MURRAY RIVER TO BROKEN HILL BULK RAW WATER TRANSFER PIPELINE & ASSOCIATED WORKS

INITIAL OPTION ASSESSMENT

Report No. DC14199

October 2014

Client: NSW Office of Water

Project Sponsor: Infrastructure NSW

Acknowledgement

This report was prepared by NSW Public Works for NSW Office of Water and commissioned by Infrastructure NSW.

NSW Public Works team managed the report preparation including initial engineering assessments, development of the initial feasibility option and cost estimating.

The NSW Public Works team would like to thank Essential Energy (Broken Hill office) for their contribution and assistance to the project.

Project Disclaimer

The information contained in this report is based on readily available data, knowledge and understanding at the time of writing (October 2014) and was subject to the very short allocated time available.

No field investigation work has been undertaken by NSW Public Works to directly support option identification, engineering assessments and the views formulated. It is acknowledged that subsequent investigation work and further studies will be required to progress the initial option developed and to confirm all aspects. As a result the outcomes and conclusion may subsequently change or need to be revised.

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1 Introduction

1.1 General

This document considers the provision of a bulk raw water transfer pipeline from the Murray River to Broken Hill and associated works as a potential means to confidently address long term and ongoing water supply security concerns and water shortages that periodically affect Broken Hill. The main driver of this situation is understood to be both local climatic conditions and those within the catchments contributing to Darling River flows past Menindee along with the respective general demand for water, limited available storage capacity at Broken Hill and very high surface water evaporation rates. The Darling River and the Menindee Lakes Storages Scheme, located approximately 100km to the southeast of Broken Hill, provide the primary means of water supply drought security via the above ground Menindee pipeline.

Currently in times of extended drought when the Darling River nears cease-to-flow conditions, water stored within the Menindee Lakes Storages is relied upon for the bulk of Broken Hill's water supply needs. However, this resource is also limited and emergency measures have needed to be implemented in the past to access otherwise isolated pools of residual stored water of poor quality.

Commensurate with the time available, the work undertaken for this report has focused primarily on the development of an initial single preferred option for the supply of bulk water from the Murray River directly to Broken Hill. The developed option is considered to be feasible, realistic and a practical solution whilst acknowledging that further thorough cost benefit analysis would be required. The preferred option is supported by the application of an appropriate level of engineering assessment along with consideration of a range of identified alternatives or otherwise typically available options both aimed at minimising indicative capital and operating costs. As necessary, knowledge and information gaps have been addressed by applying engineering judgement and experience and by the adoption of assumptions appropriate to this initial project investigation stage.

Liaison has been had with Essential Energy as the current Broken Hill water supply scheme owner and operator for the purpose of leveraging their relevant available knowledge and information, awareness of potential issues, experience, and any views on potential solutions and benefits associated with an option such as that proposed. This approach is regarded to have led to the development of an initial preferred option, presented herein, which is effective, suitably flexible, has appropriate performance and is aimed at maximising value for money.

A cost estimate has been prepared for the initial preferred option based on direct construction costs plus an appropriate contingency amount for the type of work involved.

1.2 Background

Essential Energy supplies water to approximately 18,777 people (Census, 2011) in Broken Hill (high and low service areas), South Broken Hill and Railway town. The communities in Menindee, Sunset Strip, and Silverton of approximately 370, 75, and 50 people respectively are also supplied with reticulated water. This report is aimed at delivering bulk water directly to Broken Hill for distribution within the locality of the town and to Silverton since other independent options are available and are currently being considered for the other areas supplied by Essential Energy in the vicinity of Menindee.

The service area is the most arid in the State, experiencing extreme climatic variations including more frequent drought than coastal areas. Eight years in ten, the town water supply is dependent on water sourced from the Darling River and pumped over the 116km Menindee pipeline to Broken Hill (i.e. Stephen Creek Reservoir). These unique operational circumstances combined with drought conditions cause salinity and other water quality problems in the raw water which must be treated at generally higher costs than other areas within the State.

Essential Energy owns and operates the following three (3) existing bulk water reservoirs (dams) which are regulated by the NSW Dams Safety Committee (DSC):

- *Stephens Creek Reservoir Dam* – 19.9 GL, located 17km northeast of Broken Hill

  The dam is the main bulk water supply reservoir for Broken Hill. It receives water directly from the catchment as well as water pumped from the Darling River via a transfer pipeline from Menindee.

  The reservoir has a large surface area and relatively shallow depth which contribute to large evaporation losses. A series of internal levees has been constructed and are operated in a manner that reduces the total surface area of the reservoir at lower water levels to minimise evaporation losses.

- *Imperial Lake Reservoir Dam* – 0.67 GL, located 3km northeast of Broken Hill

  The dam is an emergency bulk water supply reservoir for Broken Hill in the event that the transfer pipeline from Stephens Creek Reservoir fails. It is understood that the dam is seen as high risk (“High C” consequence category) by the Dams Safety Committee (DSC) due to an insufficient spillway capacity to cater for the required design flood and the potential for piping erosion of the earthfill embankment. The cost of upgrade works are understood to be greater than $5M.

  The transfer pipeline from the dam to Broken Hill is separate from and additional to the transfer pipeline from Stephen Creek to Broken Hill. The emergency transfer capacity is 22 ML/day which is short of the current 25 ML/day average summer demand for Broken Hill and considerably less than the peak demand (see *Subsection 1.5*.)

  The Imperial Lake Reservoir supply is understood to be unreliable, with often poor water quality, and is dependent on the storage being maintained from raw water sourced by pumping from the Darling River via Stephens Creek Reservoir.

- *Umberumberka Reservoir Dam* – 7.6 GL, located around 36km northwest of Broken Hill
- The dam is the main bulk water reservoir for the town of Silverton and also serves as a supplementary supply source for Broken Hill. The transfer capacity of 11 ML/day from the dam to Broken Hill is less than half that needed to meet the average summer demand for Broken Hill (*see Subsection 1.5*).

  The reservoir has a large surface area, significant siltation and subsequent shallow depth which contribute to large evaporation losses. The reservoir is dry periodically.

1.3 Key Benefits of a Pipeline from the Murray River

Liaison with Essential Energy has identified a number of potentially significant benefits of providing a bulk raw water transfer pipeline from the Murray and these are presented in the following points. A number of additional benefits may be gained depending on the proposed pipeline discharge point option to be pursued and these are outlined within *Subsection 2.3.*

- Potential to greatly increase the overall water supply drought security of Broken Hill.
- Provide increased economic certainty for the Broken Hill community by removing major concerns surrounding the availability, reliability and quality of water supply during frequent long drought periods.
- Remove the need to replace the 99km Menindee to Stephens Creek above-ground pipeline (near end of useful life) at a saving advised by Essential Energy to be $160M+.

  Pumping is understood to have been interrupted 20 times during the 2013/2014 summer due to pipeline and pumping stations failures.

  The existing aged 600mm diameter mild steel cement-lined (MSCL) pipeline would become redundant allowing it to be decommissioned and sold for recycling.

Either option would also save significant and rising ongoing maintenance and repair costs associated with the failing pipeline along with the need to maintain and operate three (3) pumping stations and two (2) booster pumping stations currently installed to supply water to Stephens Creek Reservoir. However, these pumping station costs may only be partially offset by the Murray pipeline as it would also require a number of pumping stations.

A further beneficial outcome may be the potential to transfer the existing Menindee township and Sunset Strip water supply infrastructure and operations to Central Darling Shire Council as it is within their area of operations.

- Avoid or otherwise minimise the need for significant future capital expenditure on the renewal of aged assets near or past their design life.
- Reduction in the use of water treatment chemicals leading to operational cost savings and the potential to automate the existing Broken Hill "Mica Street" water treatment plant (WTP) by reducing raw water quality variability at the plant. Lower raw water salt content would be one likely significant improvement of a Murray source thus minimising the impacts of increasing salinity of residual storage water in reservoirs as evaporation progressively increases salt concentration.
- Potential need for less algae management within Stephens Creek Reservoir in part due to significantly lower inflow water temperatures, if a below ground pipeline were utilised to deliver water along with improved water quality.
- Elimination of the need for a reverse osmosis (RO) desalination plant in Broken Hill and the associated high capital and operating costs. The significant issues associated with brine disposal could also be avoided if an RO plant was not required.
- Potential for major advantages if the Broken Hill town water supply was removed from the operating requirements/rules for the Menindee Storage Lakes scheme. Potential operational changes may be able to reduce large evaporation losses making the savings available for other uses such as, for example, irrigation and/or environmental purposes.

1.4 Basis for Option Development

Development of the initial single preferred option has been based on the following broad functionality requirements and basic design criteria provided as part of the brief:

- Liaise with Essential Energy on technical matters relating to the development of a suitable pipeline system option, particularly demand and logistics aspects.
- Murray River to be used as the source of raw water.
- Identify the most suitable river Lock and Weir Structure for extraction of raw water from the respective weirpool.
- Pipeline to only deliver raw water.
- Identify a suitable pipeline route including the location of any necessary pumping stations and allowing for a potential new mine located around 60km to the south of Broken Hill.
- Consider the potential to retire/replace major aged or likely subsequent redundant assets.
- Provide an outline of the initial feasibility design for the pipeline and pumping stations.
- Although not specifically stated, the indicative pipeline discharge point needs to be identified noting a general initial assumption that Stephens Creek Reservoir would be used consistent with the existing discharge point for the Menindee pipeline.

Typical aspects <u>not</u> required to be considered at this initial stage:

- Consideration to any environmental impact assessment process or issues.

- Land ownership issues or need for any easements.

1.5 Required Capacity & Demand

The current water supply demands for Broken Hill have been provided by Essential Energy

Average demands:

- 25 ML/day Summer
- 14 ML.day Winter

Peak Demands:

- 31 ML/day Summer

Mica Street WTP has a current treated water capacity of 31.5 ML/day. The raw water demand is higher to meet the needs of raw water consumers such as mines, parks, ovals, and the township of Silverton.

An additional raw water supply of 2 ML/day is currently needed to maintain minimum water levels in Stephens Creek Reservoir and Imperial Lake.

Critical to minimising pumping costs, Essential Energy currently must manage the time of day in which pumping is undertaken, particular to avoid peak supply cost periods and tariff premiums.

If, for example, the Monday to Friday peak tariff periods were to be avoided from 7am to 9am in the morning and 5pm to 8pm in the evening then daily demand would need to be meet with no more than 19 hours of pumping. A shorter total pumping time would be required to serve as a buffer to these peak times since to operate at maximum capacity for a period of 15 minutes in any calendar month generates a very high premium.

Considering the above a pipeline capacity of 36 ML/day has been selected in consultation with Essential Energy and agreed to with NOW as the basis for the development of an initial preferred option for the provision of a bulk raw water transfer pipeline from the Murray River to Broken Hill.

The capacity would need to be confirmed as part of any later project development stage.

2 Initial Route Selection

2.1 General

The main factors considered in selecting the initial pipeline route from the Murray River to Broken Hill include, in no particular order:

- location of extraction and discharge points
- location of on route consumers
- pipeline length
- topography (e.g. hills, creek crossings, flood prone areas)
- suitability of ground conditions
- proximity to available electrical power supply
- minimisation of direction changes
- construction and operational access.

2.2 Murray River Extraction Point Options

The project requires that raw water be sourced from the Murray River. The nearest town south of Broken Hill on the Murray River is Wentworth located 267km away via the Silver City Highway or 242km directly in a straight line. Wentworth is also located at the confluence of the Darling and Murray Rivers and is just upstream of Lock & Weir No. 10. A number of other existing Lock & Weir structures are also located relatively nearby in the region

Figure 2-1 shows the location of these Lock & Weir structures along with that of Lake Victoria and Fort Courage. Lake Victoria is a major off-stream storage that plays a significant role in the regulated supply of raw water to South Australia (SA) and Fort Courage is the location of the existing Anabranch pipeline pumping station.

The straight line distances from these sites to Broken Hill is provided in *Table 2-1* for comparison. For the sites located on the Murray River these direct distances were used as a first pass in identifying a suitable point of raw water extraction since in relatively flat country, minimising pipeline length is key to realising a least cost option, assuming favourable ground conditions.

Table 2-1: Straight line distances from Broken Hill to Murray Lock & Weir Structures and also to Lake Victoria & Fort Courage

Site	Distance (km)	Comment
Lock & Weir 6	232	Located in South Australia
Lock & Weir 7	235	Located just upstream of Rufus River confluence (i.e.) Lake Victoria outlet
Lock & Weir 8	241	
Lock & Weir 9	248	Enables diversion of water into Lake Victoria
Lock & Weir 10	242	At Wentworth
Lock & Weir 11	255	At Mildura
Fort Courage	238	Existing Anabranch PS site. Generally northern most point along the length of the Lock 9 weirpool.
Lake Victoria	220	Not a direct Murray River source

The minimum distance is 232km to Lock 6 in SA whilst the minimum distance in NSW is 235km to Lock 7. The maximum distance is 255km to Lock 11 at Mildura. The difference in NSW distances is only 20km which is considered to be relatively minor at this stage and considering the likely overall length of the proposed pipeline.

Notwithstanding that Lake Victoria is not a direct Murray River source, it would not be a favoured location since it is an active storage with normal water level fluctuations of around 3m which is not conducive to optimised pumping, has significant cultural heritage issues and stored water is understood to be allocated for SA rather than NSW use.

Access to Lock 7 and 8 is complicated by Frenchmans Creek to the north which draws water off the Lock 9 weirpool for storage within Lake Victoria. These Locks and respective weirpools are also generally surrounded by flood affected lands.

A pipeline drawing off the Lock 10 weirpool close to the upstream side of the respective Lock structure seems viable although a major pumping station installation would likely conflict with the values of the adjacent parkland area. To the north is an expanse of flood prone lands and Thegoa Lagoon. Drawing off the weirpool further upstream is seemingly more difficult due to land development and the need to cross the Darling River at some point.

Fort Courage, located adjacent the Lock 9 weirpool and 20km to the west of Wentworth, has a number of favourable characteristics identified as:

- Previous selection as the site of the existing Anabranch pumping station delivering water into the pipeline which runs to the north.
- Close proximity to Wentworth and potentially relatively close to a suitable electrical power supply source.
- Favourable topography.
- A higher normal weirpool level (27.4mAHD) that more downstream weirpools. For example, 2.8m above the Lock 8 normal weirpool (24.6 mAHD) and 8.15m above the Lock 6 normal weirpool (19.25mAHD).
- Generally the northern most point along the Lock 9 weirpool and also for the whole of the river reach between Lake Victoria and Wentworth.
- Well placed in relation to potential early identified pipeline routes to Broken Hill which have generally good construction and, operation and maintenance access along the routes.
- Potential to provide a logical consolidation of pumping infrastructure installations (i.e. adjacent) which may offer operation and maintenance cost synergies.

Fort Courage has been identified as the initial preferred site for a raw water extraction pumping station within a Murray River to Broken Hill pipeline system, on the basis of the above.

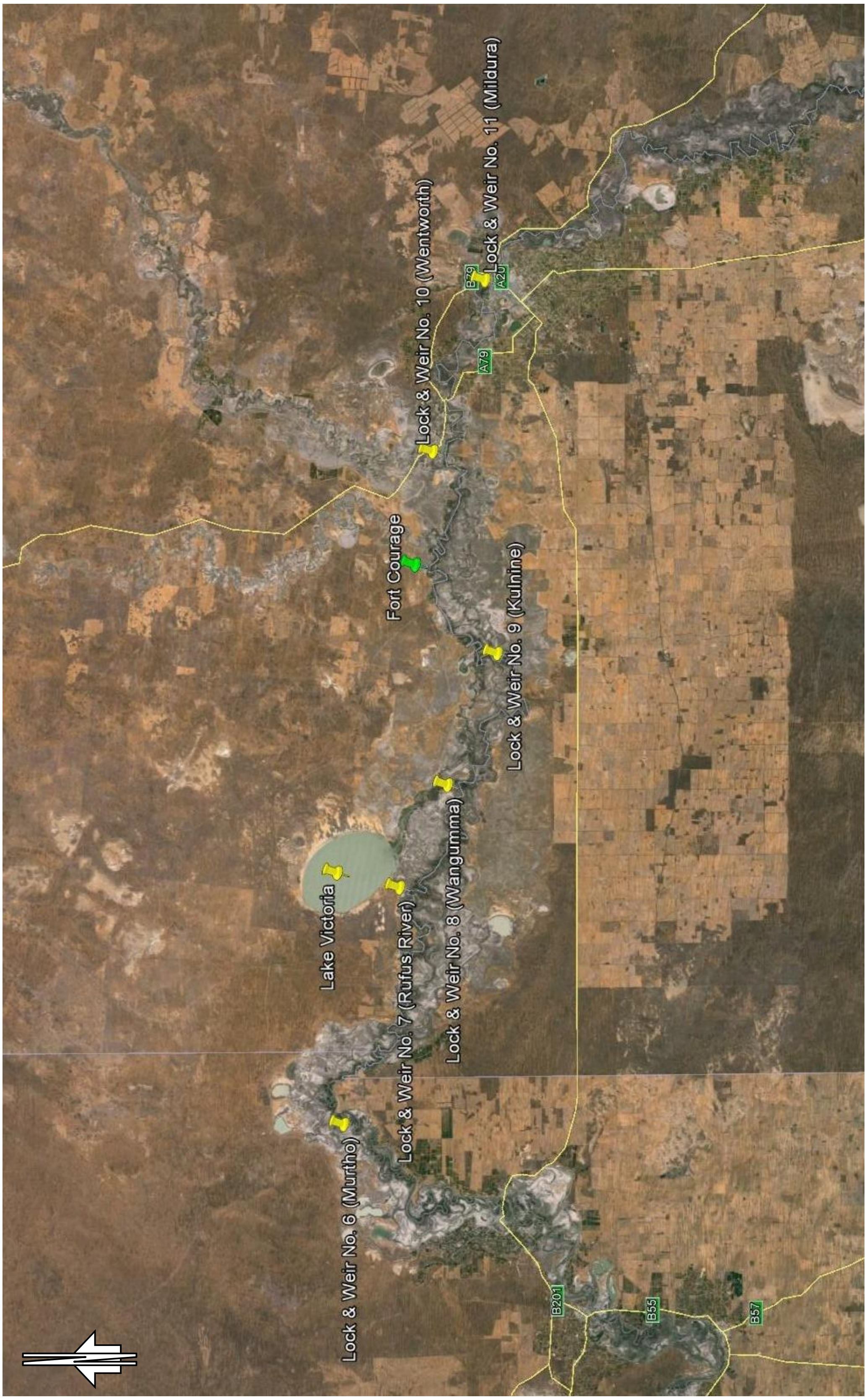
2.3 Discharge Point Options & Associated Benefits

During the study two main pipeline discharge point options were identified in discussion with Essential Energy as follows:

- Stephens Creek Reservoir
- Mica Street Water Treatment Plant within the town of Broken Hill.

The straight line distance from Fort Courage to Stephens Creek is approximately 246km whilst to Mica St WTP the distance is 238km. If the route to Stephen Creek went via the town of Broken Hill then the difference in route lengths could be expected to increase slightly from 8km to nearer 20km.

Figure 2-1: Location of Murray Lock & Weir structures & Lake Victoria near Wentworth



Liaison with Essential Energy has identified a preference for a Murray pipeline to discharge raw water directly at the Mica St WTP rather than delivery via Stephens Creek Reservoir. A number of key benefits in addition to those raised in *Subsection 1.3* have been put forward and each of these is outlined as follows:

- *Elimination of the need for a proposed new emergency use Stephens Creek Pumping Station "HL4"*.

  The existing Stephens Creek pumping station building was constructed in the 1880's initially as a steam driven pumping station. The building construction is primarily of timber frame and iron cladding construction. This pump station is the only permanent source of supply to Broken Hill, assuming the availability of pumped raw water from Menindee, as Umberumberka and Imperial Lake reservoirs can dry up during extended drought periods.

  If the building was destroyed, by fire for example, Broken Hill would be on immediate severe restrictions as it would take months to restore pumping.

  To mitigate the risk of total loss of supply to Broken Hill during a drought, an emergency pumping station with a single pump unit is currently due for construction to commence in 2018/19. The estimated cost for "HL4" has been advised by Essential Energy to be $3.8M excluding overheads.

  If a 36 ML/day supply from the Murray was delivered directly to the Mica St WTP, the Stephens Creek Reservoir and existing pumping station would effectively become a supplementary supply to Broken Hill during drought periods thereby removing the need for the proposed "HL4" pumping station.

- *Opportunity to decommission the high risk Imperial Lake Dam*

  The dam is employed to cover the potential failure of the Stephens Creek pipeline or pumping station

  If a 36 ML/day supply from the Murray was delivered directly to the Mica St WTP, the need for an emergency supply from Imperial Lake would no longer be required 'when' the supply from Stephens Creek fails. Consequently, Imperial Lake Dam could be decommissioned resulting in the removal of a future major infrastructure upgrade expenditure requirement The estimated cost to upgrade the dam has been advised by Essential Energy to be greater than $5M.

- *Mitigation of the risk of failure of the Stephens Creek to Broken Hill pipeline*

  The pipeline was installed in the 1960's and at the time, consisted of three (3) above ground MSCL sections and two (2) Rocla (reinforced concrete pipe) below-ground sections. In 2008, the 2.4km Rocla section (No. 4) was replaced. The other Rocla section (No. 5) is 3km long and passes down Lane St, Broken Hill and is understood to have 10 to 20 years life remaining.

  So far in 2014 the pipeline is understood to have failed twice.

  If a 36 ML/day supply from the Murray was delivered directly to the Mica St WTP, the water supply to Broken Hill would not be at major risk 'when' the pipeline fails and the emergency supply from Imperial Lake or Umberumberka is not available.

- *Mitigation of the risk of failure of the Stephens Creek Pumping Station*

  The majority of the motor starters and common control equipment were installed and commissioned from 1989-1991 and failure events are now understood to be increasing.

  If a 36 ML/day supply from the Murray was delivered directly to the Mica St WTP, the water supply to Broken Hill would not be at major risk 'when' the pumping station fails and the emergency supply from Imperial Lake or Umberumberka is not available.

- *Potential for reverse flow from the Mica St WTP to Stephens Creek Reservoir and from the existing Block 10 tanks in Broken Hill to Imperial Lake Dam*

  The ability for reverse flow to the storage reservoirs would provide operational flexibility and allow an emergency storage/supply function to be incorporated into either reservoir. This may allow the current emergency supply role of Imperial Lake to be transferred to Stephens Creek assuming a Murray pipeline discharged directly to the Mica St WTP. These provisions would further support the potential for decommissioning of Imperial Lake Dam.

  Additionally, reverse flow of likely better quality raw water sourced from the Murray would assist in maintaining or improving water quality within the reservoir/s or otherwise enable mixing of higher salinity water from the reservoirs and anticipated lower salinity Murray water at the point of feed to the WTP.

- *Significantly lower water temperatures* from a potential ‘below-ground’ Murray pipeline option would remove a key need to cool water within the Stephens Creek Reservoir as is currently the case for the Menindee pipeline. This aspect is discussed further in *Subsection 3.1* along with public health risk.

  If a below-ground pipeline were to be pursued then a major obstacle against the feasibility of discharging raw water directly to the WTP would be removed.

On the basis of the above and assuming a below-ground pipeline were to be selected, then the Mica St WTP can been identified as the initial preferred site for a raw water extraction pumping station within a Murray River to Broken Hill pipeline system.

2.4 Pipeline Route Options & Selection

Discussion in the preceding *Subsections 2.2* and *2.3* have respectively identified that the proposed Murray pipeline be commenced at Fort Courage and discharge directly to the Mica St WTP in Broken Hill.

Given these start and end points three (3) main overall route options were identified during various discussions as follows:

(A) Straight line from Fort Courage to the edge of Broken Hill then via a selected route to Mica St WTP.

(B) Pipeline route aligned with the existing 220 kV electricity network (TransGrid) transmission line easement on the assumption that power could be cost effectively tapped for use by anticipated on-route pumping stations.

(C) Pipeline located generally within road reserves between Fort Courage to the edge of Broken Hill then via a selected route to Mica St WTP.

Following brief consideration it was agreed with NOW that the most realistic and practical route to be pursued at this initial stage was the general overall route represented by Option C. It is noted that no geotechnical data covering any route was available for this initial study. It is understood, however, that suitable data may be available from geotechnical investigation work undertaken for the recent provision of NBN conduits along the Silver City Highway which may provide a considerable benefit and cost saving to any next stage.

Option A was not favoured and was considered to be generally too simplistic and most likely to lead to later complications regarding land ownership and easement issues. It would also likely have the least favourable inherent access conditions.

Option B was also not favoured as the transmission line route could not be join until around 49km north of Fort Courage and that this route would likely have less favourable access conditions than those for Option C for the purposes of construction and maintenance. It was subsequently identified, as conveyed within *Section 5 – Electricity Network (offsite),* that the costs of accessing a suitable power supply from the transmission line for use by any on-route pumping stations was extremely high.

For the initially preferred general overall route (Option C), two northern sub-options (Northern Options 1 & 2) were identified at Broken Hill for the route into Mica St WTP and two southern sub-options (Southern Options 1 & 2) were identified, one via the Anabranch Mail Rd and the other via the Silver City Highway.

Figure 2-2 shows a plan of the preferred general overall route and the identified sub-options noting that the route between the northern and southern sub-option areas would be a common route section along the alignment of the Silver City Highway.

Figure 2-3 shows a plan detail of the southern route sub-options.

Southern Sub-option 2, along the Silver City Highway has been identified as the initial preferred alternative based on the following:

- There is only an estimated 0.3km difference between the two alternative routes (i.e. 70.9km for Option 1 and 71.2km for Option 2).
- Anticipated lower cost for Option 2 due to the route being significantly straighter, requiring far less horizontal bends and associated costly thrust restraint provisions.

  The lower cost expectation remains despite added costs which would be associated with two long bridge crossings over the Anabranch of approximately 160m in length for the north existing bridge crossing and approximately 115m in length for the south existing bridge crossing. It is noted that in these locations the steel pipeline diameter may be reduced over the crossings to say OD 559 at a small additional pumping head cost but lessor overall crossing capital cost. For this diameter the pipeline velocity would increase up to 1.97 m/s at 36 ML/day but still be well within acceptable limits.
- Either route is feasible, noting that selection of one route or the other is not anticipated to affect pumping station siting since the first pumping station beyond Fort Courage is anticipated to be further north than the point of convergence (i.e. Pt. “X” on *Figure 2-3*) of the two route alternatives. Also, the route profiles of either route are sufficiently similar as to not be considered a significant factor at this stage.
- Favourable topography is associated with both routes which are seen as avoiding significant flood prone areas.
- Option 2 potentially affords the benefit of utilising existing geotechnical data that is understood to be available in relation to the recent NBN installation within the Silver City Highway road reserve.

Figure 2-4 shows a plan detail of the northern (town) route sub-options.

Northern Sub-option 2, which approaches the Mica St WTP generally from the southeast and passing the existing Block 10 raw water supply reservoirs, has been identified as the initial preferred alternative based on the following:

- Sub-option 2 is supported by Essential Energy.
- Shorter route.
- Avoids hills and very hard rock areas anticipated by Essential Energy. Later geotechnical drilling of any pipeline route would be required to confirm the suitability of ground conditions.
- Avoids crossing the Barrier Highway twice.
- Has the potential to connect into a relatively new (1990) existing section of 500mm diameter DICL main adjacent the existing Block 10 tanks running from Mica St WTP.

- The route past the Block 10 tanks has the potential to allow the topping up of these raw water supply reservoirs on route to the WTP.
- Either sub-option is required to cross an existing above ground pipeline and the Sydney to Perth trans-national railway line, which comprises a single line at this location.
- Sub-option 1 was identified first following generally the western town limits before running east into town along the alignment of the existing Umberumberka pipeline. It was thought that the proposed Murray pipeline could create the additional benefit of allowing for the replacement of a section of the existing pipeline which runs to the Mica St WTP. Overall benefits of Sub-option 2 are considered to outweigh those of Sub-option 1.

Figure 2-5 shows a plan of the general overall route against the topography digital elevation model (DEM) produced for the study area. The DEM developed has been based on a 30m grid LiDAR data set obtained from GeoScience Australia and used for preliminary hydraulic assessment of the preferred Murray pipeline route and initial siting of pumping stations.

Summary Identification of the Initial Preferred Route

The initial preferred route for a Murray River to Broken Hill pipeline from Fort Courage (river raw water extraction point) to Mica St WTP (discharge point) is summarised as the combination of the following:

- Southern route Sub-option 2, from Fort Courage to Renmark Road, then a relatively short overland section to the Silver City Highway before following the highway road reserve to Point “X” as shown on *Figure 2-3*;
- Silver City Highway route from Point “X” to the Kanandah Road junction in Broken Hill located to the west of the airport;
- Northern route Sub-option 2, as shown on *Figure 2-4*, via Kanandah Road, along a service route behind the first row of commercial properties, under the railway line via a proposed services conduit, returning to Kanandah Road, to Griffith Street, to Gaffney Street crossing a concrete storm drain, then to the Silver City Highway up to a point adjacent the Block 10 tanks, where the route would either connect into existing 500mm diameter DICL pipework or otherwise continue following a similar route along the Silver City Highway to Kaolin St and finishing at the Mica St WTP.

The route profile for the preferred route combination is illustrated in *Figure 2-6,* albeit using data from Google Earth for convenience. However, for illustrative purposes there is not expected to be any discernible difference when compared to the DEM.

Figure 2-2: Plan of general overall route & southern and northern (town) route sub-options

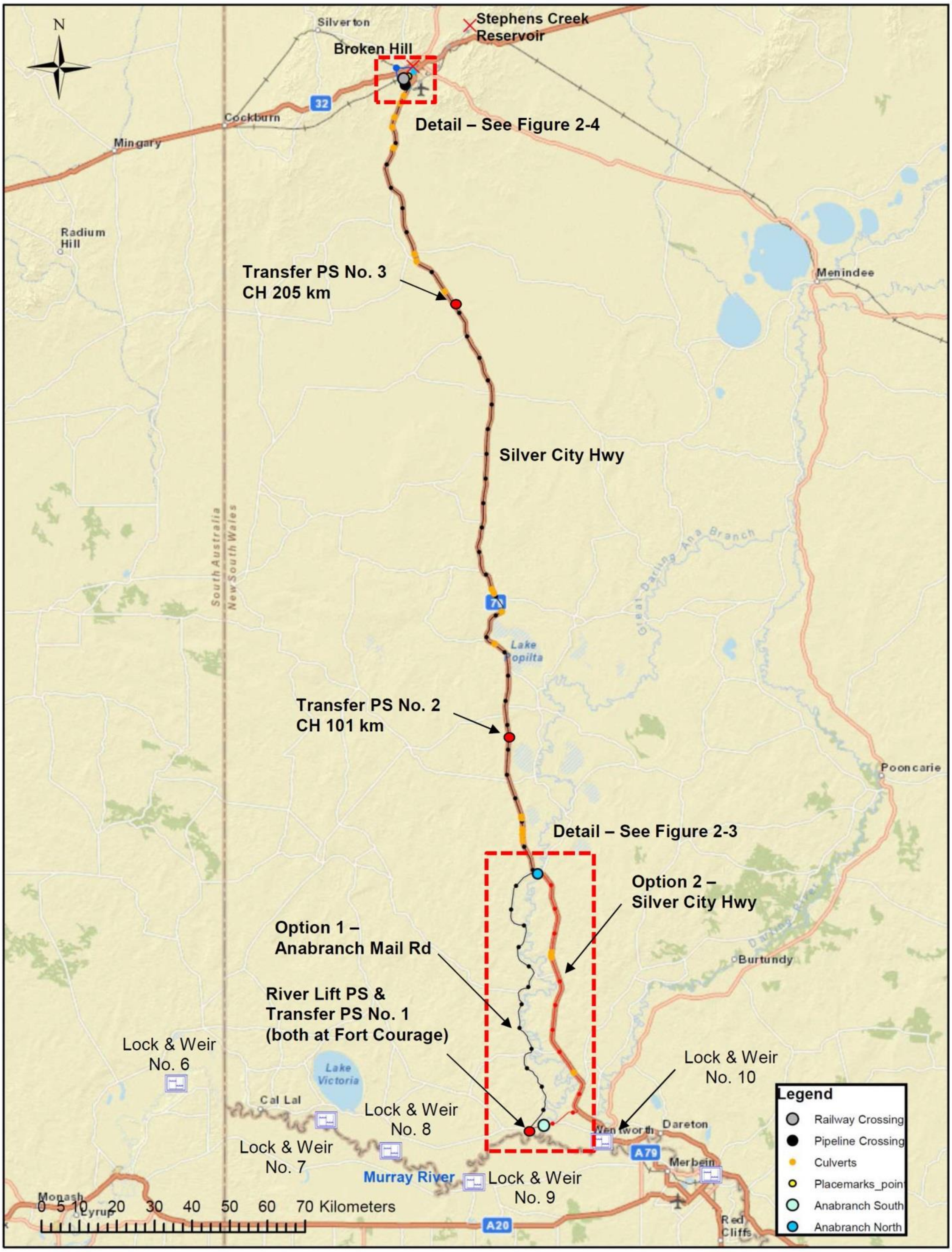


Figure 2-3: Plan detail of southern route Sub-option 1 (Anabranch Mail Rd) & Sub-option 2 (Silver City Highway)

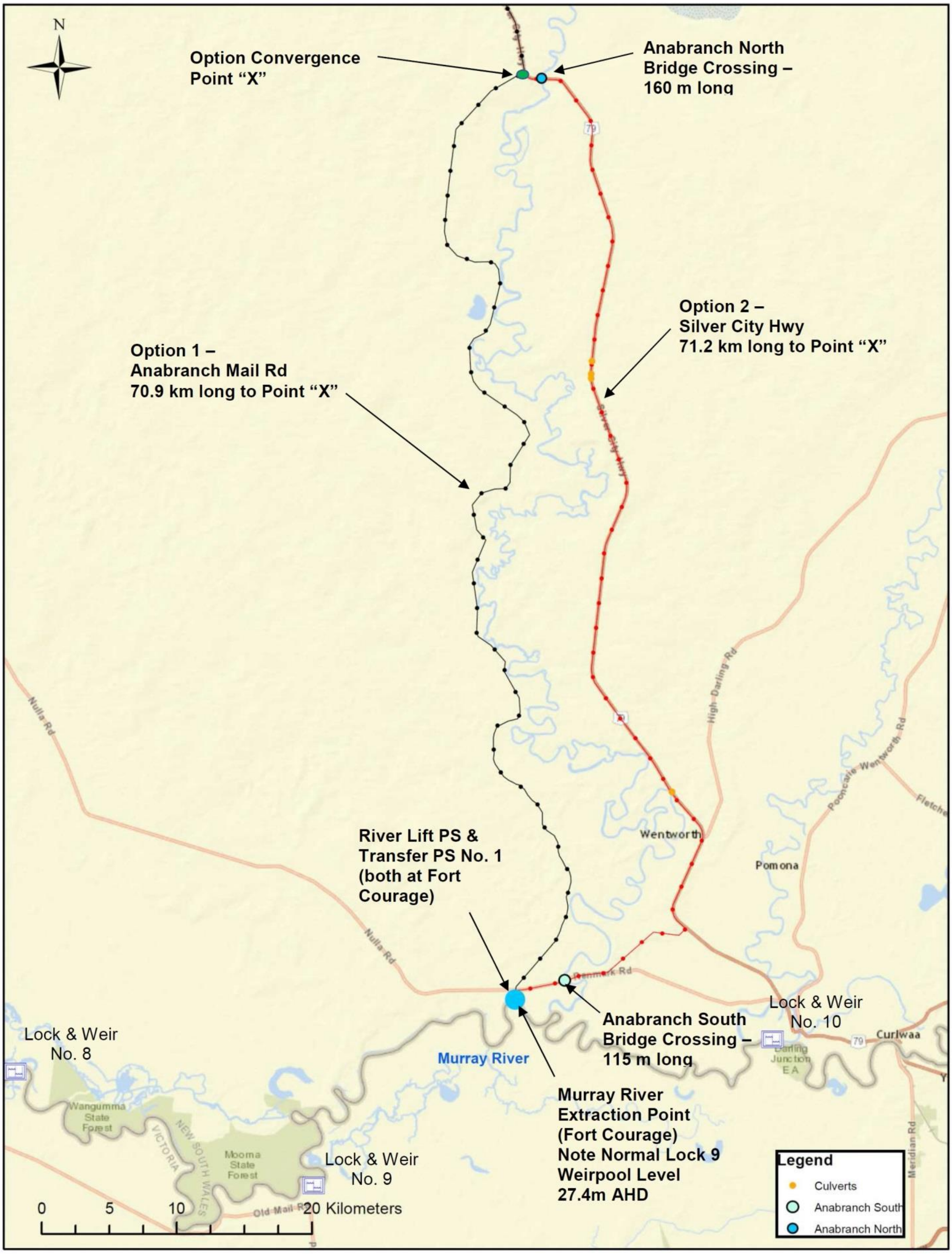


Figure 2-4: Plan detail of northern (town) route Sub-option 1 (Western fringe) & Sub-option 2 (Past Block 10 tanks)

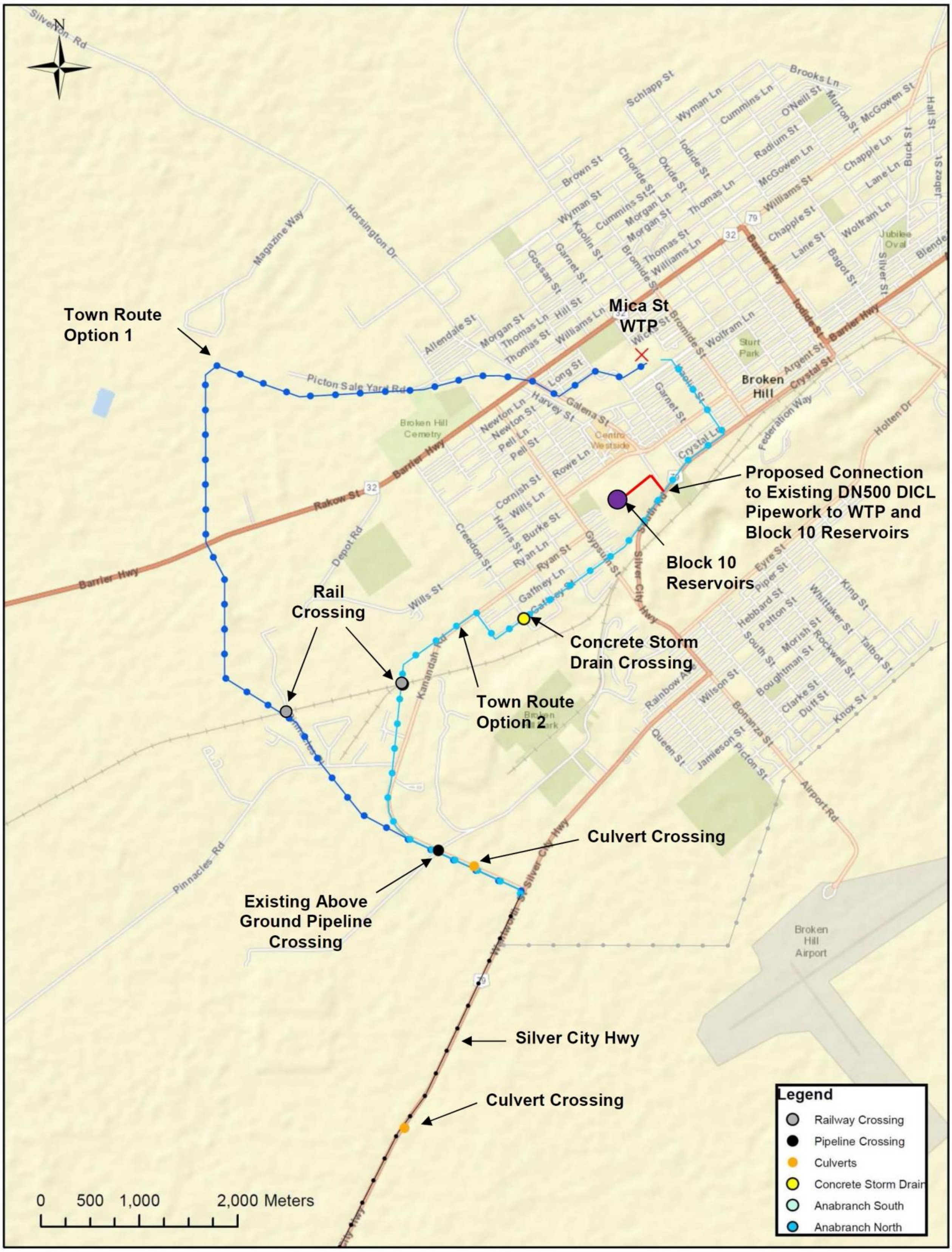


Figure 2-5: Plan of general overall route with topography DEM overlay

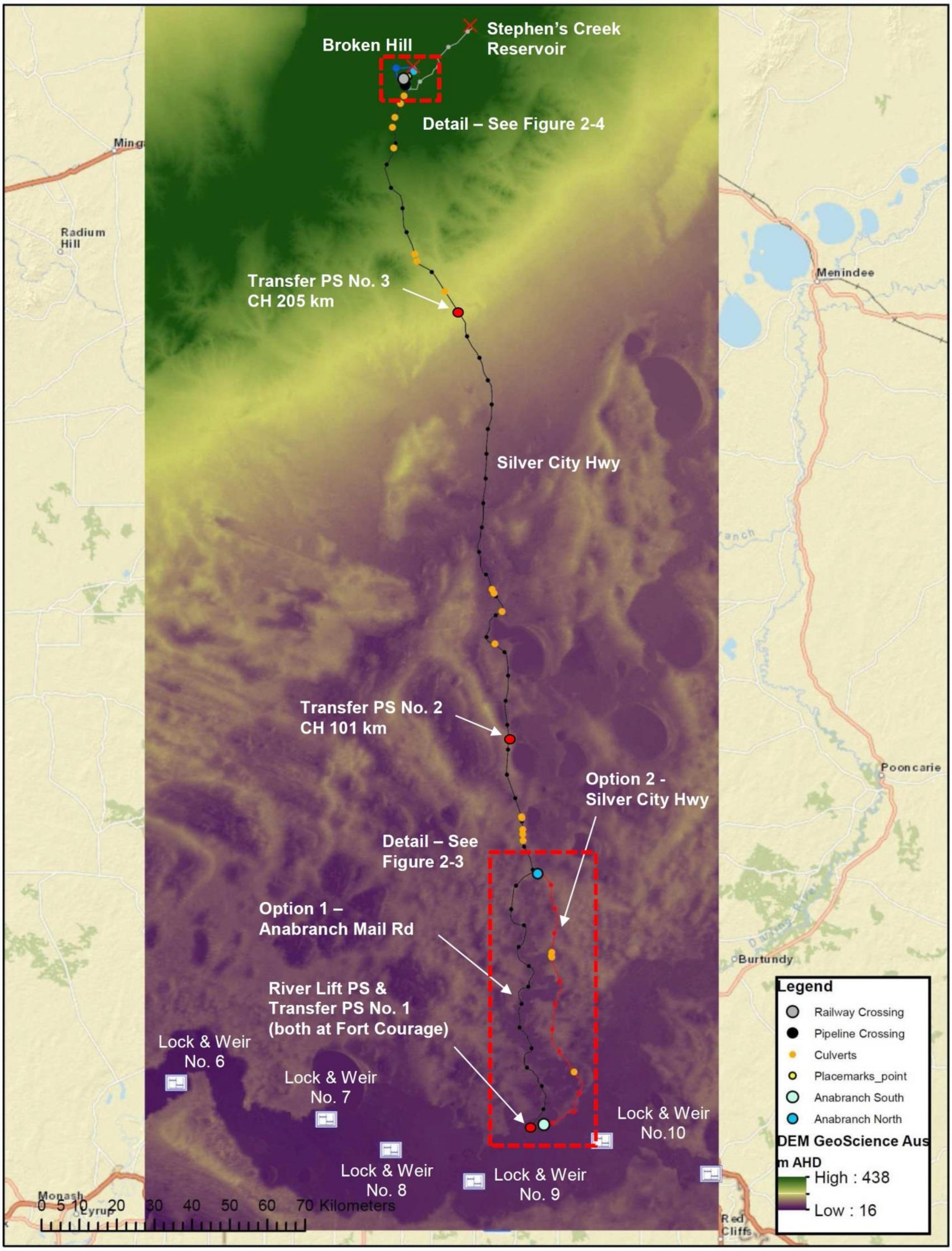
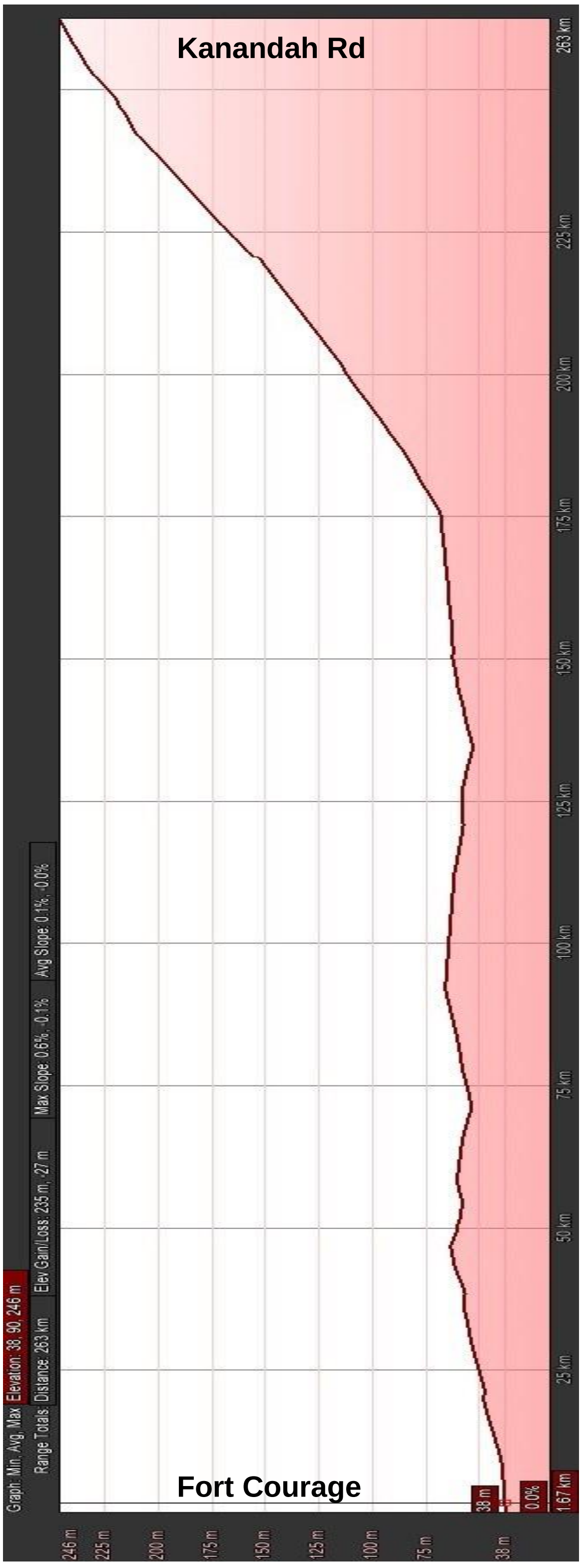


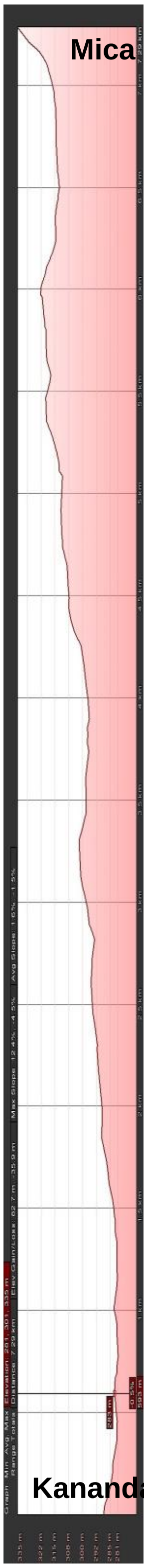
Figure 2-6: Section profiles for initial preferred Murray to Broken Hill route combination

Note: Scales for these profiles differ.

Section: Fort Courage to Kanandah Rd, Broken



Section: Kanandah Rd to Mica St



3 Transfer Pipeline System Options

This section of the report proposes the most feasible option for the installation method, material selection, pipe sizing and pumping station locations.

3.1 Method of Installation (Above or Below Ground)

Pipeline construction above ground is suitable when large distances along the route alignment require excavation in rock, or exhibit very aggressive soil conditions. Above ground construction provides easy access to the pipe for inspection for leaks, corrosion and other pipeline damage.

Deviations below ground are necessary at road, rail and other access crossings, requiring additional scour and air valves.

Above ground construction requires pipe supports (chairs) at every joint for rubber ring jointed (RRJ) pipe. In very long pipelines the cost of supports, usually of pre-cast concrete construction, would far exceed the cost of excavation, provided there are no significant distances requiring rock excavation. Support spacing can be increased if steel pipes are used as they offer longer effective lengths (13.4m), however steel pipes are not recommended for above ground installation due to reduction in design life from UV exposure.

Below ground construction would remove any risk of pipeline damage from bushfires, UV exposure, collision from vehicles and vandalism. As the pipe is supported on all sides by the bedding material, minor deflections of less than 1.25 degrees (allowing for construction intolerances) are possible without the need for thrust restraint.

Additionally, pipelines installed below ground are not exposed to high ambient air temperatures and direct solar radiation and thus piped water temperatures would remain significantly lower. Lower temperatures minimise the public health risk of the occurrence of *Naegleria fowleri* transforming and growing rapidly in high water temperatures, particularly at approximately 42°C and above.

Because of this a below ground pipeline has the potential to significantly reduce the extent and cost of water quality monitoring as well as the cost of treatment. Cooler piped water temperatures reduce the risks to the community for use and general exposure. It is understood that the water temperature discharged from the existing Menindee pipeline can reach 46°C in summer and this is a key reason for the need to discharge transferred water into Stephens Creek Reservoir for dilution and cooling rather than pumping directly to the WTP.

Our understanding of the overall geology of the proposed pipeline route is that rock would not be unlikely to be encountered at typical excavation depths (<1.6m) for most of the pipeline especially along the southern portion of the route. There is anticipated to be some degree of rock prevalent in and around Broken Hill along the pipeline route, however, this has not been confirmed by field investigation at this stage.

A feasibility level costing of above and below ground construction per km of installed pipe is given in *Table 3-1*. For the purposes of costing supports vs excavation, standard length (5.5m) Ductile Iron Cement Lined (DICL) pipe with spigot-socket rubber ringed joints was assumed.

Table 3-1: Cost of Concrete Supports vs Excavation

Item	Cost
Concrete supports per km	$214,300
Excavation, backfilling and compaction per km (no rock) [1.]	$166,000

Notes: 1. Assume 600mm cover and trenching through easily excavated soil i.e. no rock

For the proposed 270km pipeline, the below ground option would be approximately $8.7M less than above ground. Note that the above comparison does include costing for additional air and scour valves that would be required at road, rail and other crossings for above ground construction.

Given the available geological information, and the advantages and feasibility costings outlined above, this feasibility study has been developed for a below ground pipeline.

3.2 Pipeline Material Selection

Steel and DICL have been considered in this study due to their strength and durability. Polyethylene sleaved DICL pipe and fusion bonded polyethylene coated ("Sintakote") Mild Steel Cement Lined (MSCL) pipe both have a design life of 100 years or more.

Supply and deliver budget prices are shown in *Table 3-2* for DICL and MSCL pipes.

Table 3-2: Supply & Deliver Budget Costings for DICL & MSCL Pipe

Pipe Material and Size	Internal Diameter (mm)	Rated Operating Pressure (m head)	Cost ($/m)
DN 750 DICL	790	350	545
OD 762 x 8mm Steel	722	462	405
OD 813 x 8mm Steel	765	433	435
OD 914 x 8mm Steel	866	385	525

Prices for DN 750 DICL pipes are about 25% more than similarly sized steel pipes. OD 914 MSCL is comparable with DN 750 DICL but offers a larger internal diameter which would reduce required pumping heads.

The effective length of steel pipe is 13.4 m whereas DICL pipes are supplied in 5.5m effective lengths, hence steel pipe can be laid more quickly during construction. Both steel and DICL pipes are rubber ring jointed however steel pipe may be welded in the vicinity of bends, and skin friction may be used for thrust restraint instead of reinforced concrete thrust blocks. This does not necessarily mean that thrust blocks would not be required at certain locations along the pipeline, but it allows for a greater degree of flexibility in design.

Considering the above, a MSCL pipe has been selected for this study.

3.3 Pipeline Sizing & Required Pumping Stations

A natural surface long-section of proposed pipeline route was extracted from LiDAR data of the area. The total length of the route is about 270km. There are a number of local high and low points with a maximum deviation of about 40m AHD in the first 180km, with the last 90km generally rising to a final ground level of 330.4m at Mica St WTP. For the purposes of analysis the reception tank TWL at Mica St WTP was assumed to be 5m above ground level.

A preliminary steady state hydraulic analysis has been carried out for the proposed pipeline route. In this analysis the pipeline was assumed to be cement mortar lined and have a k roughness value of 0.3mm. This value includes losses through pipe bends and fittings.

When determining pipeline diameter, the Water Supply Code of Australia suggests head losses per km be kept below 3m, with velocities in the range of 0.8 to 1.2 m/s. For a flow rate of 417L/s (36ML/d) the most suitable size steel pipe would be OD 813 x 8mm. This would keep flow velocities and head losses low (0.9 m/s and 0.92 m/km), and reduce the overall pumping energy requirement.

Three (3) off-line transfer pumping stations, each with an associated break pressure balancing tank, are required for an OD 813 MSCL pipeline. An additional lift pumping station would be required to transfer water into a balance tank prior to transfer along the pipeline via Pumping Station No. 1 (discussed further in *Section 4*).

Figure 3-1 shows the hydraulic grade line (HGL) of the proposed system.

Pumping station locations have been chosen to ensure the rising main is always under positive pressure and to prevent free draining of the pipeline when the system is not operating. These locations would also help to minimise the risk of negative pressures occurring during a water hammer event. Note that these locations have been selected purely from viewing of the natural surface long-section and may need revising when more information is available such as power availability, site conditions, proximity to services etc. Locations of Transfer Pumping Station Nos. 1 and 2 are selected in such a way that pump duty/size for both pumping stations would be the same in order to have lower maintenance cost (i.e. fewer number of spares to be kept in stock).

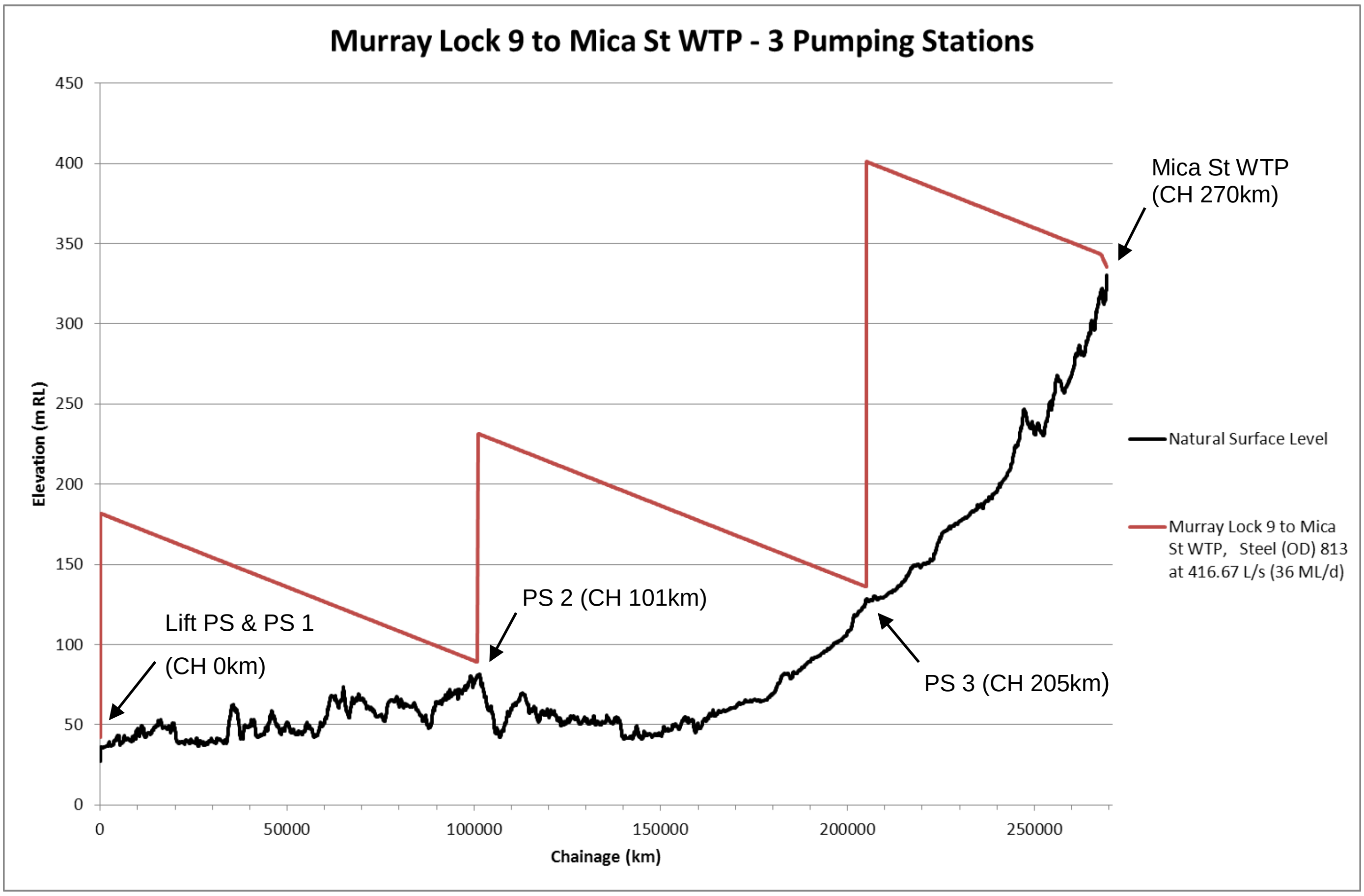


Figure 3-1: HGL for OD 813 x 8mm MSCL pipeline & three (3) transfer pumping stations

The following pump heads would be required:

- Murray River Lift Pumping Station: 15m;
- Transfer Pumping Station Nos. 1 & 2: 150m;
- Transfer Pumping Station No. 3: 275m.

It is understood that a relatively new DN 500 DICL pipeline between the Block 10 storages and the Mica St WTP has been constructed, and that if possible Essential Energy see an advantage in making use of this pipeline for bulk water transfer, particular the section aligned with the Silver City Highway in town. The analysis shows that the 1.6km of DN 500 pipeline would increase the required pump head at PS No. 3 by about 7m. The velocity in the DN 500 line would be fairly high at 1.87m/s for a 417 L/s flow rate, but is acceptable considering the short distance.

A water hammer analysis has not been undertaken for the above proposed system, however it is not anticipated that positive pressures would occur in a power failure event due to the significant length of the pipeline. Some form of surge mitigation would most likely be required to prevent negative pressures occurring at local high points on the line. A general allowance for discharge tanks or other surge protection infrastructure has been made in the costing.

3.4 Air Release, Scour & Isolation Valves

Air release valves are essential for discharge and intake of air during pipeline charging, draining and operation. Under normal pumping conditions air would be released from the water and require discharge to prevent air collecting at pipeline high points and restricting flow. Automatic air valves facilitate this air bleed-off. They also provide a point for air intake and help mitigate risks of negative pressures occurring during a water hammer event.

DN100 size air release valves are proposed for the pipeline in accordance with WSA-2011. A hydrant type isolator would facilitate the isolation of the valve for maintenance and removal.

For the purpose of costing, the number of air valves required has been estimated by taking the total pipeline length (270km) and dividing by the maximum spacing of air valves permitted by WSA-2011 (800m). This equates to a total of 338 air valves. This number can be refined during design phase.

Figure 3-2 shows a typical on-line air valve installation with hydrant isolator arrangement.

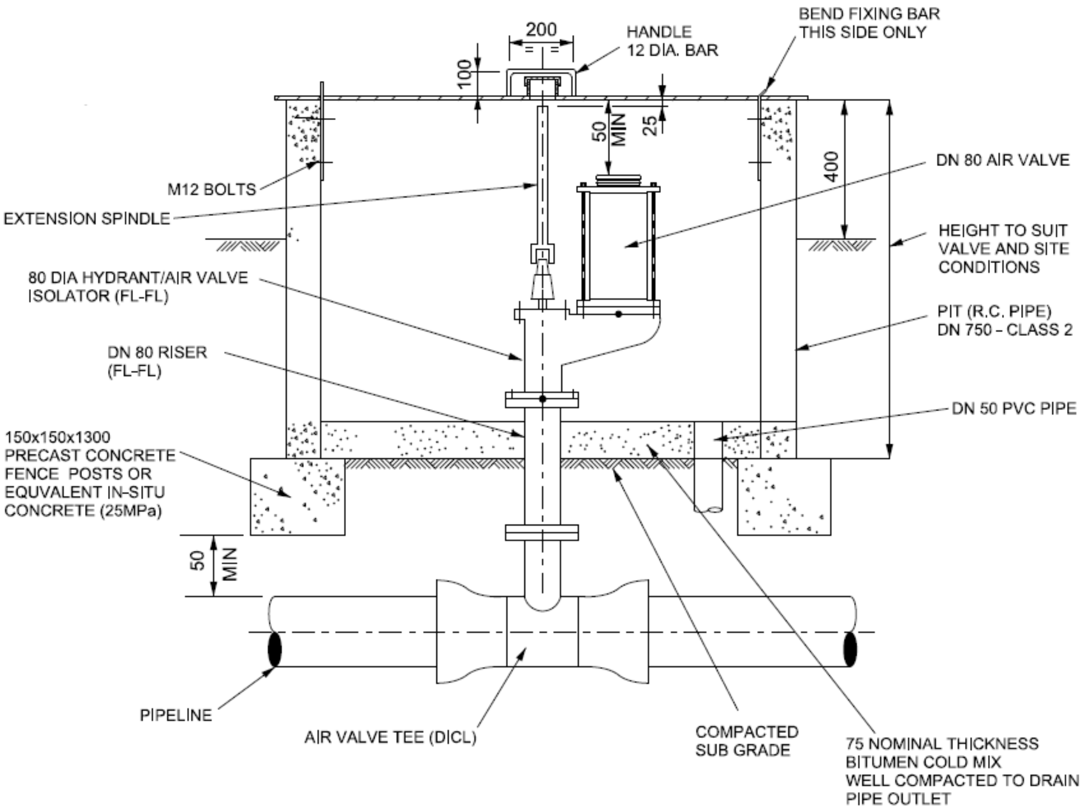


Figure 3-2: Typical automatic on-line air release valve arrangement

Scour valves should be provided at low points to facilitate draining of the pipeline when required. For the purposes of costing an equal number of scour valves as air valves has been assumed.

Isolation valves would be provided at regular intervals to allow sections of the pipeline to be taken off line for maintenance if required. For cost estimating purposes spacing of isolation valves has been assumed to be 5km as per WSA-2011 equating to a total of 56 valves.

3.5 Transfer of Raw Water from Mica St to Stephens Ck Reservoir

Raw water is currently supplied to the treatment plant from Stephens Creek reservoir via a 16.3km long mostly above ground 600mm diameter MSCL pipeline. It is understood that this pipeline is aging and reaching the end of its service life. Considering the requirements for balancing of the flows pumped via the Murray –Broken Hill pipeline and the existing capacity available at the Block 10 reservoirs, Stephens Creek may be used for this purpose. The long section of the pipeline from Stephens Creek reservoir to the WTP is shown in *Figure 3-3.*

Figure 3-3: Long-section profile of Stephens Creek Reservoir to Mica St WTP

A hydraulic analysis of gravitating from the WTP to Stephens Creek reservoir has not been undertaken, however given the profile above it is believed possible. If other unforseen factors do not allow gravitation, water may be pumped from Transfer Pumping Station No. 3 to Stephens Creek Reservoir.

4 Murray River Lift & Transfer Pumping Stations

4.1 Identification of Pumping Station Sites & Locations

The proposed scheme would consist of four pumping stations; one (1) lift pumping station drawing water from Murray Lock 9, and three (3) transfer pumping stations delivering water through the proposed new pipeline. The three transfer pumping stations would each have a 500kL balancing tank for flow attenuation. The system head would also be broken at each balance tank.

Split case type centrifugal pumps have been selected for the transfer pumping stations in order to have higher pump efficiencies. These pump models also allow for removal of the top section of the pump casing which facilitates easy inspection and maintenance. The pump discharge lines would have a tilting disc swing type, cast iron non-return valve and gate valve fitted with electric actuators for easy and reliable operation.

The discharge headers would be fitted with DN600 electro-magnetic flow meter to facilitate VSD operation to vary the pump speed and discharge rate based on the water demand and levels in the three (3) balance tanks.

A gantry type cane is proposed at each pumping station to facilitate removal of pumps and valves for maintenance and repair works.

Transfer Pumping Stations Nos. 1, 2 and 3 would have an approximate footprint size of 22m x 9m x 5m. This would include sufficient space for the pumps and motors, a switchroom to house the switchboards and an unloading/loading bay for moving the pumps and motors. Air conditioning would be provided in the switchroom with natural ventilation provided in the pump room.

The four proposed pumping station locations and details are summarised below in

Table 4-1.

Table 4-1: Proposed pumping station locations & details

Pumping Station	Location	Pump Type	Pump Size (kW)	Pump Duty Head (m)	Drawing from	Pumping to
Murray River Lift PS	Fort Courage	Submersible	55	15	Murray River Lock 9 weirpool	Balance tank No. 1
Transfer PS No. 1	Fort Courage	Split case centrifugal	450	150	Balance tank No. 1	Balance tank No. 2
Transfer PS No. 2	Ch 101km	Split case centrifugal	450	150	Balance tank No. 2	Balance tank No. 3
Transfer PS No. 3	Ch 205km	Split case centrifugal	750	275	Balance tank No. 3	Mica St WTP[1.]

Notes: 1.The option exists for the pipeline to supply (top up) the Block 10 raw water supply reservoirs within the town on route to the WTP.

4.2 Murray River Lift Pumping Station on Lock 9 Weirpool

4.2.1 Pumping Station Description & Mechanical Equipment

The Murray River Lift Pumping Station ("Lift PS") is envisaged to consist of submersible pumps housed in a wet well structure at the river bank. The PS would draw raw water from the Murray River Lock 9 weirpool into the pumping station through a 900 mm diameter screen element via DN 900 DICL pipework. The Lift PS discharges raw water into a nearby 250 kL balance tank which serves as the water source reservoir for Transfer Pumping Station No. 1.

The benefits of this arrangement include:

- ability for PS to cater for flooding in the Murray River;
- reduction in the required depth of the wet well;
- submersible pumps are capable of pumping water containing silt and sediment, commonly present in river water, without damage to internal bearings;

The Lift PS is located at Site 1 and consequently is envisaged to share a number of key components with Transfer PS No. 1. These include items such as a common electrical power supply to the site, elements of onsite electrical reticulation and the building which houses the electrical switchgear, which is provided over Transfer PS No. 1.

Drawing A-1, Drawing A-2 and *Drawing A-3* (*Appendix A*) provides the developed indicative general arrangement of the Lift PS, a typical intake screen and pump unit detail respectively. *Figure B-1* (*Appendix B*) provides the pump data sheet for the selected pump.

The Lift PS would comprise of the following components:

- Inlet screen, 900 mm diameter with 3 mm aperture (stainless steel, grade 316) together with compressed air bursting system for cleaning of the screen element;
- DN 900 DICL suction pipe from the screen to the wet well structure with inlet penstock for isolation;
- 4.2m diameter wet well type raw water pumping station, approximately 6 m deep;
- 3x 55 kW submersible pumps, two duty and one standby;
- Three VSD electrical switchgear units for the raw water pumps. As discussed above, the switchgear would be located in the same switchroom that houses the Transfer Pumping Station No. 1 switchgear.

Raw Water Pumping Station Structure & Inlet Screen

The 4.2 m diameter wet well would have a DN 900 inlet penstock, inlet screen and three (3) submersible pumps. The penstock frame and door are of cast iron construction, and spindle of stainless steel construction. A manual gear operator would be provided for easy operation of the penstock.

A DN 900 wedged type screen with 3 mm aperture “Johnsons screen” or similar equivalent, together associated compressed air system with duty/standby compressors and an air receiver, are proposed to facilitate removal of tree branches, leaves and other particles from the river water. The screen would be located in the river and bolted at the end of DN 900 DICL suction pipe. The proposed screening system is commonly used in medium scale raw water pumping stations in Australia and other countries, and has a proven record of operation.

The other end of the inlet pipe, inside the wet well is installed with the DN900 penstock to facilitate isolation of the wet well for maintenance. However maintenance of the wet well is considered as rare event for these types of raw water pumping stations. Refer Appendix 1 showing the screen details and Appendix 2 for the typical details of the proposed Lift PS.

4.2.2 Electrical Reticulation (onsite)

The electrical works would comprise the following major components:

- An Electrical Switchboard for 415V/240V power supply, located inside the Transfer Pumping Station No.1 building;
- A PLC Panel for automatic control and monitoring. This panel is anticipated to be integrated into the PLC Panel for Transfer Pumping Station No.1;
- Stand-alone low harmonic (active front end type) VSD (total 3-off) for 415V pump motor controls;
- Instruments for river water level and line pressure monitoring;

4.3 Transfer Pumping Station No. 1 at Murray River

4.3.1 Pumping Station Description & Mechanical Equipment

Transfer Pumping Station No. 1 (“PS No. 1”) is envisaged to consist of low voltage split case centrifugal pumps in a blockwork building. Water would be drawn out of the 250 kL screening and balancing reservoir, located near the Murray River bank above the flood level. Raw water is delivered into this screening/balance tank via the Lift PS.

PS No. 1 would transfer raw water from the 250 kL concrete balance tank to a 500 kL concrete balance tank at Transfer Pumping Station No. 2, located at chainage 101 km along the proposed pipeline route.

The benefits of this arrangement, in addition to those listed in *Section 4.2.1*, include:

- elimination of the majority of sediment from the main transfer pipeline. In this way any entrained sediment can be primarily screened and retained in the 250 kL balance tank for simplified periodic maintenance;
- the balancing tank would provide steady operating regime for the PS No. 1 i.e. consistent range of positive suction head provided to the pumps;
- High efficiency split case pumps have been selected to minimise operating costs;
- Low voltage motors do not require specialist high voltage electrician to attend maintenance and repair works;
- Inspection of pump internals and shaft can be easily carried out by removal of the upper casing of the pump, and hence reduces operation and maintenance costs.

Drawing A-4 and *Drawing A-5* (*Appendix A*) provide the developed indicative general arrangement of PS No. 1 and pump unit detail respectively. *Figure B-2* (*Appendix B*) provides the pump data sheets for the selected pump.

PS No. 1 would comprise of the following components:

- 250 kL concrete tank on ground. This would be of standard design generally designed and built by “HUME” or “ECONOMY TANKS”. It is anticipated that screening equipment would be installed in this tank to facilitate the capture of sediment, as discussed previously;
- 22m x 9m x 5m high pumping station building to house the pumping units and within the pumping station building, a mezzanine floor for the electrical switchroom with AC units to house raw water pumps and the Lift PS electrical switchboards;
- 3x 450 kW, axially split case centrifugal pumps driven by 690 volts LV motor, two duty and one standby, each with the duty of 210 L/s at 150 m head;
- Three 450 kW VSD switchgear units for the split case pumps;
- DN 450 suction lines from a DN 600 suction header, plus discharge pipework and valves;
- Fenced area for HV/LV power supply installation;

- 10 tonne gantry crane for the pumping station;
- Air-conditioning system for VSD switchroom and control room; and
- Package type wash-water/rainwater pumping system.

4.3.2 Electrical Reticulation (onsite)

The electrical works would comprise the following major components:

- An Electrical Switchboard for 690V power supply, located inside the Transfer Pumping Station No.1 building.
- Power Supply Authority Metering Panels for revenue metering;
- A PLC Panel with HMI (Touch Screen) for automatic control and monitoring;
- Stand-alone low harmonic (active front end type) VSD (total 3-off) for 690V pump motor controls;
- Instruments for balance tank level and line pressure monitoring;
- Building services including lighting, GPO, alarms, ventilation and/or air-conditioning;
- Lighting protection system.

4.4 Transfer Pumping Station No. 2 near Lake Nialia

4.4.1 Pumping Station Description & Mechanical Equipment

Similar to PS No. 1, Transfer Pumping Station No. 2 (“PS No. 2”) would consist of split case centrifugal pumps in a blockwork building.

PS No. 2 would transfer raw water from the 500 kL concrete balance tank to a 500 kL concrete balance tank at Transfer Pumping Station No. 3, located at chainage 205 km along the proposed pipeline route. By-pass pipework and valves would be installed at PS No. 2 with an electric actuator and non-return valve to facilitate direct pumping from Pumping Station No. 1 to 3, when pumping at a low flow rate to optimise pumping specific energy consumption (kWh / kL).

The benefits of this arrangement include:

- Flexibility in system operation to minimise pumping energy;
- the balancing tank would provide steady operating regime for the PS No. 1 i.e. consistent range of positive suction head provided to the pumps;
- Balance tank can drain back into the pipeline to prevent negative pressures during a water hammer event;
- High efficiency split case pumps have been selected to minimise operating costs;
- Low voltage motors do not require specialist high voltage electrician to attend maintenance and repair works;
- Inspection of pump internals and shaft can be easily carried out by removal of the upper casing of the pump, and hence reduces operation and maintenance costs;
- By proposing the same pump duty as PS No. 1, the pumping machinery is interchangeable and this minimises the number of spares that must be kept in stock;

Drawing A-4 and *Drawing A-5* (*Appendix A*) provides the developed indicative general arrangement of PS No. 2 and pump unit detail respectively. *Figure B-2* (*Appendix B*) provides a pump data sheets for the selected pump.

Components for PS No. 2 station would be similar to those of PS No. 1, and comprise of:

- 500 kL concrete reservoir on ground. This would be of standard design generally designed and built by “HUME” or “ECONOMY TANKS”. No provision for screening is required;
- 22m x 9m x 5m high pumping station building to house the pumping units and within the pumping station building, a mezzanine floor electrical switchroom with AC units to house raw water pumps and the Lift PS electrical switchboards;
- 3x 450 kW, axially split case centrifugal pumps driven by 690 volts LV motor, two duty and one standby, each with the duty of 210 L/s at 150 m head;
- Three 450 kW VSD switchgear units for the split case pumps;
- DN 450 suction lines from a DN 600 suction header, plus discharge pipework and valves;
- Transformer room for HV/LV power supply installation;
- 10 tonne gantry crane for the pumping station;
- Air-conditioning system for VSD switchroom and control building; and
- Package type wash-water/rainwater pumping system; and
- Surge tank facility, if required to mitigate water hammer effect to the pumping system under power failure condition.

4.4.2 Electrical Reticulation (onsite)

The electrical works would comprise the following major components:

- An Electrical Switchboard for 690V power supply, located inside the Transfer Pumping Station No. 2 building.
- An Electrical Switchboard for 415V/240V power supply, located inside the Transfer Pumping Station No. 2 building;
- Power Supply Authority Metering Panels for revenue metering;
- A PLC Panel with HMI (Touch Screen) for automatic control and monitoring;
- Stand-alone low harmonic (active front end type) VSD (total 3-off) for 690V pump motor controls;
- Instruments for balance tank level and line pressure monitoring;
- Building services including lighting, GPO, alarms, ventilation and/or air-conditioning;
- Lighting protection system.

4.5 Transfer Pumping Station No. 3 ~65km south of Broken Hill

4.5.1 Pumping Station Description & Mechanical Equipment

Transfer Pumping Station No. 3 (“PS No. 3”) would house larger capacity split case type centrifugal pumps than PS No. 1 & 2 to deliver the higher required head (i.e. 275m vs 150m). PS No. 3 would transfer raw water from the 500 kL concrete balance tank to the Mica St WTP (about 65 km away at chainage 270 km).

The benefits of this type of pump and pumping arrangement are similar to those for PS No. 1 and 2 discussed in the previous sections.

PS No. 3 would comprise of the following components:

- 500 kL concrete reservoir on ground. This would be of standard design generally designed and built by “HUME” or “ECONOMY TANKS”
- 22m x 9m x 5m high pumping station building to house the pumping units and within the pumping station building, a mezzanine floor electrical switchroom with AC units to house raw water pumps and the Lift PS electrical switchboards;
- 3x 750 kW, axially split case centrifugal pumps driven by 690 volts LV motor, two duty and one standby, each with the duty of 210 L/s at 275 m head;
- Three 750 kW VSD switchgear for split case pumps;
- DN 450 suction lines from a DN 600 suction header, plus discharge pipework and valves;
- Transformer room for HV/LV power supply installation;
- 15 tonne gantry crane for the pumping station;
- Air-conditioning system for VSD switchroom and control building;
- Package type wash-water/rainwater pumping system; and
- Surge tank facility, if required to mitigate water hammer effect to the pumping system under power failure condition.

Drawing A-4 and *Drawing A-6* (*Appendix A*) provides the developed indicative general arrangement of PS No. 3 and pump unit detail respectively. *Figure B-3* (*Appendix B*) provides the pump data sheets for the selected pump.

4.5.2 Electrical Reticulation (onsite)

The electrical works would comprise the following major components:

- An Electrical Switchboard for 690V power supply, located inside the Transfer Pumping Station No.3 building. This Switchboard would include provision for power supply from two separate Power Transformers. An Automatic Load Transfer System (ATS) would be provided to increase reliability of power supply;
- An Electrical Switchboard for 415V/240V power supply, located inside the Transfer Pumping Station No.3 building;
- Power Supply Authority Metering Panels for revenue metering;
- A PLC Panel with HMI (Touch Screen) for automatic control and monitoring;
- Stand-alone low harmonic (active front end type) VSD (total 3-off) for 690V pump motor controls;
- Instruments for balance tank level and line pressure monitoring;

- Building services including lighting, GPO, alarms, ventilation and/or air-conditioning;
- Lighting protection system.

4.6 Overall System Operation & Control Philosophy

The operation and control of the scheme is outlined below:

- Each pumping station has flow meters and telemetry with assisted control system;
- When the operator selects the pumping requirement in the SCA (i.e. flow rate and duration) the PLC would select the pumping rate from the Lift PS and the transfer pumping stations;
- Each pumping station speed and start/stop control would be determined by the level in the respective reservoir to maintain the target water level. When the level in the balance tank reaches to top water level (TWL) or bottom water level (BWL), the respective pump would stop. During pump operation the speed would vary to maintain the target water level range set by the PLC;
- Pumps would start/stop as controlled by the PLC, based on demand/time of pumping (off-peak) etc. as per the PLC programming in order to optimise pumping costs;
- Pumps are fitted with protection devices such as no-flow protection, bearings high temperature protection, high vibration protection, etc.
- PS No. 2 would have a by-pass provision in order to pump directly from PS No. 1 to PS No. 3, when required, and can be programmed to change over to direct pumping based on the command from the PLC.

4.6.1 Check Valves

The check valves would be swing type re-coil type depending on the extent of water hammer pressure. If water hammer is an issue, then re-coil check valves can be used.

4.6.2 Gate Valves

The suction and discharge valves would be of resilient seated gate type, and the discharge valves would be fitted with electric actuators.

4.6.3 Washwater Pumping System

The pumping stations require water supply for site application. A rain water collection system with small package type pumps is recommended. This system would also have the provision to source water from the suction main.

4.6.4 Surge Protection

VSD control would limit the starting/stopping speed of the pumps, hence limiting surge pressures under normal operation. It is possible for excessive surge pressure to damage the pumping system during a power failure, so suitable check valves have been selected to mitigate possible surges during a power failure event.

There are three (3) mitigation methods proposed for the pipeline as follows:

- One-way surge tanks to discharge water into the pipeline to prevent column separation. The tank is fitted with suitable filling system and ball-float valve;

- Spring loaded relief valves to release water during high surge pressures; and
- Pneumatic/hydraulic surge tanks.

A water hammer analysis has not been undertaken at this initial stage, however, would need to be included in a subsequent phase to determine suitable surge protection devices and confirm pipe pressure class requirements.

5 Electricity Network (offsite)

5.1 General

The Transfer Pipeline involves the use of large pumps located in areas that have minor electricity networks or no electricity infrastructure.

This feasibility assessment has considered Lift Pumping Station (Lift PS) and Transfer Pumping Station No. 1 (PS1) to be one (1) electrical load at a single location.

Transfer Pumping Station Nos. 2 and 3 (PS2 & PS3) are located along the Silver City Highway heading towards Broken Hill. PS2 and PS3 have firstly been considered as joined electrical loads and then secondly as individual electrical loads when developing the following power supply options.

5.2 River Lift Pumping Station & Transfer Pumping Station No.1

The estimated electrical load for this site is 1.2MVA, with the major electrical loads being 2 x 450kW pumps, 2 x 55kW pumps plus miscellaneous equipment loads. The site would require a 1.5MVA – 22kV substation.

This site is located at Fort Courage where the existing Anabranch pipeline plant is the major electrical load in this area. A 22kV electricity feeder originates at Wentworth and is run to Fort Courage. It provides power for the existing Anabranch pipeline plant but does not have the capacity for the new electrical load.

Two (2) options have been developed to provide power for LPS and PS1.

- *Option 1*: Upgrade the existing 22kV feeder by replacing the aerial conductors from Pomona (north of Wentworth) to Fort Courage, an approximate distance of 16km. This option involves major co-ordination issues in planning for sections of the existing aerials to be taken out of service to allow increased sized conductors to be installed.

  Preliminary estimate **$2.7M.**

- *Option 2*: Construct a new 22kV feeder from Wentworth following the Renmark Road to Fort Courage, an approximate distance of 17km. This option avoids working with a live feeder and is constructible along the road reserve without needing easements. Environmental issues have not been assessed with this option.

  Preliminary estimate **$2.4M.**

*Option 2 is the preferred solution at a preliminary estimate of **$2.4M**.*

5.3 Transfer Pumping Station Nos. 2 & 3

Both these pumping stations (PS2 and PS3) involve major electrical loads that are beyond the capacity of any local Essential Energy infrastructure.

The estimated electrical load for PS2 is 1.0MVA, with the major electrical loads being 2 x 450kW pumps plus miscellaneous equipment loads. The site would require a 1.5MVA – 33kV substation.

The estimated electrical load for PS3 is 1.7MVA, with the major electrical loads being 2 x 750kW pumps plus miscellaneous equipment loads. The site would require 2 x 1.0MVA – 33kV substations.

Three (3) main options have been developed to provide power for PS2 and PS3.

- *Option 1*: Transgrid has a 220kV transmission line that is "near" the locations of PS2 and PS3.

  This option involves the establishment of a Bulk Supply Point (BSP) taken from this 220kV transmission power line located in between PS2 and PS3. From the BSP, a 33kV power line would be taken away from this location to provide power for both PS2 and PS3. It is estimated that it would require an approximate 20km power line from the BSP to the Silver City Highway, then heading in both directions to the Pumping Stations. An approximate total of 124km of power line would be required to supply PS2 and PS3.

Preliminary estimate **$39M.**

- *Option 2*: From an Essential Energy Zone Substation located at Broken Hill, a new 33kV power line is envisaged that would follow the Silver City Highway road reserve connecting PS3 and then PS2. This is an approximate distance of 169km.

  Preliminary estimate **$27M.**

- *Option 3A – PS2*: A new 33kV feeder is envisaged from the Essential Energy Ellerslie Zone substation. The power line would follow the 220kV Transgrid transmission line alignment as it heads towards the Silver City Highway, then head north following the Highway road reserve to PS2. The approximate distance is 67km. Easements would be needed for part of the route.

  Preliminary estimate **$11.3M.**

- *Option 3B(1) – PS3*: Based on advice from Essential Energy, this option involves the rebuilding of the Cockburn feeder that currently supplies power to the Pinnacles Mine; then rebuilding the 19kV SWER power line that heads towards the Silver City Highway; then the new feeder travels 4km south along the Silver City Highway road reserve. The SWER feeder would be rebuilt in the existing power line alignment. Some easements would be required.

  Preliminary estimate **$9.7M.**

- *Option 3B(2) – PS3*: An alternative to Option 3B(1) is to use part of Option 2, constructing a new power line from Broken Hill to follow the Silver City Highway road reserve.

  Preliminary estimate **$11.2M.**

*Option 3A – PS2 plus Option 3B(1) – PS3 at a total preliminary estimate of **$21M** is the preferred solution.*

6 Telemetry Works

The telemetry works would ensure satisfactory operation of the water transfer system and for remote monitoring of the pumping stations from a Central Monitoring Facility (CMF).

A SCADA system would be provided at the CMF for remote monitoring of the pumping system.

It has been assumed that the SCADA system would be required to establish and maintain communication between the CMF and all pumping station sites.

Communication between the CMF and all pumping station sites has two (2) options available:

1. Telstra Next-G (3G / 4G) network; and
2. Radio (digital) network.

Each option is brief discussed as follows:

- *Option-1*: Telstra Next-G (3G / 4G) Network

  The communication system would depend on the availability of the Telstra Next-G network and signal strength at each location.

  The capital cost for this option is reasonably cheaper than the Radio Network comprising Option 2.

- *Option-2*: Radio (digital) Network

  This option is more traditional with proven technology that is used by many Councils and Water Utilities across NSW. Licensed Radio would be used for communication between sites via repeater stations.

  This option would require installation of several radio stations along the pipeline route to establish a radio communication network.

  The capital cost for this option is higher by approximately 2-3 times than the Telstra Next-G Network, but is more reliable and secure.

With developing technology, it is proposed that the higher cost option be used for budget purposes and a final decision made during a later phase.

7 Cost Estimates

The cost estimates presented here are based on budget pricing from suppliers, extrapolation from recent similar pipeline projects and experience. It should be noted that costing of particular items may vary significantly due to the emergence of information regarding the pipeline route, geology of the area etc. that was not available at the time of preparing this report. A concept level investigation is recommended should more accurate cost estimating be required inclusive of preliminary geotechnical investigation.

A feasibility level cost estimate summary is given below in *Table 7-1*. A detailed breakdown can be found in *Appendix C*.

Table 7-1: Direct Construction Cost Estimate Summary

Item	Cost (M)
OD 813 MSCL Transfer Pipeline	$279.73
Lift Pumping Station (Lock 9 weirpool, Murray River) to PS No. 1	$3.40
PS No. 1 - Adjacent to Murray River, Lock 9	$5.00
PS No. 2 - Chainage 101km	$15.35
PS No. 3 - Chainage 205km	$14.51
Telemetry Works (for entire system)	$0.70
Direct Construction Cost Subtotal	**$318.68**
Contingencies (20%)	$63.74
TOTAL (excluding GST)	**$382.42**

A net present value (NPV) analysis on different pipe sizing options has not been completed at this stage. It is recommended an NPV is completed to ascertain the most economical balance between construction capital costs (i.e. pipe sizing) and long term pumping costs.

Note that additional non-construction intangible costs would be required in addition to the above to cover aspects such as field survey, geotechnical investigation, option development, concept and detailed designs and documentation, environmental impact assessment, safety management, procurement activities, contract administration, project management and consultation.

Appendix A Indicative Drawings

Appendix B Pump Data Sheets

Appendix C Cost Estimate Breakdown

Table C-1: Direct Construction Cost Estimate Breakdown