Attachment C

KOROROIT CREEK MULTI-CRITERIA ASSESSMENT

Introduction

Kororoit Creek crosses a power easement, approximately 230 m east of Robinsons Road and Abercairn Court in Deer Park, Victoria. The location is shown in Figure 1.

The Water for a Growing West (WGW) project will require the installation of a pipeline across this waterway at this location. A multi-criteria assessment (MCA) was utilised to select the appropriate construction methodology.

Figure 1 Kororoit Creek Crossing Location

Identified values

Kororoit Creek is considered an environmental and recreational asset within Melbourne's western region. At the location of the pipeline alignment, a shared user path (bicycle and walking) connects to a trail beside Kororoit Creek. Additionally, key environmental values are present including; endangered remnant plains grassland EVC and riparian woodland EVC, Department of Environment and Primary Industries (DEPI) advisory listed arching flax-lily, geologically significant rocky outcrop formations, Aboriginal artefact scatters and growling grass frog habitat. Known growling grass frog populations occur upstream and downstream of the crossing location (Melbourne Water 2013c).

Many of these values are recognised by Melbourne Water, which designated the grassland and rocky escarpment directly adjacent to the creek as a Site of Biodiversity Significance (SOBS). This area is also a registered biosite (#5269: Kororoit escarpments-Deer Park) is fenced for conservation purposes.

A population of tough scurf-pea (*Cullen tenax*), which is listed as threatened under the *Flora and Fauna Guarantee Act 1988,* has previously been identified by Melbourne Water and is associated with the rocky escarpment. Environmental works associated with the Melbourne Water Capital Works program are planned for this area in 2014 to further enhance the site. These values, partnered with an existing City West Water (CWW) sewer main, new pump station, and proposed future Melbourne Water environmental works, potentially limit the available construction corridor width through this location, and are important considerations for designing and planning the construction across the waterway.

Key Challenges

The construction method selected for this crossing needs to provide a cost effective solution inclusive of environmental impacts, while at the same time taking into consideration other issues such as the impact of the works on adjacent landowners and reduced risk in relation to weather events and duration of dewatering. Some key challenges for the Kororoit Creek crossing include:

- consideration for the creek's continued recreational use;
- protection of recognised environmental values (flora, fauna, habitat, cultural heritage);
- existing overhead power lines;
- existing sewer main;
- impact on adjacent landowners;
- accessibility during construction for contractors and local community; and
- construction, operation and public safety.

Crossing options

A range of pipeline construction methods are available to facilitate waterways crossings. These include above ground, where the pipeline is suspended across the waterway by existing or purpose built structures, or below ground achieved through standard trenching or tunneling. Three crossing options were considered for crossing Kororoit Creek:

- open cut trenching;
- trenchless (micro-tunneling); and
- pipe bridge.

Prior to commencing the MCA, a review of the methodology details applicable to the site was conducted and the key advantages and disadvantages of each option were determined.

Option 1: Open Cut Trenching

A cost effective and predictable method of crossing waterways is normally by open cut trenching. Trenching provides a high degree of certainty with respect to environmental protection and speed of construction. Unexpected changes in ground conditions can be readily accommodated. It generally uses standard construction equipment such as excavators, rock saws, hydraulic breakers, cranes and pumps. Pipe jointing, welding and coating reinstatement is normally undertaken prior to commencing the trench excavation which minimises the length of time that the trench is required to be open and limiting waterway disruption time to a matter of days in comparison to alternative methods.

Minimising the duration and selected timing of works is able to accommodate issues such as fish spawning and frog breeding seasons and can be programmed for low flow times that normally occur during summer. Fauna fencing (such as frog movement corridors) can be constructed to guide the movement of amphibians around the construction area. Concrete encasement of the pipe as part of installation provides further protection of the pipe and stability of the waterway profile.

Trenching across waterways involves in-stream excavation and pipe laying conducted within a temporarily dewatered section of the waterway. Protection of the works from waterway flows is achieved by installing temporary dams upstream and downstream with a bypass flume or pump. Dams could be formed with water filled bladders commonly known as ‘aquadams’. In steep sided creeks, manufactured bends may be required, which may have to be lifted in as an assembled length of pipe using large cranes. Generally dewatering is still required in the ‘dry’ area and is achieved by strategically located sumps. Water resulting from dewatering will be directed to sedimentation ponds or other environmental device to separate sediment before discharge back into the waterway.

Access to the north side of the waterway for construction equipment and temporary works would be from the 30 m construction corridor north of the waterway in the power easement via Tamar Drive. Access to the south side of the waterway would be from Robinsons Road and the power easement, similar to current construction access for the CWW pump station. Delivery of the aquadams could be accomplished with a few trucks. Construction of a vehicle crossing around the waterway may require additional 10-15 truckloads of fill material. Otherwise, the construction traffic will be typical as required for the continued pipe installation along the preferred alignment. Following installation, waterway crossings will require concrete encasement for protection of the pipe. All temporary works would be removed from the dewatered area between the aquadams, and the waterway bed and banks would be reinstated in accordance with Melbourne Water guidelines, and provided with scour protection. Lastly, controlled removal of the downstream dam is followed by removal of the upstream dam. Figure 2 shows a typical waterway crossing via open trenching.

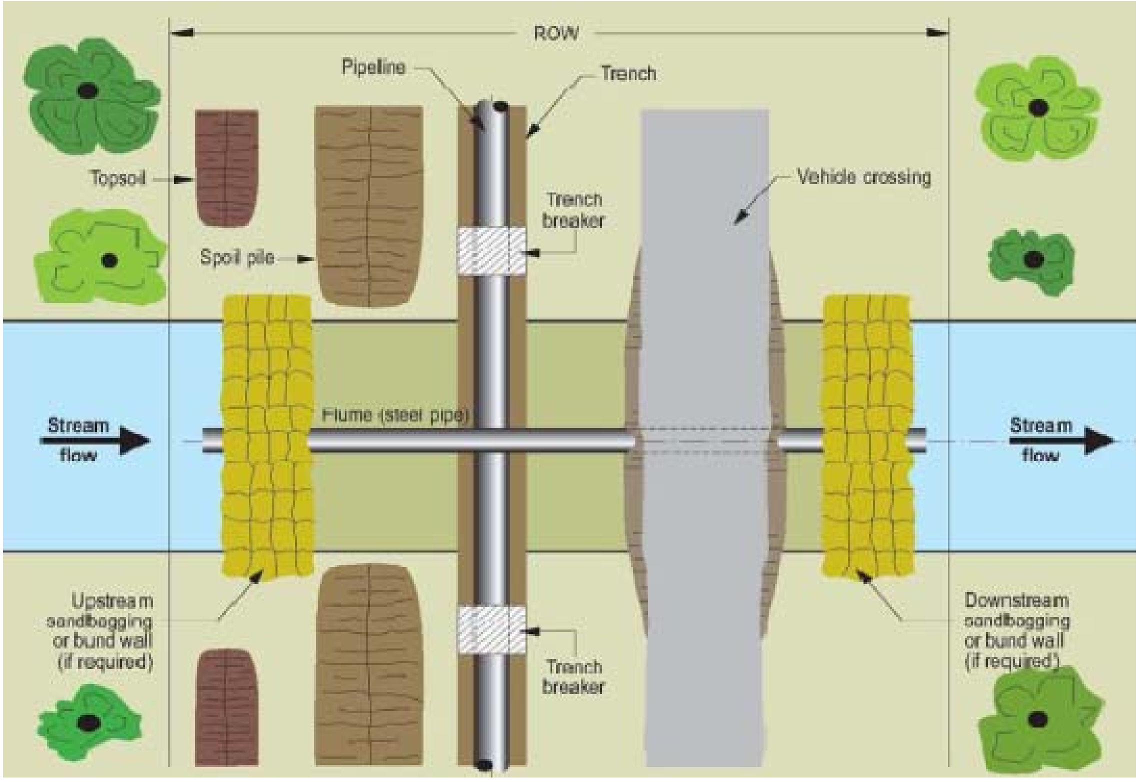

Figure 2: Typical Open Trench Waterway Crossing

Advantages

- Open trenching is the lowest capital cost option;
- Small construction staging and laydown footprint required;
- Installation can typically be accomplished with excavators;

- More flexibility to accommodate variable ground conditions and field variations (i.e. seasonal changes in waterway flow and fauna habitat);
- Generally involves shallower excavations through medium to hard rock; and
- No confined space requirements and limited working from heights' risks.

Disadvantages

- Disruption to waterway:
    - Cofferdam (aquadam) required to protect works;
    - Although waterway disruption can be minimised by preparing the pipe prior to commencing excavation, this approach still directly impacts the waterway to a greater extent than other methods.
- Work area may be susceptible to flooding – construction may therefore be seasonally dependent, i.e. summer/low flows;
- Construction noise associated with rock excavation;
- Pipe alignment includes additional bends, resulting in higher energy loss in the pipeline; and
- Potential to impact on aquatic fauna, habitat, water flow rates and water quality.

Option 2: Trenchless

Tunneling is an alternative non-invasive method of pipe installation. Micro-tunneling is the general term used to describe a remotely controlled mechanical tunneling system where the spoil is removed from the cutting head within the new pipeline which is advanced by pipe jacking. Micro-tunneling machines have been developed to work from drive shafts in most types of ground conditions; however, it is essential to know what these conditions are likely to be as they will determine the type of machine to be used, the cutting head, the spoil removal system, and the jacking forces likely to be required.

The cutting head has to be carefully selected to deal with the expected ground conditions, with the appropriate cutting tools and crushing devices for the range of gravels, sands, silts, and clays.

The launch shaft needs to be sufficiently sized to accommodate the tunnel boring machine, pipe jacking frame, jacking pipe sections and spoil removal. The reception shaft needs to be sized to allow removal of the tunnel boring machine.

Spoil may be removed from the face by an auger running through the newly installed pipeline to a skip in the base of the drive shaft.

Alternatively, water or bentonite may be used to convert the soil into slurry at the cutting face. The slurry is then pumped to the surface where the solids are separated before disposal. Both systems provide face support by mechanical earth pressure balance. Slurry pressure at the face can also be used to combat external ground water however this may present further risks of ground contamination.

With some systems, control is exercised automatically but micro-tunneling machines are generally operated from a control console in the cabin at the surface. The location and orientation of the machine is continually monitored, usually by means of a laser guidance system. Accuracy in driving usually depends on the skill and experience of the operator, especially in varying ground conditions. A schematic of micro-tunneling is shown in Figure 3.

Figure 3 Schematic micro-tunnelling

Prior to the commencement of micro-tunneling, the launch and reception shafts must be sited and constructed. Based on discussions with local contractors, it is anticipate that a 6 m diameter drive shaft, approximately 9 m deep will be required to launch and retrieve the tunnel boring machine (TBM). The construction of these shafts is expected to require a significant amount of rock excavation. Although the rocky soil conditions may prove suitable for the shaft walls, shoring protection would be required to ensure a safe working environment in the shaft.

It is assumed that shoring will be accomplished with soldier piles and lagging. An alternative shoring approach may include reinforcing mesh and shotcrete. During shaft excavation, any groundwater encountered would be pumped to sedimentation ponds or other environmental device to separate sediment before discharge back into the waterway. If significant groundwater was encountered, a slurry wall and/or slab could be constructed to minimize ingress of groundwater.

An equipment laydown area is required outside of each shaft for the removal of excavated material, shoring equipment, and pipe installation. This area would also be used for locating the TBM’s hydraulic equipment, and the TBM’s excavated spoils removal and handling equipment. A crane would be utilised to lower and retrieve equipment and materials from each shaft. Following construction, the shafts would be backfilled with the cement stabilised sand, and the work area reinstated.

Construction access to the north side of the waterway for equipment, materials deliveries, and temporary works would be from the 30 m construction corridor north of the waterway in the power easement via Tamar Drive. For construction on the east side of the creek, equipment and materials could be stored in a laydown area east of the protected SOBS, and moved to the work area via Franna crane. Access to the south side of the waterway would be from Robinsons Road and the power easement, similar to current construction access for the pump station.

Advantages

- Low impact on waterway and therefore minimal impact on aquatic fauna, habitat and water flow rates; and
- No visual impact on creek following completion.

Disadvantages

- High capital cost;
- Long construction period;
- High risk operation due to highly variable and unforeseen changed ground conditions:
  - Ground conditions dictate the type of machine to be used, the cutting head, the spoil removal system, and the jacking forces likely to be required. Changes in these conditions can result in decreased accuracy/control over the tunneling equipment, ultimately leading to abandonment of tunnels and requiring the extraction of the tunnel boring machine by open cut excavation. Based on discussions with the local contractors, the micro-tunneling operation has been unsuccessful on a number of projects in the western suburbs leading to significant schedule delays and financial impacts; and
  - Based on observations of CWW’s pump station construction at the south side of Kororoit Creek and preliminary geotechnical results, it is expected that ground conditions in this area will be highly variable.
- Control of groundwater and containment of drilling slurry can present challenges to the construction approach. There is a risk of groundwater contamination if bore fails or in highly fractured rock;
- Requires specialised equipment not readily available. If changed conditions are encountered, project delays may result whilst retrieving the boring unit and undertaking appropriate equipment modifications;
- Larger construction staging and laydown footprint requires crane on both sides of waterway;
- Construction noise during shaft construction and rock excavation;
- Work area subject to electrical safety and confined space requirements; and
- Work area within the power easement subject to flooding. Due to duration of works, construction works may be impacted by flooding as there is limited ability to avoid flood prone seasons.

Option 3: Elevated Bridge Crossing

Pipe bridges are often best suited to deep narrow gorges, and substantial waterways where conventional construction techniques are not suited and the cost of the supporting structure can be justified. They are also suited to locations where the subsurface conditions are such that tunneling or trenching is not a viable option. The types of locations where pipe bridges might be justified are:

- Streams or floodplains comprising changing ground conditions, i.e. soft ground with hard rock reefs;
- Streams or floodplains which have high normal flows or are subject to frequent flood flows that cannot be managed by fluming or pumping; and
- Streams or floodplains containing environmental, heritage or other sites of value which could be left undisturbed by suspending the pipe above the stream.

The bridge option crossing incorporates approximately a 60 m span across Kororoit Creek. The bridge is assumed to include a secure enclosure for the DN1200 pipe on a lower deck of the bridge. The pipe enclosure includes an approximate 900 mm wide maintenance walkway on either side of the pipe for inspection and maintenance. In providing a dual purpose structure for the pipe and pedestrian traffic, a 3 m wide shared use footpath is assumed on the upper deck of the bridge for public access. A typical pipe bridge is shown in Figure 4 and 5.

Figure 4 Typical pipe bridge during construction

Figure 5 Typical pipe bridge post construction

The bridge would be fabricated offsite and delivered to site in two or three pieces which would be assembled on site into a single structure. It is assumed that the bridge would be lifted into place via a single lift from the north side of the Kororoit Creek. Following discussions with reputable crane operators it was determined there is not sufficient room on the south side to set up a crane for a dual lift approach. The high voltage power lines also place restrictions on where a crane can be set up.

Based on discussions with crane operators, a 600-tonne crane would likely be required to lift the bridge into place. The crane location would be leveled out with a hardstand area constructed to accommodate the crane and outriggers. The mobilisation of this type of crane is expected to require approximately 40 full semi-trailer truck deliveries, including a 200-tonne crane to assemble the larger crane.

Normal pipeline related construction access to the north side of the waterway for equipment, materials deliveries, and temporary works would be from the 30 m construction corridor north of the waterway in the power easement via Tamar Drive. For construction on the north side of the creek, equipment and materials could be stored in a laydown area north of the protected SOBS, and moved to the work area via Franna-type crane. Access to the south side of the Creek would be from Robinsons Road and the power easement, similar to current construction access for the pump station.

Based on the preferred crane location, mobilisation and construction access for the crane would not be feasible via the 30 m pipe corridor in the power easement. Therefore, clearing and construction of a temporary 5 m wide and approximately 400 m long construction access would be required for the crane along the northern bank of Kororoit Creek from Billingham Road to the east. This would require some tree and vegetation removal to accommodate construction traffic. Truck deliveries for the crane and the pipe bridge would take place via this temporary access road.

Following placement of the pipe bridge, the crane would be demobilised and the temporary access road from Billingham Road reinstated to the Kororoit Creek Trail.

Advantages

- Elevated structure minimises impacts to waterway as opposed to trenched crossing of the waterway;

- Pipe is accessible for periodic inspection and maintenance from bridge;
- Lower energy losses due to less pipe bends compared with tunnel or trench options;
- Bridge provides access to creek crossing to public and improves safety (Note: it was observed during site visits that pedestrians currently cross the creek at rock outcroppings);
- Bridge can provide platform for other (smaller) services to cross Kororoit Creek;
- No rock removal required for installation across creek (less nuisance noise to landowners); and
- Work area not as susceptible to flooding. Construction time frame is not seasonally dependent apart from requirements of SPAusNet i.e. transmission shut-downs.

Disadvantages

- Larger construction laydown area and crane required:
    - Crane staging area anticipated on north side of creek, which requires numerous truck deliveries for mobilisation and some tree removal along the Kororoit Creek Trail
    - Impacts to cultural heritage are unknown as the area for the crane hardstand is outside of the current scope.
- Highest capital cost;
- Visual landscape impacted by bridge;
- Elevated bridge may create privacy issues; and
- Additional operation/maintenance cost associated with bridge structure.

MCA method and results

Having established the methodology and key advantage and disadvantages of each option, a multi-criteria analysis (MCA) process was adopted to select the preferred construction methodology. The MCA established headline criteria of Financial, Technical, Social and Environmental. Sub-criteria within each headline criteria were then developed in consideration of the key advantages and disadvantages identified. Weightings were then applied to each sub-criteria.

A high emphasis was been placed on the environmental weighting, due to the environmental sensitivity of Kororoit Creek and the relative environmental impacts between each of the crossing options. The social criteria capture the disruption to the local community during construction, as well as any potential benefits gained by the local community by the bridge crossing option.

The technical criteria capture the constructability considerations of each crossing option including potential for delay, transport and handling requirements and ground conditions.

The weightings proposed represent the relevant influence on the criteria when applied to each of the three methods of crossing the creek. These weightings were reviewed and agreed by Melbourne Water during an MCA workshop, though the financial weighting is pre-set by Department of Treasury and Finance (DTF).

The base case nominated was ‘trenchless’ as it is the crossing method used in Melbourne Water’s preliminary investigations and estimates. ‘Open cut trenching’ and ‘pipe bridge’ were then assessed against the base case for each criteria and assigned a score within the ±4 range

The total weighted scores for the different construction methodologies that were generated from this assessment are summarised in Table 1.

Table 1 Kororoit Creek MCA Summary

Criteria	Weighting	Open cut trenching	Trenchless	Pipe bridge
Financial	50%	7.67%	0.00%	-4.40%
Technical	20%	9.25%	0.00%	3.75%
Social	10%	0.75%	0.00%	2.75%
Environmental	20%	-5.75%	0.00%	-4.25%
TOTAL	100%	11.92%	0.00%	-2.15%

Sensitivity analysis was conducted on the MCA weightings, identifying which criteria had the greatest influence and modifying the weighting and assessing alternative outcomes to verify the validity of the original results above.

Kororoit Creek MCA exhibited minor sensitivity towards high social and environmental weightings. In all weighting scenarios however, inclusive of scenario which modeled a low financial component, open cut trenching is the preferred option.

Recommended construction methodology

The resultant scores of the various options have identified open cut trenching of Kororoit Creek as the preferred option. This method of crossing presents many benefits including; lowest overall cost, least complex construction technique, lowest potential for delay to schedule and negligible visual impact on surrounds. Environmental impacts can be managed through industry standard practice construction management techniques.