Civil Engineering Technical Requirement
CIVIL-SR-016

SERVICES UNDER RAILWAY PROPERTY
(Non-Queensland Rail Services)

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INTRODUCTION

This Technical Requirement details the criteria which must be met by:

- external service owners,
- Queensland Rail and external authorities where the service is jointly owned, and
- external service owners where Queensland Rail uses a proportion of the service, where the services are to traverse Queensland Rail’s property and / or pass under railway tracks.

The requirements for solely Queensland Rail-owned services on Queensland Rail’s property are covered in Technical Requirement CIVIL-SR-17 or the General Signalling Specification GSS Part 6 “Cable Route Construction, Cables and Cable Installation”.

Although the relevant Australian Standards for undertrack service crossings are used as the basis for this Technical Requirement, a number of special measures are required. These are to increase the level of safety for the railway as well as for field staff performing future excavation work in the vicinity of those crossings. Increased depths below the track and natural ground surface or the provision of stronger encasing pipes are required to minimise the potential dangers caused by combustible, high pressure or high voltage services.

Those additional measures have been determined from past experience with undertrack excavation failures, associated problems and the need to perform the work in and around the operating railway.

The interaction of Queensland Rail’s track protection staff and the drilling / boring operators is described. A fundamental measure for preventing railway traffic damage and derailment is continuous observation by contractors’ and Queensland Rail’s staff during the excavation work under and in the vicinity of the tracks. Any variation from the pre-existing track geometry will be immediately assessed by Queensland Rail’s staff on site for the necessary imposition of traffic restrictions and follow-up remedial trackwork.

The minimum depths of services below the track have generally been increased over the Australian Standard’s minimum requirements in order to decrease the effects of the bore on the surface and to improve safety for future excavation work in the area.

A range of drilling / boring / tunnelling / pipe ramming / trenching methods are available and it will remain the responsibility of the service provider and contractor to determine the most appropriate method for each job site subject to appropriate geotechnical assessment. The method chosen and the appropriate controls must aim to eliminate the possibility of lifting / lowering / altering the track geometry in any way.

Wet boring (high pressure water drilling) must not be used under any circumstances.

Where this Technical Requirement prescribes a higher degree of protection than any other standard, including Australian Standards, then this document will take precedence.
2 ALL TYPES OF UNDERTRACK SERVICES

2.1 Queensland Rail’s Costs to be covered by Service Owner

All of Queensland Rail’s costs associated with the work and the implementation of these Technical Requirements will be charged to the service owner or its agent. This includes any remedial work necessary to the track and trackside drains as a result of this work and any accidental damage, as well as costs associated with train delays. Rates will be set by Queensland Rail.

2.2 Australian Standards and Codes of Practice

AS 4799 “Installation of underground utility services and pipelines within railway boundaries” provides for the minimum requirements, while also allowing the railway authority to impose those additional safety matters described in this Technical Requirement.

Water Services Association of Australia provides guidance for undertrack crossings by water and sewer pipes through their “Water Supply Code of Australia” and “Sewerage Code of Australia”.

AS 1289 “Methods of testing soils for engineering purposes” provides information for the compaction of backfill where a service has been installed in a trench.

The requirements for the design, operation and maintenance of gas and fuel pipelines as they relate to this Technical Requirement are covered by:
- AS 2885.1 “Pipelines – Gas and liquid petroleum – Design and construction”,
- AS 2885.3 “Pipelines – Gas and liquid petroleum – Operation and maintenance”,
- AS/NZS 4645.1 “Gas distribution networks – Network management”,
- AS/NZS 4645.2 “Gas distribution networks – Steel pipe systems”, and
- AS 2832.1 “Cathodic protection of metals – Pipes and cables”.

2.3 Safety during Service Installation and Maintenance

It is the responsibility of the service owner / its agent to perform safely all work associated with the installation and maintenance of the service.

The following additional Technical Requirements must be satisfied while all workers are on Queensland Rail’s property:
- CIVIL-SR-002 “Requirements for work in or about Queensland Rail’s property”, and
- CIVIL-SR-003 “Requirements for work adjacent to overhead line equipment” (if appropriate).

2.4 Orientation, Location and Depth of Services

All externally-owned services should be orientated in plan to pass through Queensland Rail’s property in a straight line and within approximately 5° of 90° to the track centreline. 90° was chosen so that any future subsidence or heave along the line of the service will not create a rolling effect between the rails which would cause a derailment. This restriction may be relaxed in exceptional circumstances at the discretion of the Rail Infrastructure Manager if the depth of the service is greater than 4 m below formation level or if geotechnical investigation shows that the bore will be self-supporting under railway loads.

For a service which Queensland Rail jointly owns or where Queensland Rail uses an externally-owned service, and where that service runs along the corridor, the alignment will be:
- within approx. 1 m of the boundary fence,
- more than 6 m from the toe of a bank or top of a cutting, and
- more than 10 m from the nearest rail.

These conditions also apply in exceptional circumstances, where externally-owned services may be permitted to run along the corridor. Permission may be given at the discretion of the Rail Infrastructure Manager. These conditions are so that the service will generally be clear of future Queensland Rail developments.
No services should pass within 5 m horizontally of any infrastructure foundation or pipe / culvert (cross-track drainage). If this is impractical in a specific location, the details of the situation need to be presented to the Rail Infrastructure Manager for a determination based on the nature of the footing and the diameter of the pipe.

No services are to be located under track turnouts or crossovers. Any future subsidence or heave under these critical areas would cause a derailment.

Services are only permitted to pass under level crossings with the bitumen / road surface remaining in place, if installation is by pipe ramming. If any other method is used, the road surface must first be removed and then replaced after the service installation has been completed. This restriction is because experience has shown that holes can appear below the bitumen / road surface without being detected by survey checks of rail level. The subsidence only becomes apparent under the passage of the next train.

The minimum clear horizontal distance between an existing service and a new service must be greater than 2 m. For the situation where a new service is to be 2 m – 3 m from a gas pipeline, the owner of the new service must first obtain a permit / approval from the owner of the gas pipeline (copy to Queensland Rail). For new services being installed in a group, it is preferable to combine all services into a single enveloping pipe. For a number of bores in a group, the minimum clear horizontal distance between enveloping pipes within the group must be 2 m.

Non-Queensland Rail services must be at a depth greater than 2 m below both formation level and ground level. Depths less than 2 m are reserved for Queensland Rail’s services and activities. The required minimum depth (2 m or greater) depends on the nature of the service (Section 2.7); its method of installation (Section 3); the effect on the track should the service fail; and the safety issues associated with future excavation work.

No service will be allowed vertically above / below and parallel to another service or an existing service.

Where a new service is to pass above / below an existing service, where they are not parallel (usually at 90°), a vertical clearance typically greater than 300 mm should be achieved. The owner of the new service must contact the existing service owner for a determination of the required clearance in each case. This clearance will depend on the accuracy of the installation method (trench, laser guided micro-tunnelling, etc.) and the nature of the crossing (gas, water, fibre optic cables, etc.).
No manholes, chambers, pits or anchor blocks are to be installed in Queensland Rail’s property as part of services solely owned by non-Queensland Rail authorities. For pipelines carrying liquids under pressure, a valve is to be installed in the pipeline (on the inlet side) outside of Queensland Rail’s boundary.

The contractor is responsible for determining the exact locations of all underground services in the vicinity of the proposed work. The approximate locations of Queensland Rail-owned services will be provided in response to the contractor’s application. It should be noted that many of Queensland Rail’s services (water, sewerage, electrical, signalling, etc.) were installed many years ago and do not have permanent markers showing their locations and have not been installed at right angles to the track and at the minimum depths below the track as nominated in AS 4799.

### 2.5 Entry and Exit Pits / Shafts

For drilling / boring / tunnelling methods, entry and exit pits are to be outside of Queensland Rail’s property. For safety reasons, the movement of the contractor’s staff on Queensland Rail’s property is to be minimised.

In exceptional circumstances, pits / shafts may be permitted in Queensland Rail’s property at the discretion of the Rail Infrastructure Manager subject to site-specific railway traffic protection requirements. After the installation of the service, the pits / shafts are to be backfilled with material appropriate to the nature of the surrounding soil / rock:

- If the pit / shaft will be free draining, the backfill material may be fine crushed rock, sand, gravel, lean mix concrete or other material approved by the Rail Infrastructure Manager. The backfill is to be compacted to 90% of the maximum dry density (Modified Compaction Test) up to 600 mm below formation / ground level. The top 600 mm is to be compacted to 95% of the maximum dry density (Modified Compaction Test). This is to be in accordance with AS 1289.E2.1. The fill is to be placed and then compacted in 300 mm layers.

- If the pit / shaft is non-draining, e.g. impervious rock, the backfill material is to be impermeable when compacted. Cement stabilised sand (2% cement) may be used or other material approved by the Rail Infrastructure Manager. The backfill is to be compacted to 95% of the maximum dry
density (Modified Compaction Test). This is to be in accordance with AS 1289.E2.1. The fill is to be placed and then compacted in 300 mm layers.

2.6 Geotechnical Advice

For bore holes / tunnels greater than 150 mm dia. and prior to any excavation work commencing on site, the service owner / its agent is required to obtain a geotechnical assessment of the ground conditions (soil types and depth of water table) over the length of the bore. For smaller diameter holes, this advice can be sought at the discretion of the service owner / its agent. This information is to be used by the service owner / its agent to determine the most suitable method for the work and the detailed equipment requirements to successfully complete the bore without causing any disruption to the track and ground surface.

The service owner must make the contractor aware that obstacles, such as large rocks, old rails and old timber bridge piers, may be encountered while excavating through railway embankments or areas of fill. Problems have also been encountered where the bore has broken into loose material, e.g. ballast, causing the loose material to run freely into the bore, creating a sink hole / subsidence at the surface.

If exploratory vertical bore holes are to be sunk, they must not be on the line of the bore / tunnel. They must be properly backfilled and sealed.

2.7 Future Track Safety and Protection of Services from Excavations

Special requirements are to apply to services which have the ability to cause damage to the ground surface and track should they fail (leak / rupture / break / collapse) or to create a dangerous situation in the event of future excavations damaging the service.

These measures involve:
- using an impact-resistant enveloping pipe, or
- installing a concrete slab and warning tapes above the service (trench installation only), or
- increasing the depth of the top of the bore to more than 3 m below both the top of the railway formation (underside of ballast) and the ground surface level, and apply to the full length of the service under Queensland Rail's property.

Enveloping Pipes

A suitable enveloping pipe provides an additional level of safety:
- against rupture from future excavation work or deterioration of the carrier pipe which would allow the escape of combustible gases / liquids or pressurised water into the track area, and
- in the case of sewers and stormwater drains, against erosion of the soil around a break in the pipe and the formation of a cavity leading to a sink hole / subsidence under the track.

Where a suitable enveloping pipe is used, grouting may be required outside (depending on the method of installation), but not necessarily inside the enveloping pipe. This allows for the future replacement of the carrier pipe if necessary. The ends of the enveloping pipe are to be sealed.

In the case of a steel enveloping pipe (subject to corrosion because of soil contact):
- cathodic protection must be established and maintained for the life of the service, and
- the enveloping pipe must be grouted both externally and internally.

The enveloping pipe must be able to withstand the impact of an excavator, e.g. a Class 4 concrete pipe or a steel enveloping pipe grouted outside would be suitable. Plastic materials are generally not suitable, however HDPE pipe with impact resistance of PN20 and material PE100 would be acceptable. Enveloping pipes made from other materials may be submitted to the Rail Infrastructure Manager for comment on suitability / acceptability.

Slab Protection

For gas and liquid fuel lines and electrical conduits (all with or without an enveloping pipe) to be installed at a depth of 2 m – 3 m, the service must be installed in a trench and protected from future excavation by a concrete protection slab and buried warning tapes.
**Increased Depth**

For gas and liquid fuel lines and electrical conduits, if the provision of an impact resistant enveloping pipe or concrete protection slab is impractical in a specific location / application, the depth of the service must be increased to more than 3 m below both formation level and ground level in an attempt to eliminate the possibility of future accidental damage.

To ensure that this depth of cover is maintained where the pipe passes under a water course / gully / drain, the service owner is to perform regular inspections for erosion above the pipe. Typically, additional inspections would be required after heavy rains where erosion is occurring. Any decrease in the cover will require the service owner to arrange for remedial earthworks to restore cover and to stabilise the soil against further erosion.

**2.7.1 Water Supply, Sewers and Stormwater Drains**

Track safety can be compromised in the future by the failure of these services.

A suitable enveloping pipe must always be used with these services, irrespective of the depth. In the case of pressurised services, e.g. water supply or rising sewer mains, the enveloping pipe adds an extra level of safety against pressurised liquid finding its way to the surface, causing erosion of the formation / ballast, striking the underside of trains or interfering with the overhead electrical traction wiring. In the case of pipes which do not flow full, e.g. gravity sewers or stormwater drains, the enveloping pipe is to prevent sink holes / subsidence forming should a piece break out of the carrier pipe.

**2.7.2 Electrical Power Cables**

These requirements apply to both low and high voltage cables.

The requirements for the various methods of installation are:

- **Trench** …. This method is suitable for HDPE conduits where the top of a protection slab (above the conduits) is between 2 m and 3 m depth below both formation level and ground level. An enveloping pipe is not required in this case. Protection from future excavation will be achieved by the use of a protection slab similar to that described in AS 4799. The slab is to be a minimum of 150 mm thick reinforced concrete designed to resist excavator impact. It is to be 1000 mm greater in width than the group of conduits and is to be placed centrally over the conduits. Electrical warning tapes are also to be used. The minimum depth of the top of the conduits below the underside of the slab is to be 300 mm. Groups of conduits below the slab are to be protected by backfilling the trench with flowable grout (approx. 2 MPa) up to a minimum of 300 mm above the uppermost conduit.

- **Directional drilling** …. HDPE conduits (without an enveloping pipe) may be used where the depth of the top of the bore is greater than 3 m below both formation level and ground level. The conduits are to be installed within a single bore with a maximum diameter of 350 mm. If a larger bore is necessary, a different installation method must be used. An enveloping pipe is not essential in this case.

- **Pipe jacking / tunnel boring / micro-tunnelling / pipe ramming** …. These methods can be used to install a suitable impact-resistant enveloping pipe, e.g. HDPE, steel or concrete. The top of the bore must be greater than 2 m below both formation level and ground level.

HDPE conduits are to be at least designation PN12.5 and material PE100. The HDPE enveloping pipe is to be at least designation PN20 and material PE100.

Steel enveloping pipes are to be grouted inside and outside, as well as having cathodic protection in accordance with Section 2.7 Enveloping Pipes.

Concrete enveloping pipes are to be Class 4 and grouted inside and outside.
Figure 2: Vertical Sections Showing Electrical Power Services Under the Railway Corridor
2.7.3 Gas Pipelines

Gas carrier pipes are usually made from either high density polyethylene (HDPE) or steel coated with a protective film.

**HDPE Gas Carrier Pipe**

An enveloping pipe of HDPE, concrete or steel is required to be used for the full length of the service under Queensland Rail’s property, irrespective of the depth.

A HDPE enveloping pipe is to be at least designation PN20 and material PE100, with the space between the gas pipe and the enveloping pipe is to be sealed and vented at the ends outside of Queensland Rail’s property. The vent pipes are to be clear of and not attached to the boundary fence.

Steel enveloping pipes are to be grouted inside and outside, as well as having cathodic protection, in accordance with Section 2.7 Enveloping Pipes above.

Concrete enveloping pipes are to be Class 4 and grouted inside and outside.

The requirements for the various methods of installation are:

- **Trench** .... This method is suitable for a HDPE enveloping pipe protected from above by a concrete slab where the top of the slab is between 2 m and 3 m below formation level and ground level. Protection from future excavation will be achieved by the use of a protection slab similar to that described in AS 4799. The slab is to be a minimum of 150 mm thick reinforced concrete designed to resist excavator impact. It is to be 1000 mm greater in width than the enveloping pipe and is to be placed centrally over it. Warning tapes are also to be used. The minimum depth of the top of the enveloping pipe below the underside of the slab is to be 300 mm. The gas line below the slab is to be protected by backfilling the trench with min. 20 MPa mass concrete up to a minimum of 300 mm above the top of the enveloping pipe.

- **Directional drilling** .... HDPE may be used for the enveloping pipe where the depth of the top of the bore is greater than 3 m below both formation level and ground level. The maximum diameter of the bore is to be 350 mm. If a larger bore is necessary, a different method must be used.

- **Pipe jacking / tunnel boring / micro-tunnelling / pipe ramming** .... These methods can be used to install a suitable impact-resistant enveloping pipe, e.g. HDPE, steel or concrete. The top of the bore must be greater than 3 m below both formation level and ground level.
Figure 3: Enveloping Pipe and Venting Arrangement- Underground Gas Pipeline

Courtesy of APA Group

Installation in a Trench
(section through trench)
Installation by All Non-trenching Methods
(section through bore)

Figure 4: Vertical Sections Showing Gas Line Under the Railway Corridor

Steel Gas Carrier Pipe

Steel pipes are generally used for the carriage of high pressure gas. These installations may or may not be designed to use an enveloping pipe. Typically, an enveloping pipe could be a fully grouted (inside and outside) Class 4 concrete pipe. For pipelines without an enveloping pipe, the protective coating needs to provide greater protection from corrosion and abrasion than if an enveloping pipe had been used.

Steel gas pipelines must be designed, constructed and maintained in accordance with AS 4799, as well as AS 2885 or AS 4645, as applicable. The steel carrier pipe’s strength, wall thickness and depth are to be sufficient to resist all expected stresses, including internal gas pressure, bending stress during installation, and the worst case for railway and soil loading. The Registered Professional Engineer of Australia (RPEQ) engaged by the pipeline owner is to provide confirmation that the design meets all of these requirements.

As part of the design process for each installation within railway property, the pipeline owner must conduct a risk assessment in accordance with AS 2885. The risk assessment is to document the threats confronting the particular pipeline as it crosses under railway property. It needs to identify the threats, evaluate each threat and analyse the likely consequences. The Rail Infrastructure Manager is to be given the option of attending the risk assessment to ensure that all threats are identified and reduced to acceptable levels. In response to this information, the pipeline owner is to detail and document the design, the physical protection and procedural measures that will be used during and after installation in order to mitigate these threats. A copy of the risk assessment document is to be provided to Queensland Rail.

For services without an enveloping pipe, if additional protection on either side of the tracks is required to ensure safety from future excavator activity because of the site conditions, warning tapes and a concrete protection slab are to be installed in a similar arrangement to Figure 4, but with the following differences. The protection slab and marker board / tape are to be installed above the pipeline between the property boundary and a point 1 m from the ends of the sleepers (both sides of the tracks). The slab would be 800 mm - 1 m below ground level, 1.2 m greater in width than the pipe’s diameter, and placed centrally over it.

To provide protection against corrosion, the carrier pipe must have both a durable coating, as well as cathodic protection.
The coating is to be of sufficient thickness and hardness to prevent any damage to the coating during installation. An abrasive resistant protective coating of greater thickness than required by the relevant Australian Standard is required for a carrier pipe installed without an enveloping pipe. Coating continuity tests, e.g. a Jeep / Holiday inspection, are to be performed to identify any defects before installation of the pipe, and again after the pipeline is in place to check whether the coating has been damaged during installation.

The cathodic protection system is to satisfy AS 2832.1. There is to be a test point outside the railway property boundary, adjacent to the gas pipeline marker post.

The pipeline owner must certify (copy to Queensland Rail) that it will conduct regular tests:
- of the cathodic protection, at least every 6 months,
- a leak survey at least every 6 months, and
- regular checks on the integrity of the pipeline.

The pipeline owner is to have protocols in place so that Queensland Rail is advised if the ongoing mitigation measures remain effective. The Rail Infrastructure Manager is to be provided with copies of the results of these tests, surveys and patrols of the crossings. The pipeline owner is to advise Queensland Rail if any actions are necessary to maintain the pipeline’s integrity.

If a steel enveloping pipe is to be used, it must be grouted inside and outside, as well as having cathodic protection, in accordance with Section 2.7 Enveloping Pipe.

The requirements for the various methods of installation are the same as for “PE Gas Carrier Pipe” above.

2.8 Boreholes below the Water Table

Excavation below the water table can greatly increase the likelihood of subsidence or heave at the surface. In those excavation methods where it is necessary to balance the hydrostatic pressure of the groundwater against the pressurised slurry inside the bore, the risk to track safety is unacceptable and the work must be performed during a track closure.

The service owner must be informed of its liability for injuries and the cost of repairs resulting from any damage to railway property and for any disruption to train services. This cost can be substantial.

The preferred installation method in this situation is pipe ramming, where the spoil is not removed until the enveloping pipe is fully in place. A track closure would not be required.

2.9 On-site QR Involvement

Before work commences, an on-site meeting is to be held between a Queensland Rail representative (usually the Track Maintenance Supervisor) and the contractor. The contractor is to explain all details of the work and also present the Work Method Statement (Track Safety).

The Rail Infrastructure Manager will conduct field audits during the progress of the work to check on compliance with the Work Method Statement (Track Safety).

A Track Protection Officer is required to be on site at all times while the contractor is on Queensland Rail property.

The Rail Infrastructure Maintainer will appoint a track competent person to be on site at all times while undertrack work is being performed under or within 3 m horizontally of the outer edge of the ballast on the railway tracks. The role of the track competent person will be:
- to observe the work,
- to ensure the safety of railway traffic by assessing any changes in the track alignment / level and applying a speed restriction / closure / other formal operational control if required,
- for pipes greater than 600 mm dia., to arrange for inspections of the site while running the road, checking for any changes in the track alignment / level during the week after the completion of work, and
- to arrange for repairs, should any settlement / heave / alignment problems occur in the track.
Undertrack work by the contractor must not proceed unless the track competent person and Track Protection Officer are on site.

The Track Maintenance Supervisor is to inform the local track maintenance gang of the location and timing of the service installation.

Speed restrictions for trains crossing the bore should be applied by the Rail Infrastructure Maintainer during the work according to the following:

- From the time that the excavation reaches a point 3 m horizontally from the outer edge of the ballast on the closest railway track until the work is fully completed, including grouting: 25 km/hr. The purpose of this speed restriction is to reduce vibrations and pressure exerted on the bore and the boring equipment, as well as to minimise the damage resulting from a train derailing on misaligned track (heave / subsidence) above the bore.
- A speed restriction of 50 km/hr is to be applied for 24 hrs after completion of the work for pipes greater than 600 mm diameter only. This allows for any delayed settlement or heave as the result of having introduced water to the surrounding soil.
- The support of the bore needs to be complete before this speed restriction is removed.
- The purpose of this speed restriction is to reduce vibrations and pressure exerted on the bore and the boring equipment, as well as to minimise the damage resulting from a train derailing on misaligned track (heave / subsidence) above the bore.
- The above requirements for speed restrictions may be relaxed in exceptional circumstances at the discretion of the Rail Infrastructure Manager based on geotechnical advice that the depth of the service and the material are such that the track alignment will be isolated from any defects occurring in the bore.

2.10 Track Monitoring

The track competent person on site will observe the work and take any appropriate actions to ensure the safety of railway traffic.

The contractor is responsible for engaging a suitably qualified surveyor (registered with the Surveyors' Board) to monitor the alignment and level of each track at the service crossing. For example, if the service passes under four tracks, each track is to be monitored.

The requirements for track monitoring during the work are as follows:

- Survey marks are to be established in pairs on sleepers along each track, one on each side of the rails of each track. The marks need to be on the sleepers closest to the centre-line of the pipe, and then at 2 m, 5 m, 8 m and 10 m away from the pipe in both directions along each track.
- Prior to the start of excavations, the surveyor must take the datum readings for alignment and level.
- While the bore is under and within 3 m horizontally of the track ballast, the surveyor must take readings between 15 and 40 minutes prior to the passage of every train across the bore.
- Readings need to be taken using a Total Station surveying instrument (for alignment and level) and / or a Spirit Level (for level). The surveyor must check the results immediately against the datum readings.
- Any deviation from the datum must be reported to the track competent person immediately, so that they can assess the situation and implement any necessary actions to protect railway traffic.
- If the track competent person is not on site and a deviation from the datum in excess of 15 mm is observed, this must be reported by telephone / radio to Queensland Rail Control immediately with a request to stop trains running through the site. Excavation work must also stop. Trains and excavation are not to resume until the situation has been assessed by a track competent person and the required actions have been completed.
- After remedial works to track / formation / drainage have been performed, further monitoring of the situation will be required until all movement has stabilised.
Monitoring by the contractor is to be continued after the completion of the work in case of settlement or lift in the following situations:

- pipes greater than 600 mm dia. (all installation methods),
- all directional drilling and micro-tunnelling installations (all pipe diameters) where the bore has passed through expansive clays. The contractor is to advise the Rail infrastructure Manager of the presence of this type of clay.

Readings are to be taken after each of the next three trains, at the end of the next day, and then after another 2 days.

2.11 Permanent Markers

The Contractor is to provide permanent markers at Queensland Rail’s property boundaries directly above the service as described in AS 4799. These markers will remain the property of the service owner and it will be their responsibility to maintain them in good condition and to make any replacements as required.

The Rail Infrastructure Manager will:

- Check the installation of the markers,
- Maintain a register of the locations and nature of all services under Queensland Rail’s property for its own use, and
- Conduct future regular inspections in accordance with the Civil Engineering Structures Standard MD-10-586.

2.12 As Constructed Drawings

As constructed plan and section drawings (in electronic pdf format), showing the vertical and horizontal alignment of the service in relation to the ground surface, railway track and all infrastructure within approx. 10 m of the service, as well as the railway km and line (e.g. 610.450 km Western Line), shall be submitted to Queensland Rail’s Property Section within 30 working days after practical completion of the service installation for permanent storage.
3 METHODS OF INSTALLATION

3.1 Directional Drilling

The process of directional drilling involves a number of drilling and reaming runs before the enveloping pipe is installed in the bore. A pilot hole is first drilled from the entry pit to the exit pit. This is followed by a number of cuts with reamers of increasing size until the final diameter is reached. The enveloping pipe with a diameter smaller than the bore is then pulled through the bore. At the completion of the work, the annulus between the enveloping pipe and the bore remains filled with a clay slurry. If a drilling / reaming run is interrupted for more than 2 days before running the full length of the bore, precautions must be taken to prevent the equipment from seizing in the bore.

During drilling, reaming and pipe installation, a specially designed slurry is pumped at high pressure through the drill pipes to the cutting head, from where it is forced back along the outside of the pipes, thereby clearing away the cuttings and providing some support to the bore. A potential problem exists if the bore becomes suddenly obstructed and the slurry pressure rises rapidly. The slurry either lifts the ground surface (including the track) or it breaks through to the surface in a fissure. Because of this problem and the serious implications for railway traffic, directional drilling requires strict operational controls.

It should be noted that certain soil types, e.g. clays, appear to be more prone to lifting of the surface. From Queensland Rail’s experience, it is clear that this can occur despite reasonable controls and vigilance on the part of the operator of the equipment. Consequently, for directional drilling it is expected that track alignment problems will occasionally occur. To control the consequences and prevent derailments, it is imperative that track monitoring procedures and the requirements of Section 2.10 are fully in place.

At all times during the work, the contractor must remain vigilant to the slurry and water pressures and the return flow from the bore to ensure that the bore remains clear. The pressure must not be allowed to increase to a level which will cause track heave.

AS 4799 does not cover the specific requirements for this type of work.

The following special conditions shall apply:

- Only pipes with a diameter up to and including 250 mm (max. hole dia. 350 mm) are permitted to be installed using directional drilling. This value has been set as larger diameter bores have an increased potential to cause surface heave if a blockage should occur. Larger pipes are to be installed by boring and pipe jacking, micro-tunnelling, pipe ramming or trenching as approved by the Rail Infrastructure Manager.

- Under the track and within 3 m horizontally of the outer edge of the track ballast, the minimum depth of the top of the bore is to be 3 m below the top of railway formation (underside of ballast). This value has been set in an attempt to limit the amount of surface heave if a blockage should occur. This depth restriction may be relaxed in exceptional circumstances at the discretion of the Rail Infrastructure Manager if specific site conditions and service arrangements make this requirement impractical.

- From the Queensland Rail boundary to 3 m horizontally from the outer edge of the track ballast, the minimum depth of the top of the bore will be 2 m below ground surface level. This is to minimise restrictions on the future use of the railway corridor.

- To reduce the possibility of track lift as a result of an undesirable increase in slurry / mud pressure, the pump equipment should have fitted an automatic cut-off device which will shut off the pump immediately a pre-determined increase in the slurry pressure is reached. An expert’s recommendation for this cut-off pressure and the contractor’s confirmation that the chosen pressure has been set are to be provided to the Rail Infrastructure Manager before drilling commences. The contractor should also provide evidence that the cut-off device has been calibrated and is in sound functioning condition.

- The contractor is to provide Queensland Rail with a Work Method Statement (Track Safety) including:
  - Plan and longitudinal section showing location (horizontally and vertically) of other services and railway corridor infrastructure within approx. 10 m of the proposed service.
Information to be shown typically includes property boundaries, railway tracks, culverts, bridge piers, buildings and footings for masts. The locations of the entry and exit pits, the proposed pipe alignment and the depths of the service below the ground and formation levels, as well as horizontal clearances to the nearest existing services and structures are to be shown.

- Copy of the geotechnical recommendations as they relate to possible surface heave / subsidence problems associated with the soil type.
- The work process including controls, process monitoring and the automatic slurry cut-off pressure. This pressure is to be determined and certified by a qualified and experienced expert competent in this field, as determined appropriate for the geotechnical site conditions.
- Establishment arrangements.
- Survey arrangements to establish the bore alignment.
- Identification of the risks and methods of control for possible problems that could cause interference to the railway track (lifting / settlement / change of alignment).
- Track monitoring procedures to detect lifting / settlement / change of alignment.

These points should be addressed briefly in a single document. One copy will need to be provided to Queensland Rail’s Property Section for assessment as part of the application and a second copy provided to the Track Maintenance Supervisor at the pre-start meeting.

- The directional drilling, reaming and pipe installation work under the track formation must be performed during certain hours set by the Rail Infrastructure Manager. This will avoid peak railway traffic times. In suburban areas, the available time during daylight hours would be typically 9:30 am – 2:30 pm. Night works between the afternoon and morning peak periods may be possible, subject to the availability of staff and the noise impact on neighbours.
- Directional drilling work is to stop temporarily while a train is crossing the bore site. Notification of train arrival times will be communicated to all on-site staff by the Track Protection Officer.

**Figure 5: Cross-section Showing Service Pipe Under the Railway Corridor Installation by directional drilling**

### 3.2 Pipe Jacking / Tunnel Boring / Micro-tunnelling

The term “pipe jacking” covers a number of excavation methods, including “tunnel boring” and “micro-tunnelling”. All generally involve making a bore using a cutting head and shield attached to an enveloping pipe, which is pushed forward by hydraulic jacks. This means that the bore is always supported. Additional pipes are lowered into the entry pit and joined to the previous pipe. The excavation and jacking process is then continued. The process leaves a negligible gap between the bore and the outside of the enveloping pipe. “Micro-tunnelling” is a method of excavation used for the smaller diameter pipe jacking work. “Tunnel boring” is another method of excavation which uses a
shield and a rotating cutting head. There are numerous variations on these methods, but they can be considered in the same way with regards to railway operations.

There are a variety of different cutting heads, face support, excavation and spoil removal methods used, depending on the ground conditions. Steering of the excavation can be achieved by such means as laser and computer guidance for the shield. It is important that suitable equipment and methods are used to control the stability of the face of the tunnel, particularly in unstable ground.

AS 4799 covers the minimum requirements for this type of work. However, the following special conditions shall also apply:

- Pipes of any diameter may be installed using pipe jacking / tunnel boring / micro-tunnelling.
- The minimum allowable depth of the top of the bore below both the top of the railway formation (underside of ballast) and the ground surface level depends on the type of service and whether a suitable impact resistant enveloping pipe is used. See Section 2.7. This is to minimise restrictions on the future use of the railway corridor. The depth restrictions may be relaxed in exceptional circumstances at the discretion of the Rail Infrastructure Manager if specific site conditions and service arrangements make this requirement impractical.
- The contractor is to provide Queensland Rail with a Work Method Statement (Track Safety) including:
  - Plan and longitudinal section showing location (horizontally and vertically) of other services and railway corridor infrastructure within approx. 10 m of the proposed service. Information to be shown typically includes property boundaries, railway tracks, culverts, bridge piers, buildings and footings for masts. The locations of the entry and exit pits, the proposed pipe alignment and the depths of the service below the ground and formation levels, as well as horizontal clearances to the nearest existing services and structures are to be shown.
  - Copy of the geotechnical recommendations as they relate to possible surface heave / subsidence problems associated with the soil type.
  - The work process including controls and process monitoring.
  - Establishment arrangements.
  - Survey arrangements to establish the bore alignment.
  - Identification of the risks and methods of control for possible problems that could cause interference to the railway track (lifting / settlement / change of alignment).
  - Track monitoring procedures to detect lifting / settlement / change of alignment.

These points should be addressed briefly in a single document. One copy will need to be provided to Queensland Rail's Property Section for assessment as part of the application and a second copy provided to the Track Maintenance Supervisor at the pre-start meeting.

- The boring and pipe jacking work under the track formation must be performed during certain hours set by Queensland Rail. This will avoid peak railway traffic times. In suburban areas, the available time during daylight hours would be typically 9:30 am – 2:30 pm. Night works between the afternoon and morning peak periods may be possible, subject to the availability of staff and the noise impact on neighbours.

- Boring / pipe jacking is to stop temporarily while a train is crossing the bore site. Notification of train arrival times will be communicated to all on-site staff by the Track Protection Officer.

- The enveloping pipe must be installed to the full extent of the bored length prior to the passage of every train across the bore site.

- A cementitious grout (5 MPa) is to be pressure injected into the annular space between the outer surface of the enveloping pipe and the bored hole. This work is to be done between trains. A requirement for internal grouting between the carrier pipe and the enveloping pipe will be determined for each case.
3.3 Pipe Ramming

The process of pipe ramming involves direct driving of a steel enveloping pipe in a similar fashion to pile driving. Additional pipes are lowered into the entry pit and welded / attached to the previous pipe. The ramming process is then continued. The spoil within the pipe is only removed once the pipe is fully in place with the use of compressed air and / or water or an auger. There is no gap between the outside of the enveloping pipe and the surrounding soil. This method is preferred because water and pressurised slurries are not used during installation of the enveloping pipe and do not come into contact with the surrounding soil. Soil disturbance around the pipe is minimised, with no ground heave / settlement occurring during / after installation.

AS 4799 does not cover the specific requirements for this type of work. The following special conditions shall apply:

- Pipes of any diameter may be installed using pipe ramming.
- The minimum allowable depth of the top of the bore below both the top of the railway formation (underside of ballast) and the ground surface level depends on the type of service. The pipe being rammed as part of this method would be considered to be a suitable impact resistant enveloping pipe. See Section 2.7. This is to minimise restrictions on the future use of the railway corridor. This depth restriction may be relaxed in exceptional circumstances at the discretion of the Rail Infrastructure Manager if specific site conditions and service arrangements make this requirement impractical.
- The contractor is to provide Queensland Rail with a Work Method Statement (Track Safety) including:
  - Plan and longitudinal section showing location (horizontally and vertically) of other services and railway corridor infrastructure within approx. 10 m of the proposed service. Information to be shown typically includes property boundaries, railway tracks, culverts, bridge piers, buildings and footings for masts. The locations of the entry and exit pits, the proposed pipe alignment and the depths of the service below the ground and formation levels, as well as horizontal clearances to the nearest existing services and structures are to be shown.
  - The work process including controls and process monitoring.
  - Establishment arrangements.
  - Survey arrangements to establish the bore alignment.
  - Identification of the risks and methods of control for possible problems that could cause interference to the railway track (lifting / settlement / change of alignment).
• Track monitoring procedures to detect lifting / settlement / change of alignment. These points should be addressed briefly in a single document. One copy will need to be provided to Queensland Rail’s Property Section for assessment as part of the application and a second copy provided to the Track Maintenance Supervisor at the pre-start meeting.

• The pipe ramming work under the track formation must be performed during certain hours set by the Rail Infrastructure Manager. As there is never any unsupported material in this method, and consequently no danger of surface heave or subsidence, it is not necessary to avoid work during peak railway traffic times. Night works may be possible subject to the availability of staff and the noise impact on neighbours.

• Pipe ramming can continue while trains are crossing the bore site and there is no need to impose a speed restriction.

• The requirement for internal grouting between the carrier pipe and the enveloping pipe will be determined for each case.

3.4 Trenching

Trenching under the tracks is the least preferred method (most expensive and time consuming) and will only be permitted by the Rail Infrastructure Manager if all other methods are shown to be impractical. It involves the excavation of a trench across Queensland Rail’s property and under the tracks, causing disturbance to the formation, ballast and track. Normally, excavation under the track would be done during a track closure, but if this is not possible, the use of track supports would be necessary. It may lend itself to low traffic lines where the equipment for other methods is not readily available.

However, for services running parallel to the property boundary (not under the tracks), it could be a viable alternative for particular services and with specialised installation equipment. Special consideration would need to be given to the circumstances for its use.

When trenching under overhead traction wiring, an isolation will be required, as well as special methods for installing the shoring, as no equipment, e.g. crane, is to come within the electrical exclusion zone.

All Queensland Rail’s costs related to trenching are to be paid by the service owner. In addition to the cost of a track closure, these include the following work which would be performed by Queensland Rail’s staff:

• removal and replacement of the track components,
• removal, replacement and compaction of the ballast, and
• the provision of temporary track supports (if required).

AS 4799 covers the minimum requirements for this type of work with the following modification. After the service has been placed in the trench, it will be necessary to backfill with fine crushed rock, sand, gravel, lean mix concrete or other material approved by the Rail Infrastructure Manager. The backfill is to be compacted to 90% of the maximum dry density (Modified Compaction Test) up to 600 mm below formation level. The top 600 mm is to be compacted to 95% of the maximum dry density (Modified Compaction Test). This is to be in accordance with AS 1289.E2.1.

The following special conditions shall also apply:

• Pipes of any diameter may be installed using trenching.

• The minimum allowable depth of the top of the bore below both the top of the railway formation (underside of ballast) and the ground surface level depends on the type of service and whether a suitable impact resistant enveloping pipe or concrete protection slab is used. See Section 2.7. This is to minimise restrictions on the future use of the railway corridor. This depth restriction may be relaxed in exceptional circumstances at the discretion of the Rail Infrastructure Manager if specific site conditions and service arrangements make this requirement impractical.

• The contractor is to provide Queensland Rail with a Work Method Statement (Track Safety) including:
  • Plan and longitudinal section showing location (horizontally and vertically) of other services and railway corridor infrastructure within approx. 10 m of the proposed service. Information to be shown typically includes property boundaries, railway tracks, culverts,
bridge piers, buildings and footings for masts. The proposed pipe alignment and depths below the ground and formation level, as well as horizontal clearances to the nearest existing services and structures are to be shown.

- The work process including controls and process monitoring.
- Establishment arrangements.
- Survey arrangements to establish the bore alignment.
- Identification of the risks and methods of control for possible problems that could cause interference to the railway track (settlement / change of alignment).
- Track monitoring procedures to detect settlement / change of alignment.

These points should be addressed briefly in a single document. One copy will need to be provided to Queensland Rail’s Property Section for assessment as part of the application and a second copy provided to the Track Maintenance Supervisor at the pre-start meeting.

- The trenching work under Queensland Rail’s property must be performed during certain hours set by Queensland Rail. This may be during a track closure or between trains and under traffic. Night works may be possible subject to the availability of staff and the noise impact on neighbours.

Excavations will cease while a train is crossing the site. Notification of train arrival times will be communicated to all on-site staff by the Track Protection Officer.