1. RISK ASSESSMENT

The following risk assessment matrix, shown below, has been used to assess risks associated with the identified hazards. The risks are assessed before any controls are applied (initial risk level) and then reassessed using any applicable recognized standard first and any additional design control measures (revised risk level). The level of acceptability descriptions is shown in Table 1 below.

TABLE 1 – RISK MATRIX

Likelihood — Consequences

	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
1 Rare	Low (1)	Low (3)	Medium (6)	High (10)	High (15)
2 Unlikely	Low (2)	Low (5)	Medium (9)	High (14)	Extreme (19)
3 Possible	Low (4)	Medium (8)	High (13)	Extreme (18)	Extreme (22)
4 Likely	Medium (7)	High (12)	High (17)	Extreme (21)	Extreme (24)
5 Almost certain	High (11)	High (16)	Extreme (20)	Extreme (23)	Extreme (25)

TABLE 2 - LEVEL OF ACCEPTABILITY

EXTREME RISKS **If risk is "extreme", STOP.** **This is an unacceptable level of risk. Task should be ceased until risk is reduced to a tolerable level.**
High Risk **If risk is "high" STOP.** **Control or action should be taken as soon as possible**
MEDIUM RISKS **If risk is "medium" STOP.** **Management to decide on acceptability of risk and actions required**

-LOW- **The risk is acceptable and can be managed by routine procedures**

1.1. THE HIERARCHY OF RISK CONTROL

Work Health and Safety Regulations require duty holders to work through the hierarchy shown in Table 3 below to choose the control that most effectively eliminates or minimizes the risk in the circumstances. (Safe Work Australia, 2012)

TABLE 3 - HIERARCHY OF CONTROL

The following control options shall be considered and may be applied individually or in combination.		
Elimination	Complete removal of the hazard	**Hard Controls**
Substitution	Replacing the material or process with less hazardous one	**Most Effective**
Engineering	Redesign the equipment of process	
Isolation	Separation of the hazard by guarding or enclosing it	
Administration	Providing controls such as training or procedures	**Soft Controls**
PPE	**Use of PPE where no other controls are not practical**	**Least Effective**

2. RISK REGISTER

TABLE 4 - DESIGNER'S RISK REGISTER

Item No.	Hazard Category	Detail of Hazard	Initial Risk Level	Reducing Risk Through Design	Revised Risk Level	Construction Stage Contingency	Reference
1	**Launch and Receival Pits**						
1.1	Ground Collapse	Injury or death caused from worker being struck/buried by ground collapse	E (23)	Benching and Battered slopes designed for the insitu ground conditions. Designed to Safe Work Australian, Code of Practice	L (5)	Excavation to be inspected daily prior to entering the pit to commence work.	Excavation Work - Code of Practice
1.2	Ventilation	Injury or death caused from workers being exposed to insufficient ventilation or poisonous gases while working in launch and receival pits	M (9)	Low risk as size and shallow depth of pits assists with ventilation however contractor to install gas detectors and forced ventilation if required.	L (5)	Gas monitoring onsite if required. Staff will be briefed on Emergency Evacuation Plans. No works undertaken until restricted space atmosphere tested and approved. Communication is by visual and verbal methods at all times between the spotter & operator	Safe Work Australia - Code of Practice: Confined spaces
1.3	Flooding	Injury or death caused from workers being unable to escape working pits during flooding. Damage and failure of plant and equipment due to flooding of pits, compromising the excavation work beneath the railway. Part of these pits will be above ground level and flooding risk will be minimal.	H (13)	Flood protection barrier/bunding by raising ground around excavation and directing runoff away from pit, rail and site access road. Sump pit and pump to be installed within the pits.	L (5)	Pump to be installed in sump in the event of potential flooding	
1.4	Working in Confined Space	Injury or death caused from workers being exposed to confined space hazards and being ill-equipped.	E (23)	Size of pits has been designed to accommodate a safe means of Access and Egress, ventilation and any other requirements for working in a confined space.	L (3)	If pits are classified as a **confined space**, then anyone entering the pit or pipe is to be confined space trained. Staff will be briefed on Emergency Evacuation Plans. No works undertaken until restricted space atmosphere tested and approved. Communication is by visual and verbal methods at all times between the spotter & operator	Safe Work Australia - Code of Practice: Confined spaces
1.5	Machinery causing entrapment	Injury or death caused from workers carrying out works with moving plant and machinery	E (21)	Size of pits designed to ensure adequate space to provide sufficient working room. Auger Boring /AVN machine located within the pit with sufficient room for operators to work safely. Working around machinery risks to be managed separately.	L (5)	Experienced operators to carry out works. SWMS to address how operators will work safely around machine. Signs/alarms/lights to be operational. Correct PPE to be worn hard hats, safety boots, glasses, high visibility long sleeved shirt & long pants. Maintain line of sight with excavator operator	
2	**Augerboring and Microtunnelling Operations**						
2.1	Steel Enveloper failure - Jacking Loads	Jacking loads exceed the steel casing capacity causing lining failure and resulting in the Augerbore/Microtunnel being unable to be complete or not meet required specifications	H (17)	Jacking force loads are calculated based on ground conditions and the plant to be used. Steel Enveloper pipe is chosen based on these criteria. Designed to Australian Standards	L (5)	Jacking pressure to be monitored whilst jacking pipes forward. Jacking pressure not to exceed maximum pipe forces specified by manufacturer.	Jacking Pipe Capacity Assessment Reports; James Thompson, Pipejacking & Microtunnelling-1993

Item No.	Hazard Category	Detail of Hazard	Initial Risk Level	Reducing Risk Through Design	Revised Risk Level	Construction Stage Contingency	Reference
2.2	Enveloper Pipe failure - Buckling	Buckling of the pipe caused from high overburden and live loading or due to installation loads. Results in a reduced design life or failure during installation.	H (17)	Ground loading and Live loads are calculated based on ground conditions. Enveloper pipe is chosen based on these criteria. Designed to Australian Standards	L (5)	Steel casing to have sufficient wall thickness to satisfy design criteria.	Jacking Pipe Capacity Assessment Reports
2.3	Higher jacking forces than expected	Higher jacking forces resulting in damage or failure of the steel casing.	E (21)	Conservative calculations carried out to determine jacking load requirements. Pipes designed with FOS. Augerbore machine and AVN machines have been appropriately sized.	L (5)	Jacking pressure to be monitored whilst jacking pipes forward. Jacking pressure not to exceed maximum pipe forces specified by manufacturer.	Thompson, James, 'Pipejacking and Microtunnelling'

Item No.	Hazard Category	Detail of Hazard	Initial Risk Level	Reducing Risk Through Design	Revised Risk Level	Construction Stage Contingency	Reference
4	**Other Risks Associated with the Works**						
4.1	Settlement	Surface settlement	E (18)	The Augerbore and Microtunnelling have been designed to reduce settlement impacts to the surface as much as reasonably practical. A settlement monitoring will be carried out to ensure the theoretical ground movement is of an acceptable limit. Long term settlement will be mitigated through external annulus grouting works.	L (5)	Industry best practice for tunnelling operations will be followed. Grouting of annulus to be carried out ASAP following the completion of the bore. Grout strength of 2MPa to be used. The surface along bore alignment shall be inspected and monitored to identify any significant settlement/ground movements.	
4.2	Verification & location of existing services	Damage to underground cables, electrocution, explosions, fire, flooding, persons injured, members of the public injured, damage to equipment/structures & power / communication / water / gas affected by outages	H (17)	Design of alignment has been carried out with knowledge of the location of existing services.	L (5)	Current DBYD plans on site at all times. Locate & expose all services within boring alignment. Protect exposed services as required by statutory authorities.	

4.3	Environmental Incidents	Fluid fracture, grout coming to surface.	H (13)	Augerbore works do not use any fluid other than the introduction of water to the face if required. There will be no build-up of pressure from the introduction of water. Grouting of external annulus to be gravity fed and therefore no pressure build up risk introduced. Microtunnelling works will use bentonite lubrication in external annular space when needed. Pressure will not cause any significant risk which can cause frac out on the surface.	L (3)	Experienced operators to carry out the works.	- Grouting methodology: Jacking Pipe Capacity Assessment Report
4.4	Lifting steel casing	Injury or death from being struck by falling object	E (21)	Make sure the exact weight of steel casing is known in order to use an appropriate lifting gear. Lifting plan is in place before lifting operation (where necessary).	L (5)	• Daily checks on all chains & slings for damage & service dates/serial numbers, quarterly inspection tags. • All pipes to be chocked to ensure stability and checked before and after any movements as well as not to be stacked more than one high where possible • Designated traversing spotter in place when plant is operational • Check all attachment points, quick hitches & safety pins • Ticketed and competent operators only to use excavator equipment. • Dogman to be in place at all times when conducting lifting operations. • Tag lines to be used when conducting lifting operations. • Watch movement of all loads • Never lift over other personnel or work under suspended loads • Stay well clear of slew radius	Contractor SWMS, Bothar Boring SWMS.
4.5	Welding of steel casing	• Burns, flash foreign bodies, electrocution, fire and/or explosion	E (18)	• Risk assess area for welding and comply with Category "A";" B" or "C" welding environment as per AS 1674.2-2007 Safety in Welding and Allied Process (electrical)	L (5)	• Fire extinguishers located in boring pit & above ground • Welding/Electrical leads & equipment checked daily • Welding/Electrical leads & equipment to be protected & elevated • Welding helmets & gloves to be worn at all times whilst welding • Make sure appropriate barricading /signage surrounds the work area to protect others from welding flash • Earthing to the opposite end of casing • Soft sling to be used while welding casing to separate chains from excavator. • Ensure sling is sufficiently away from welding area. • Welder to be above the pit to reduce toxic gas into the pit. • Ventilation to be utilised while welding Welding Procedure Ensure casings are free from debris and paint before welding. Full penetration weld to be achieved around the whole of the casing. Slag can be chipped off to inspect weld underneath.	Contractor SWMS, Bothar Boring SWMS
4.6	Electricity	Danger of electrocution while working close to live overhead powerlines	E (21)	Works area location designed to be safe distance from overhead lines.	L (5)	Contractor to follow safe work practices and have accepted works method statement in place	Contractor SWMS, Bothar Boring SWMS.