HDD path. The Contractor shall not commence excavation or HDD operations until the location of all underground utilities within the work area have been verified and the verification details to be submitted to the Administrator. **Hold Point 10**

7.4 Project execution

The Contractor shall maintain control of Site operations at all times. The Contractor has the ultimate responsibility for the Site safety, the environment, quality workmanship and the satisfactory completion of the work as authorised under the Contract.

The Contractor is to notify the Administrator if any deviations from the original design methodology are required **Witness Point 2**

7.5 Annulus grouting

Outer annulus grouting is undertaken to ensure a uniform contact between the casing pipe and the excavated ground to prevent the ground settlement over time. Outer annulus grouting shall be undertaken unless otherwise approved. The grouting requirement will be reviewed by the Administrator on a case by case basis dependent on the ground conditions and type of installation.

Where grouting is required the Contractor is to submit a grouting procedure for approval before the commencement of work. A cementitious material should be used and the grouting pressure should not exceed the P_{max} and any pressure limitation of the carrier pipe.

Grout used shall obtain a minimum strength of 1 MPa at 48 hrs. Previous performance of the grout mix design shall be demonstrated to the Administrator before use.

7.6 Drilling, reaming and conditioning

The Contractor shall incrementally perform drilling tasks to prepare the bore hole for the pipe pull. The process shall be in the following stages:

a) Drill and steer the pilot hole along the approved alignment

b) Ream the pilot hole out to the specified diameter as per the Contractor's design and guide shown in Table 7.6, and

c) Condition and clean the borehole until the Contractor and the Administrators' representative is satisfied that the hole is clean and ready for the casing pipe pull.

Upon successful completion of pilot hole and acceptance by the Administrator, the Contractor (if required) shall ream the bore hole, using the appropriate HDD tooling, to a size recommended by Table 7.6 below. **Witness Point 3**

Reaming tools are to be in good working order and appropriate to the ground conditions indicated.

Table 7.6 – Product diameter and reamed diameter recommended relationships (NASTT 2008)

Product Diameter	Reamed Diameter
< 8" (< 200 mm)	Diameter of product plus 4" (100 mm)
8" - 24" (200 mm – 600 mm)	1.5 times diameter of product
> 24" (> 600 mm)	Diameter of product plus 12" (300 mm)

7.7 Monitoring and Reporting

A reporting and auditing schedule in accordance with MRTS50 *Specific Quality System Requirements*, must be prepared by the Contractor and provided to the Administrator for review prior to commencing the Works. **Witness Point 3**

During the HDD works the Contractor is to provide the following records: **Milestone**

a) drill rig Log, (pilot, reaming and hole conditioning stages)

b) steering Log

c) pipe pull back logs (casing and carrier)

d) grouting logs (if required)

e) plotted bore path as-built alignment

f) pipe welding logs, and

g) drilling fluid logs (type used, volumes, losses).

7.8 Instrumentation and monitoring

Geotechnical instrumentation and monitoring shall be undertaken where infrastructure assets could be affected by the proposed HDD works. The proposed monitoring regime, including the frequency of monitoring and post construction monitoring (where applicable) shall be defined in the design documentation. This shall be submitted for review to the Administrator before the commencement of Work. Normally survey monitoring of ground deformations is considered acceptable, and this monitoring over carriageways shall consider:

a) survey markers at the edges of the shoulder points, edges of the pavements, each line marking, and otherwise at 3 m intervals along the HDD centreline

b) a baseline survey must be performed prior to commencement of any HDD operations. During critical drilling activities survey shall be performed daily, until the zone of active excavation has passed and no further movement is detected, and

c) baseline measurements must be forwarded to the Administrator and accepted before commencement of any works on Site.

Reporting of ground deformations to the Administrator shall be in accordance with the agreed instrumentation and monitoring plan. The monitoring plan shall specify the trigger levels, trigger level criteria, responsible persons and actions required. A notification trigger criteria shall be defined, typically being as follows:

a) no action – if deformations are less than 80% of the agreed values, excavation can continue

b) action – if deformations are greater than 80% but less than 100% of the agreed values then the Administrator shall be notified within 24 hrs. The frequency of monitoring shall be increased, and

c) alarm – if the deformations are greater than the agreed values, the Administrator and key personnel (as outlined in the Monitoring Plan) shall be notified immediately and the excavation works shall be stopped until a mitigation strategy is agreed upon.

7.9 Acid sulfate soils

Prior to undertaking any works onsite an investigation to identify the possible presence of acid sulfate soils shall be undertaken according to MRTS04 *General Earthworks*. Where acid sulfate soils are identified, the requirements detailed in MRTS04 *General Earthworks* shall be followed.

7.10 Remediation of disturbed areas

Any area disturbed by the works shall be replaced/reinstated on a 'like for like' basis in accordance with the relevant Technical Specification. These include MRTS04 General Earthworks, MRTS03 *Drainage, Retaining Structures and Protective Treatments*, and MRTS16 *Landscape and Revegetation Works.*

All disturbed areas must be backfilled or excavated to return the area to the level of the natural ground surface that was present prior to the works being undertaken, unless approved otherwise and shown on the Standard Drawings.

All excess spoil shall be removed from site upon completion of the works and disposed of in accordance with the relevant regulations.

8 Tolerances

The HDD bore path must follow the approved designed alignment and conform to the allowable tolerances depicted in Table 8 below unless otherwise specified by the Administrator.

Table 8 – Horizontal Directional Drilling tolerances

	Tolerance
Distance from planned surface exit	Within 1 m
Horizontal	± 500 mm
Vertical	± 500 mm

These tolerances are understood to be achievable by all combinations off HDD equipment currently available bore diameter and bore length achievable and geological conditions are likely to be encountered. More stringent limits / tolerances may be specified by the Administrator or third party utility service owner taking into account the specific installation conditions and outcomes required.

9 As constructed records

The Contractor shall provide the following as constructed records to the Administrator in relation to each HDD bore, no later than 10 days after completion of the works: **Milestone**

a) as built survey record of the completed HDD bore, including steering records from during installation

b) grouting records (if carried out)

c) ground deformation monitoring records, including final measurements taken once no further movement is recorded, and

d) final dilapidation report capturing all area's disturbed by the works, providing photographic evidence that all required remediation has been completed.

10 Critical HDD crossings

A critical HDD crossing is defined as a crossing where the risks associated with the proposed crossing are deemed to be higher and therefore there is a requirement for more detailed analysis during design, certification of the design and a heightened level of documentation and record keeping during construction.

The Administrator will nominate whether a crossing is "critical" and in such instance the Contractor must address the additional requirements outlined in Clause 10 of this Technical Specification.

The Administrator shall seek the advice of the Transport and Main Roads Pavements Materials and Geotechnical branch when assessing the requirement for a proposed crossing to be deemed critical.

10.1 Design of critical HDD crossings

All design elements, outlined in Clause 5.2 of this Technical Specification, are to be certified by a Registered Professional Engineer of Queensland (RPEQ) having suitable experience in the field of Horizontal Directional Drilling and shall be submitted to the Administrator's Representative for review prior to commencement of any work.

The additional design drawings to be certified are outlined in Table 10.1.

Table 10.1 – Additional design drawing requirements

Drawing Description	Drawing Detail	RPEQ Signoff
HDD Over Bend Details	Plan + Elevation	Required

10.2 Governing documentation for critical HDD crossings

The Contractor is to submit a settlement management plan four weeks prior to the commencement of any work to the Administrator. **Milestone**

10.3 Critical HDD crossing personnel requirements

Where deemed "critical" the personnel requirements as outlined in Clause 7.2 of this Technical Specification will be amended to the requirements as outlined in Table 10.3.

Table 10.3 – Key HDD personnel training and experience

HDD Role	Training / Qualification	Experience in Role (Years)
HDD Driller	Rig and fluid training	3
HDD Engineer	Min higher Education Diploma	2
HDD Mudman	Fluid training/bore tracking	1
HDD Steerer	Survey equipment training	2
HDD Supervisor	Rig and fluid training	5
Project Manager	Min Higher Education Diploma	5

10.4 Critical HDD crossing project execution

Where deemed "critical" the monitoring and reporting requirements as outlined in Clause 7.7 of this Technical Specification will be amended to the requirements as outlined in 10.4.

Table 10.4 – Required technical HDD information records

HDD Record / Report	Included Information	Handover Frequency / Details
Annular Pressure Graph	Pmin, Pmax and Pactual. Bore Profile, ground level	By noon the next day
Drilling Fluid Logs	Type, volume, and records of losses	By noon the next day
Filling and Pre-Hydro Test Logs	Water quantity, time and pressure	By noon the next day
Grouting Logs	Grout Quality, time and pressure	By noon the next day
Pipe Pull Back Logs (Casing and Carrier)	Rod time, torque and carriage forces. Fluid Comments.	By noon the next day
Plotted Pilot Hole As-built (real time)	Plotted as-built bore path relative to the designed and planned bore path	By noon the next day
Rate of Penetration Chart (ROP)	Rod cutting time. Face Time. Rig gear forces. Bit size	By noon the next day
Rig Log (Pilot, Reaming and Conditioning)	Rod time, torque and carriage forces. Geology and fluid comments (returns / losses)	By noon the next day
Settlement Logs	Details of settlement or heave along the HDD alignment	Daily
Steering Log	Azimuth, length and inclination. 3 & 10 joint checks. Position to be referenced to the designed alignment.	By noon the next day
Welding Logs	Welder, weld type, number, date, if tested and rods used	By noon the next day

10.5 Drilling fluids for critical HDD installations

The Contractor is to use drilling fluid to efficiently support the borehole and carry the cuttings away in solution to the surface.

Fluid design, performance and monitoring are the responsibility of the Contractor. The Contractor is to submit a Fluid Design and Management Procedure that details the design and required functionality of the fluid to the Administrator prior to the commencement of any works. **Hold Point 3**

The Contractor is to test the drill fluid a minimum of three times a shift to ensure optimum performance.

The Contractor is to test and verify the fluid against the design in the following areas:

a) viscosity

b) pH

c) fluid weight

d) gel strength

e) fluid loss

f) water hardness, and

g) calcium content.

All drilling fluids are to adhere to Clause 6.6 of this Technical Specification.

10.6 Annular pressure monitoring for critical HDD installations

The Contractor's design must include a theoretical calculation of hydrofracture for each point along the crossing alignment. This calculation is to be graphed against chainage and vertical elevation. The graph is to include plotted lines representing the following parameters:

a) the topographic surface

b) the vertical bore hole alignment

c) the minimum pressure required to create fluid returns in the entry pit (P_{min})

d) the maximum allowable pressure could the geology can withstand without hydrofracturing (P_{max}), and

e) the Contractor's design must prove that P_{min} will remain lower than P_{max}, including a minimum factor of safety allowance of 2.0.

The Contractor must monitor annular pressure during the pilot hole operation and supply real time annular pressure plots showing theoretical vs actual.

It is the Contractors responsibility to implement suitable risk averse precautionary measures if P_{actual} approaches P_{max}.