TECHNICAL MEMORANDUM

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TO	Iftekhar Omar, GM Regulation of Sydney Desalination Plant
FROM	John Brown; Mike Predkowski
COPY	Kevyn Lockyer
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SUBJECT	Sydney Desalination Plant Pipeline Design Life – Technical Memorandum

Executive Summary

The Sydney Desalination Plant pipeline (the pipeline) is the singular means for Sydney Desalination Plant Pty Limited (SDP) to deliver desalinated drinking water from the desalination plant to Sydney Water Corporation's (SWC) distribution system. The pipeline extends 17 km from Kurnell to Erskineville and includes an under-sea crossing of Botany Bay.

As part of IPART's review of SDP's prices for 2012-17, the asset life for the pipeline assets was assumed to be 140 years rather than its design life of 100 years on the basis that 140 years was the assumed asset life of Sydney Water's similar pipeline assets. SDP requested a review of the valuation in 2017 following which IPART commissioned Atkins Cardno to undertake a technical review of the asset life value. Atkins Cardno recommended an asset life of 120 years, which IPART adopted in its 2017 Determination of SDP's prices.

This technical memorandum presents a review of the asset life of SDP's pipeline assets and investigates the technical assessments IPART commissioned in 2017. This memorandum also considers the design standards, the geographical and environmental conditions the pipeline is located in, the risks placed on the pipeline by other land users, the pipelines condition and the maintenance practices and opportunities available.

KBR was part of Sydney Water's 'Water Delivery Alliance' responsible for the design and construction of the Sydney Desalination Plant pipeline in 2010. KBR was the designer for the pipeline and pump station, and has completed asset condition assessments and provided ongoing technical advisory services to SDP for the pipeline. With this experience, KBR is uniquely qualified to provide an opinion on the design life aspects of SDP's pipeline assets.

Key points and findings of KBR's assessment include;

- The design basis of the pipeline assets was a 100 year design life and the sub-elements of the pipeline that sustain it were designed on the basis the pipeline was to achieve a 100 year design life and not more
- The pipeline is located in an aggressive marine environment and a 100 year asset life is an appropriate value

Kellogg Brown & Root Pty Ltd
ABN 91 007 660 317
Level 13, 201 Kent Street Sydney NSW 2000
GPO Box 1618 Sydney NSW 2001 Australia
Phone" +61.2.8284 2000
Fax: +61.2.8284 2200

- The pipeline is a singular asset with no redundancy, and the concept of averaging design life between the land-based and under-sea sections pipeline is not appropriate

KBR's research and analysis considers the pipeline assets were designed to achieve a design life of 100 years and as such the asset life should be 100 years.

Context

Sydney Desalination Plant Pty Limited (SDP) supplies high quality drinking water to Sydney. SDP is classified as a monopoly infrastructure business and its prices are therefore regulated by the Independent Pricing and Regulatory Tribunal of NSW (IPART). IPART's 2017 Determination assumed the life of the SDP pipeline to be 120 years, which is the average of 140 years for the land-based section of the pipeline and 100 years for the undersea section of the pipeline.[1]

SDP supplies drinking water to Sydney via a desalination pipeline. The desalinated water delivery pipeline is divided into three (3) main sections, namely:

1) Kurnell Desalination Plant to Silver Beach
2) Silver Beach to Kyeemagh (Bay Crossing)
3) Kyeemagh to the City Tunnel at Erskineville

The SDP pipeline was designed to operate for 100 years. This design life of 100 years does not align with IPART's asset life assumption of 120 years. We understand this means that SDP will not recover its initial capital invested before the end of the pipeline asset's design life.

KBR has been engaged by SDP to assess and provide an opinion on the design life of its pipeline assets.

KBR was part of Sydney Water's 'Water Delivery Alliance' responsible for the design and construction of SDP's pipeline in 2010. KBR was the designer for the pipeline and pump station, and has completed asset condition assessment of the pipeline and continues to provide technical advisory services to SDP. KBR's experience in major water supply pipelines extends to all capital and regional centres throughout Australia and includes the Warragamba pipelines (NSW), Mardi to Warnervale pipeline (NSW), Melbourne to Geelong pipeline (Victoria) and Southern East Queensland water gird. With this experience, KBR is uniquely qualified to provide an opinion about the design life aspects of SDP's pipeline assets.

Scope

The scope of this assessment is to provide an opinion, based on KBR's experience in the design of major water infrastructure pipelines including the design and construction of the SDP pipeline as a member of the Sydney Water lead Water Delivery Alliance, in relation to the following matters:

- What is the actual design life of SDP's pipeline assets, given the environmental and geographical conditions in which those assets are located, and the technical specifications established by the designers of the asset
- Consider the feasibility to operate the pipeline asset for 120 years (as assumed by IPART) without undertaking major refurbishment investment in the pipeline asset
- Assess the risks and possible costs associated with operating the SDP pipeline for 120 years.

[1] IPART, *Sydney Desalination Plant Pty Ltd: Review of prices from 1 July 2017 to 30 June 2022*, June 2017, page 128

1. Asset life assumption adopted by IPART

IPART's *Sydney Desalination Plant Pty Ltd, Review of Prices 1 July 2017 to 30 June 2022* report released in June 2017 adopted an asset life value of 120 years for the desalination pipeline. Section *9.3.2 of the IPART Report* explains that the asset life value of the pipeline was based on an assessment it requested by its consultant, Atkins Cardno. The report noted that as per Atkins Cardno's assessment:

- *The current assumption of 140 years is consistent with asset lives applied to Sydney Water's water mains of a similar diameter in similar locations and environments within the Sydney Area.*
- *The undersea component of SDP's pipeline asset is in a more aggressive environment than the land based sections.*
- *Under the current plant operation mode, the design flow is 250 ML/d with a lower pumping head. This means that the pipeline is not under full design flows and pressures until the second stage of the desalination plant is operational. There is no indication that this will be needed in the short run.* [2]

Based on Atkins Cardno's recommendations, IPART adopted an asset life assumption for the SDP pipeline of 120 years and noted as follows:

"This reflects that half the length of the pipeline is land-based (140 years) and the other half is in a more aggressive environment under Botany Bay (100 years). We set asset lives on the principle of economic life (i.e. over what period should the asset provide a service), and not on its design life. This is consistent with Atkins Cardno's rationale." [3]

The Atkins Cardno report *Sydney Desalination Plant - Expenditure Review Supplementary Report Version 1.4 25 May 2017,* included assessment of the asset life (refer section 5 Asset Lives). In determining its recommendation, the report included the following findings:

We accepted the 100-year design life for the under-sea pipeline in our Final Report. We did not accept that this design life can be equally applied to land-based sections of the pipeline. There are several reasons for this which we detail below.

(i) The current assumption of 140 years is the same as SWC applies to its water mains of a similar diameter. It would be inconsistent to apply varying design lives to assets in similar locations and environments within the Sydney Area;

(ii) The under-sea section of pipeline is in a more aggressive environment than the land-based sections and we have accepted this assumption;

(iii) SDP referred us to a report which sets out the design criteria for the pipeline. This refers to the pipeline asset life as 100 years for the complete length and references the WSAA Code. The WSAA Code paragraph 1.2.6 states that 'distribution systems shall be designed for a nominal asset life of at least 100 years and table 1.2 refers to typical asset design lives of 100 years for pipelines;

(iv) The pipeline is designed for an ultimate flow of 500 Ml/d when the second stage of a desalination plant is constructed. Under the current Full Operation Mode, the design flow is 250 Ml/d with a lower pumping head. This means that the pipeline is not under full design flows and pressures until the second stage of the desalination plant is operational. There is no indication that this will be needed in the short run;

(v) SDP has demonstrated that it is applying good asset management practice for the pipeline with appropriate condition monitoring. This should give adequate warning of any deterioration in condition. Asset life can be extended through replacement of ancillaries such as cathodic protection under periodic maintenance; [4]

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[2] IPART, *Sydney Desalination Plant Pty Ltd: Review of prices from 1 July 2017 to 30 June 2022*, June 2017, page 128

[3] IPART, *Sydney Desalination Plant Pty Ltd: Review of prices from 1 July 2017 to 30 June 2022*, June 2017, page 128

[4] *Sydney Desalination Plant - Expenditure Review Supplementary Report Version 1.4 25 May 2017, page 26*

Atkins Cardno concluded: *"the land-based pipeline asset life should be 140 years. A lower 100 year asset life for the length of main in twin under-sea pipelines, some 50% of total length, should be appropriate. We conclude that a weighted life of 120 years should be used to take account the relative lengths of pipeline on land and under the sea."* [5]

2. SDP pipeline assets design criteria

2.1 Basis of design

The design life of an asset is defined by the responsible party (in this case Sydney Water) and may be found in the general terms and conditions of a contract or in its specification. Design life is defined as the expected period of time over which the asset is physically able to deliver services without major maintenance. When specifying the design life, designers take account of the design load on the asset, environmental risk factors and other asset lifecycle issues to ensure the resulting asset has the capacity to meet this value.

The pipeline was designed and constructed by Sydney Water and the Water Delivery Alliance (WDA) in 2010. The design life for the pipeline and associated assets were defined from standard reference specifications used for the design and construction of water infrastructure. The WSAA Water Supply Code of Australia was the primary reference standard for the pipeline assets. Table 1.2 of Section 1.2.6 defines design lives for the various elements of water supply distribution assets and copied below as Table 1. Section 1.2.6 states that *"All water supply distribution systems shall be designed for a nominal asset life of at least* ***100 years*** *without rehabilitation. Some components such as pumps, valves, metering, and control equipment may require earlier renovation or replacement."*[6i]

Table 1 - Typical asset design lives (Table 1.2 of WSAA Water Supply Code of Australia)

Item	Water Mains	Reservoirs	Pumps	Valves	SCADA
Expected design life, years	100	50	20	30	15

Sydney Water and WDA prepared *Water Delivery Alliance Basis of Design Report WDA-BoD-REP-001* for the pipeline to meet the project requirements. The Basis of Design report outlines the scope of work, functional requirements and technical design criteria for the construction of the pipeline assets including the land pipelines, Botany Bay submarine (under-sea) pipelines and associated fittings, valves and flowmeters.

The Basis of Design report also defines the design life for pipeline assets[7]. As shown in Table 2 below, the design life of the pipe material is set at 100 years. While the WSAA code nominates "at least 100 years" the Water Delivery Alliance Basis of Design is clear in its definition of design life as being "100 years" and it should not be considered an "at least" value.

The establishment of the design life is also a key criterion for design of sub elements of the pipeline that sustain the pipeline to achieve its design life. This includes cathodic protection, pipe wall thickness, protective coating and lining, joint design, as well as procurement of pipe and fitting manufacture and supply. If a greater design life was required, then the designs of these sub elements would have been developed accordingly. Similarly design life is also factored into the construction methods employed for the pipeline to deliver a 100 year design life.

For example, all tunnelled pipe sections (with the exception of Kurnell, Freight Rail South to Freight Rail North) are to be monitored for possible corrosion. Cathodic protection will be installed at tunnelled sections if ongoing monitoring finds the corrosion rates high. This decision was based on the volume of grout in the annulus between the carrier pipe and the concrete outer pipe and the inert

[5] *Sydney Desalination Plant - Expenditure Review Supplementary Report Version 1.4 25 May 2017, page 26*

[6] Water Supply Code of Australia WSA 03-2011-3.1 Sydney Water Edition 2014 section 1.2.6

[7] *Water Delivery Alliance Basis of Design Report WDA-BoD-REP-001*

(corrosion free) environment provided by the grout. The design philosophy for discrete elements of the design such as cathodic protection were influenced by the pipeline design life and the proposed construction methods.

Table 2 - Pipeline design criteria[8]

Design Criterion	Value
Design life	100 years
Component life (e.g., valves)	30 years
Cathodic Protection System	25 years
Pipe material: • DN900 or larger • DN750 or smaller	 • Mild steel cement lined (MSCL) • Ductile iron cement lined (DICL)
Pipe jointing	Welded joints (WJ) using double fillet welds. Single external fillet welds used for pipe installation with tunnelling shafts that connected two adjoining tunnelled sections. Full penetration butt welds were used for the carrier pipes installed within the tunnels.
Pipeline isolation valves	Isolation valves are butterfly valves with a failsafe locking device in the closed position. The valves are buried with no access pits. Valves are suitability protected with the gear boxes buried and provided with a spindle rising to surface boxes.
Air valve assemblies	In trenched conditions air valves are installed below ground in pits and with access lids. If pipe is raised/mounded or subject to flooding, air valves are installed above the existing ground level. Air valves are installed at: • all high points in the pipeline • on both sides of section valves • at changes in grade where draining down or pipe break may cause absolute pressures below 5 m (–5 m gauge pressure) (significant knees) • a maximum spacing of generally 800 m (max. 1000m). Air valves are designed to avoid air pockets/vacuum.
Scour valve assemblies	Scour assemblies are 2x250mm gate valves in diameter installed in series, below ground and in pits with access lids. Located at all low points and on the higher elevation side of isolation valves.

[8] Water Delivery Alliance. *Basis of Design Report Work as Constructed (Document Number: WDA-BoD-REP-001).*; 2009, page 37-39

Design Criterion	Value
Inspection openings	Inspection access points are provided at most air valve locations on the main delivery pipeline. Inspection openings comprise a DN900 tee offtake installed vertically with an appropriate flange to facilitate the installation of the air valve.
Corrosion protection	• All trenched, mounded, and above ground pipes have been supplied with a fusion bonded polyethylene or 2mm thick epoxy external coating. In addition, these pipes are cathodically protected. • The tunnelled section in Kurnell has been incorporated into the impressed current corrosion protection system installed for the submarine crossing of Botany Bay. Cathodic protection is also provided at the tunnelled section between Freight Rail South and Freight Rail North. All tunnelled sections provided with cathodic protection have been constructed using MSCL pipe with fusion bonded polyethylene external coating. All other tunnelled sections have been installed with bare steel pipe with the annulus between the steel pipe and tunnel pipe filled with cementitious grout. The environment produced by the grout provides corrosion protection to the steel. • DICL—standard loose polyethylene sleeving as per WSAA Standards.
Bypass valves at section valves	200mm diameter isolation valves have been provided to allow pressure equalisation on either side of section valves. These valves are provided with spindles and surface boxes to allow operation of the buried valves.

2.2 Design standards

The technical requirement of the design included a range of Australian and International Standards and latest editions of Sydney Water's standards which included the following. [9]

Design Standards
• SWC Protective Coating Specifications – PCS No. 101A and 105A and SWC General and Environmental Requirements – PCS Parts B and C
• SWC Engineering Product Specification EPS 210
• WSAA Water Supply Code of Australia WSA 01 and WSA 03 (Sydney Water's Edition)
• WSAA Pumping Station Code WSA04

Marine Pipeline
• API 5L: Specifications for Line Pipe
• API 1104: Welding of Pipelines and Related Facilities
• API 1110: Pressure Testing of Liquid Petroleum Pipelines

[9] Water Delivery Alliance. *Basis of Design Report Work as Constructed (Document Number: WDA-BoD-REP-001).*; 2009, Section 3

Marine Pipeline
• AS2556: Buried Flexible Pipelines
• ASME B16.47: Large Diameter Steel Flanges, NPS 26 Through NPS 60 Metric/Inch Standard
• AWWA C207-01 Steel Pipe Flanges for Waterworks Service-Size 4 in. through 144 in. (100 mm through 3,600 mm)
• AWWA M11: Steel Pipes – A Guide for Design and Installation
• AWWA C200-97: Steel Water Pipe 6in (150mm) and Larger
• AWWA C205-00: Cement-Mortar Protective Lining and Coating for Steel Water Pipe, 4in (100mm) and Larger, Shop Applied
• AWWA C209-00: Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections and Fittings for Steel Water Pipe
• AWWA C213-01: Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
• AWWA C214-00: Tape Coating Systems for the Exterior of Steel Water Pipelines
• DNV-OS-F101: Submarine Pipeline Systems, October 2005
• DNV-RP-B401: Cathodic Protection Design, 1993
• DNV-RP-E305 On bottom Stability Design of Submarine Pipelines, October 1988
• DNV-RP-F102: Pipeline Field Joint Coating and Field Repair of Line pipe Coating, April 2006
• DNV-RP-F106: Factory Applied External Pipeline Coatings for Corrosion Control, April 2006
• DNV-RP-F107: Risk Assessment of Pipeline Protection, January 2006.

Land Pipeline
• AS 1289: Method of testing soils for engineering purposes
• AS 1579: Arc welded steel pipes and fittings for water and wastewater
• AS 1646: Elastomeric seals for waterworks purposes—General requirements
• AS 1726: Geotechnical site investigations
• AS 2528: Bolts, studbolts and nuts for flanges and other high and low temperature applications
• AS 2518: Fusion bonded low density polyethylene coating for pipes and fittings
• AS 2566: Buried flexible pipelines
• AS 2638.1: Gate valves for waterworks purposes—metal seated
• AS 2638.2: Gate valves for waterworks purposes—resilient seated
• AS 2758: Aggregates and rocks for engineering purposes
• AS 3862 External fusion-bonded epoxy coating for steel pipes
• AS 4321: Fusion bonded medium density polyethylene coating and lining for pipes and fittings
• AS 4795: Double flanged butterfly valves for waterworks purposes
• AS 4853: Electrical hazards on metallic pipelines
• AS 4936 / NZS 4936: Air Admittance Valves (AAV) for use in sanitary plumbing and drainage systems

3 Review of IPART assessment and asset life valuation

IPART's *Sydney Desalination Plant Pty Ltd, Review of Prices 1 July 2017 to 30 June 2022* report released in June 2017 adopted an asset life assumption of 120 years for SDP's pipeline. The 2017 Determination explains that the asset life value of the pipeline was based on an assessment it requested by its consultant, Atkins Cardno. The assessment concluded: *"the land-based pipeline asset life should be 140 years. A lower 100 year asset life for the length of main in twin under-sea pipelines, some 50% of total length, should be appropriate. We conclude that a weighted life of 120 years should be used to take account the relative lengths of pipeline on land and under the sea[10].*

Atkins Cardno accepted the 100-year design life for the under-sea section of the pipeline but did not accept that this design life should equally apply to land-based sections of the pipeline. Atkins Cardno's reasons for that assessment are assessed below.

3.1 Comparison between SDP and Sydney Water assets

(i) The current assumption of 140 years is the same as SWC applies to its water mains of a similar diameter. It would be inconsistent to apply varying design lives to assets in similar locations and environments within the Sydney Area;

Sydney Water's water supply network includes an estimated 5,000 kilometres of large diameter critical pipelines of a network of 22,000 kilometres. The network has inherent flexibility with many of its delivery systems interconnected. This means Sydney Water can divert water between systems to meet demand in different areas or shut down for maintenance or repair. The construction of the Sydney Water assets, while varied, include a significant quantity that is generally accessible, with many of its major pipeline assets located above ground in dedicated corridors, which facilitates condition assessment and maintenance which would extend asset life.

By contrast SDP's water supply infrastructure consists of a single delivery pipeline with no redundancy or ability to divert or shut down when the desalination plant is operating. The SDP pipeline consists of 9,812m of DN 1800mm pipe (land-based pipe), and 14,132m of DN 1400mm (laid as a twin pipe crossing 7,066m under-sea). The pipe traverses a distance of 16,878m from Kurnell to Erskineville while the total length of pipe is 23,934m.

A breakdown of the pipe construction and location is as follows.

- 59% is laid under-sea
- 27% is in micro tunnel construction
- 14% is combination of trenched, mounded or above ground
- the land based pipe includes two river crossings and long lengths are in landfill areas.

While SDP's pipeline has been designed to the required standards, we note that 86% of the pipe (under-sea and in tunnel) is inaccessible for routine condition assessment or maintenance and as such if any degradation in condition is to occur there is limited ability to either detect or rectify. If any part of the pipeline is damaged or removed from operation, be it land based or under-sea, then the whole pipeline would be out of service. We therefore consider that the design life should be aligned with the lowest discrete value (lowest common factor) rather than a weighted value as Atkins Cardno recommended.

While Sydney Water's pipeline design standards and specifications are the same as those used for SDP's pipeline the factors described above afford Sydney Water the ability to assume an asset life of 140 years. These factors are not transferrable to SDP's pipeline assets due to:

- the differences in asset base, asset criticality
- no network redundancy or flexibility
- 59 % of the pipeline being under sea (not 50% as assumed by Atkins Cardno)

[10] IPART's *Sydney Desalination Plant Pty Ltd, Review of Prices 1 July 2017 to 30 June 2022* report released in June 2017

- 86% of the pipeline being inaccessible for routine condition assessment or maintenance due to being either under-sea or constructed at depth in tunnel

3.2 WSAA and Basis of Design

(iii) SDP referred us to a report which sets out the design criteria for the pipeline. This refers to the pipeline asset life as 100 years for the complete length and references the WSAA Code. The WSAA Code paragraph 1.2.6 states that 'distribution systems shall be designed for a nominal asset life of at least 100 years and table 1.2 refers to typical asset design lives of 100 years for pipelines;

The Basis of Design is a record of the design criteria of the pipeline. While it is agreed the WSAA code nominates "at least 100 years" for pipelines, the Water Delivery Alliance Basis of Design is clear in its definition of the design life for SDP's pipeline as being explicitly "100 years". It is incorrect to infer that the Basis of Design of 100 years is an "at least" value. Furthermore, the setting of design life to 100 years is a factor in the design, manufacture, supply and construction and maintenance of all elements of the pipeline.

3.3 Impacts of pipeline flow and pressure

(iv) The pipeline is designed for an ultimate flow of 500 Ml/d when the second stage of a desalination plant is constructed. Under the current Full Operation Mode, the design flow is 250 Ml/d with a lower pumping head. This means that the pipeline is not under full design flows and pressures until the second stage of the desalination plant is operational. There is no indication that this will be needed in the short run;

The pressure of the system is limited by the system capacity at shaft 11C Erskineville and the connecting Sydney Water network. For Stage 1 (250ML/d), the maximum normal operating hydraulic gradient (HGL) is calculated 60 m Australian Height Datum (AHD). For Stage 2 (500ML/d), the maximum normal operating HGL it is estimated to be 60-70 m AHD. In KBR's opinion, the differences have limited impact on design life and as such would not be a factor to consider a change in design life.

3.4 Condition assessment and preventative maintenance

(v) SDP has demonstrated that it is applying good asset management practice for the pipeline with appropriate condition monitoring. This should give adequate warning of any deterioration in condition. Asset life can be extended through replacement of ancillaries such as cathodic protection under periodic maintenance;

Steel cement line pipelines are selected for their structural robustness and suitability to accommodate a range of environmental and operational demands. The pipeline is located in the public domain and exposed to risks from land users via a variety of means. In the less than 15 year life of the pipeline there has been a range of failures discovered that if left undetected would have reduced the life of the pipe and required major refurbishment.

Figure 1 Loss of external coating and corrosion

An inspection of the pipeline and associated assets was completed in stages between 2016 and 2018. The internal pipeline was visually inspected to assess evidence of steel corrosion (refer Figure 1) and deterioration of the cement mortar lining (CML). Random delamination testing was performed on the internal lining along the pipeline, as well as additional testing around significant cracks or other features. Broadband electromagnetic (BEM) pipe scanning was also undertaken at four sites.

The condition assessment identified items which have the potential to impact the long-term serviceability of the pipeline assets. The main issue relates to the observed cracking of the CML on the main pipe and risers. Although cracking is expected, and within the specified widths for initial acceptance, the long-term performance of cracked CML in protecting large steel pipes is not well documented, and routine internal inspection is recommended to monitor the condition of the CML into the future. In addition to the cracking there were several possible areas of lining debonding identified.

It is noted however that monitoring is not possible for an operational pipeline and the under-sea section is not accessible.

The external protective coating of the above-ground pipeline sections at Kurnell and Shaft 11C is in poor condition, with several locations of cracking, flaking or bulging of the epoxy coating especially around some fasteners and flanges and some corrosion visible on the underlying steel.

There have been several failures of the pipeline to date including third party interference which are listed as follows.

- Multiple failures of the pipes external Polyethylene (PE) protective coating along the above sections of the pipe which were assessed as having been struck by machinery
- Multiple premature failures of welded pipe joint coatings due to weather and UV exposure
- Failure of the pipe from a geotechnical machine drilling a hole through both the pipe and its external concrete encasement
- Failure of cathodic protection equipment caused by construction contractors severing cables and leaving the damage unreported and the pipeline unmonitored for over 2 years until it could be repaired
- Multiple sub-surface investigations by property development along the pipe alignment adding to further risk of damage to the pipe and its protection systems
- Changes to the pipe's environment due to the construction and operation of roadways, tunnels, bridges and earth embankments over and under the pipeline with increases to pipe loads and accumulated stresses (refer Figure 2)
- Loss of pipeline access due to the increased development of the lands along the pipeline route which limits the ability to monitor and maintain the pipeline
- 86% of the pipeline is constructed in micro tunnel or under-sea sections, which has limited or no accessibility for monitoring or maintenance

Figure 2 Construction of Sydney Gateway

Third party interference continues to be a risk to the pipeline and the inability to monitor large lengths of the pipeline. To achieve a design life of 100 years is dependent on controlling these risks.

3.5 Single pipe analogy

We (Atkins Cardno) conclude the land-based pipeline asset life should be 140 years. A lower 100 year asset life for the length of main in twin under-sea pipelines, some 50% of total length, should be appropriate. We conclude that a weighted life of 120 years should be used to take account the relative lengths of pipeline on land and under the sea.

SDP's pipeline has been designed to the required standards and a design life of 100 years. Unlike Sydney Water's assets it is a single whole entity and if any part of the pipeline is damaged or removed from operation, be it land based or undersea, then the whole pipeline would be out of service. If any part of the under-sea sections are lost, then the whole of pipeline would be out of service for an extensive unknown period. Repairs will necessitate extensive planning and construction expertise to reinstate.

It is therefore KBR's view that the design life should be aligned with the lowest discrete value (lowest common factor) rather than a weighted value and therefore set at 100 years. Further to this once the undersea pipeline section reaches its design life, replacement options are limited at this time and the whole of the pipeline would cease to function.

3.6 Design Life values in other Australian States

As part of this assessment a comparison was made to other major water authorities/utilities in Australia. In all cases each of the utilities refer to the WSAA Code (WSA03-2011-3.1), as shown in Table 3. The water authorities listed below use 100 years for design life of watermains with lower design lives for pipe components. A case for design life to 140 years was not established with our investigation.

Table 3 - Design life used for water mains from various Australian water authorities

State	Major water provider	Design Life Reference
New South Wales (NSW)	Sydney Water Corporation	WSAA Code (WSA03-2011-3.1)
Queensland (QLD)	Seqwater	WSAA Code (WSA03-2011-3.1)
Victoria (VIC)	Melbourne Water	WSAA Code (WSA03-2011-3.1)
Western Australia (WA)	Water Corporation	WSAA Code (WSA03-2011-3.1)
South Australia (SA)	SA Water	WSAA Code (WSA03-2011-3.1)

4. Risks to achieving design life

4.1 Preventative Maintenance

The design life of the pipeline represents the reasonable expectation of the physical life of the pipeline. As described in Section 2 above, the design life of the pipeline is 100 years for pipe material and less for other elements. This design life is expected to be achieved by the materials and construction methods used, the applied protective measures such as concrete encasement and cathodic protection installed to address specific conditions and environments. No major maintenance is assumed to be required over the design life, but at the same time, the 100 year design life cannot be expected to be achieved without regular monitoring and preventative maintenance.

Figure 3 Third Party Interfaces

Preventative maintenance of an asset is based on the continuation of routine operational maintenance activities and does not consider major reactive/ capital maintenance. In order to capture additional maintenance requirements, routine condition assessment maintenance activities are carried out to identify issues such as corrosion or other failures/ defects that would reduce asset life without mitigation. These failures need to be addressed to achieve design life. In addition, components that have shorter design lives will need to be renewed, and in some cases multiple renewals will be required in order for the pipeline, as a whole, to reach the 100 year design life.

Figure 4 Cement Lining Damage

In 2016, SDP undertook an inspection and condition assessment of the land based pipeline (*refer to Sydney Desalination Pipeline Condition Assessment Inspection Report SEG850-002-TD-PL-REP-0001*)[11]. This was completed on all internal (approximately 40%) and external (approximately 5%) accessible parts of the pipeline including its associated components (i.e., fittings, pits, and structures). Based on the inspections and condition assessment, an asset register was completed which included an estimate of the remaining design life of the pipeline and its associated components. A summary of the asset register is shown in Table 4. In general, the remaining life of components is consistent with the design life of the pipeline and its age. There are some exceptions such as failures in pipe coatings (refer figure 4) and corrosion of valve/fittings that are failing ahead of design life, which will need to be addressed.

In order to achieve the specified design life, a series of maintenance repairs need to be undertaken for which additional costs should be considered. Additional tasks/activities would include:

- Periodic inspection and condition assessment
- Routine maintenance of components
- Patch repair of internal cement lining
- Unplanned maintenance repairs such as identified above
- Cathodic Protection (CP) system testing and monitoring
- Replacing or renewing pipeline components as they reach the end of their asset life
- Flushing of pipeline prior to reuse.

[11] *Sydney Desalination Pipeline Condition Assessment Inspection Report SEG850-002-TD-PL-REP-0001*

Table 4 - Summary of pipeline and associated component estimated design life

Pipeline components	Typical design life as per WSAA Code	Estimated remaining design life (years)
Pipeline (1800mm dia)	100	50 – 80
Access (Stairs/Ladders/Platforms)	50	25 – 40
Actuator	20	10 - 20
Air Valve	30	10 – 50
Air Valve Cage	50	40 – 50
Air Valve Isolator	30	10 – 50
Anchor Block	100	80
Anchor Point	30	0 – 50
Bypass Valve	30	40
Cathodic Protection – Anode	30	20
Cathodic Protection – Impressed Current	30	20
Cathodic Protection – Test Point	30	20
Dismantling Joint	100	90
Distribution Board	20	10 – 15
Expansion Joint	100	80
Flow Switch	15	10
Gas Arrestor	30	20
Grounds	100	90
Isolating Gasket Kit	30	20
Pipe Support	100	90
Pit	100	20-100
Scour Valve	30	25 – 50
Section Valve	50	25 – 40
Sliding Joint	100	80
Transition Shaft	100	80 – 90
Water Meter	20	15

Pipeline components	Typical design life as per WSAA Code	Estimated remaining design life (years)
Water Quality Instrumentation	15	15

4.2 Feasibility to Extend the Design Life

To maintain the pipeline to its 100 year design life, there is a required level of routine maintenance, renewals (in some cases multiple renewals) of components that have a design life of less than 100 years and unplanned maintenance repairs.

To extend the design life of the pipeline beyond 100 years, an extension of the additional tasks/activities discussed in Section 3 will be required, as well as planning for potential renewal of components of the pipeline that are no longer serviceable after their 100-year design life (i.e., the pipeline and pipe supports). Pipeline renewal would require significant planning, investment and operational downtime. Techniques to renew large diameter pipelines would include in-situ lining, slip lining with smaller diameter pipelines or traditional dig and replacement.

The Botany Bay section of the pipeline is under sea and is subject to an aggressive marine environment. This section of the pipeline is concrete coated and protected by an impressed current corrosion protection system. This section of the pipeline is the most vulnerable, and should it be decided to extend the life of the pipeline beyond 100 years, there is a probability it would require replacement. This replacement would incur significant capital expenditure and operational downtime (beyond routine maintenance and refurbishment). In the event of pipeline failure, water supply would not be possible, and thus the plant would not be able to supply desalinated water for an extended period.

Any plan to increase the design life beyond 100 years must consider the pipeline under Botany Bay. Options to extend the design life of this section of the pipeline are limited and may prove to be technically impossible due to the pipe diameter and distance under the bay.

5. Conclusion

IPART's 2017 report *Sydney Desalination Plant Pty Ltd, Review of Prices 1 July 2017 to 30 June 2022* assumed that the asset life of SDP's pipeline is 120 years. IPART based this assumption on advice from its consultant Atkins Cardno.

We have reviewed the assessment conducted by Atkins Cardno and the reasons for their recommendations of having different asset life assumptions of 140 years for the land-based section of the pipeline and 100 years for the under-sea section of the pipeline. We have also reviewed Atkins Cardno's conclusion that a weighted average life of 120 years should be adopted. While there is consensus that the under-sea section of the pipeline should have a 100 year asset life, it is our opinion that it is not appropriate to assume the land based section of the pipeline has an asset life of 140 years. Nor is it appropriate that a weighted value (i.e., the average) is then applied to the pipeline as a whole. Unlike Sydney Water's assets, the SDP pipeline is a single whole entity and if any part of the pipeline is damaged or removed from operation, be it land based or under-sea, then the whole pipeline would be out of service. If any part of the under-sea sections are lost, then the whole of pipeline would be out of service for an extensive unknown period and the plant cannot supply water. Further to this, once the Botany Bay pipeline reaches its design life replacement options are limited at this time and the whole of the pipeline ceases to function.

Comparing SDP's pipeline to Sydney Water's pipelines is not appropriate. The Sydney Water network of trunk watermains has inherent flexibility with many of its delivery systems being interconnected. This means Sydney Water can divert water between systems to meet demand in different areas or shut down for maintenance or repair. Also, Sydney Water's major transfer systems are constructed generally above ground in dedicated corridors. By comparison SDP's pipeline assets have no redundancy or flexibility, 59 % of the pipeline is under sea (not 50% as assumed by Atkins Cardno) and 86% of the pipeline is inaccessible for routine condition assessment or maintenance.

SDP's pipeline is located in the public domain and exposed to risks from land users via a variety of means including property developers, major transport projects including WestConnex, Sydney Gateway and M8. In the 15 years since the pipeline's construction there has been a range of failures discovered that if left undetected would have reduced the life of the pipeline and required major refurbishment. An inspection of the pipeline and associated assets was completed in stages between 2016 and 2018. The internal pipeline was visually inspected and identified evidence of steel corrosion and deterioration of the CML, while externally protection coatings and joint wrappings were failing which increases likelihood of reduced asset life.

It is therefore considered that the design life for SDP's pipeline, both land-based and under-sea sections, should be reset to 100 years. We also consider that the asset life assumption for the total pipeline should be aligned to the lowest discrete value for pipelines (i.e., 100 years for the under-sea pipeline) rather than a weighted value.