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Support of the Water Reconciliation Strategy for the Algoa Water Supply System

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DEPARTMENT OF WATER AND SANITATION

Directorates: National Water Resource Planning and Options Analysis

Support of the Water Reconciliation Strategy for the Algoa Water Supply System

FEASIBILITY-LEVEL ENGINEERING DESIGN – CONVEYANCE INFRASTRUCTURE

Final: March 2020

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Department of Water and Sanitation
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SUPPORT OF THE WATER RECONCILIATION STRATEGY FOR THE ALGOA WATER SUPPLY SYSTEM

APPROVAL

Title	:	Feasibility-level Engineering Design – Conveyance Infrastructure
Consultant	:	Aurecon South Africa (Pty) Ltd
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Document Index

Reports that will be produced as part of this Study are indicated below.

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Executive Summary

Introduction

The objective of the Feasibility Component of the *Support of the Water Reconciliation Strategy for the Algoa Water Supply System* study is to:

- limit risks of shortfall in supply to the Nelson Mandela Bay Municipality (NMBM) and the Lower Sundays River Government Water Scheme (LSRGWS),
- remove potential operating system constraints for the sustainable delivery of bulk Orange River water supply to the LSRGWS and NMBM, for water requirements up to 2040, and
- limit operational risks to acceptable levels.

The existing Scheepersvlakte Balancing Dam is a balancing facility that is currently used for water supply to both LSRWUA and NMBM but has inadequate capacity for emergency supply to NMBM.

The focus of this feasibility study investigation is to provide dedicated balancing storage for water supply to the Nooitgedagt water treatment works (WTW), which provides potable water to NMBM. The main purpose of the proposed new balancing dam, at the Lower Coerney site, is to improve operation and provide balancing storage for NMBM.

After investigation of a number of potential dam sites, the Lower Coerney site was found to be the most favourable site for the proposed new balancing dam for emergency water supply to NMBM. The proposed dam is referred to as ‘Coerney Dam’ in this sub-report and future reports, as there is no Upper Coerney Dam.

Pipeline Design

The proposed scheme comprises two gravity pipelines, namely a pipeline supplying water from the Kirkwood Primary canal to the proposed Coerney Dam, and a pipeline supplying water from the proposed Coerney Dam to a tie-in point on the existing Nooitgedagt pipeline that feeds the Nooitgedagt WTW (refer to **Figure E1**).

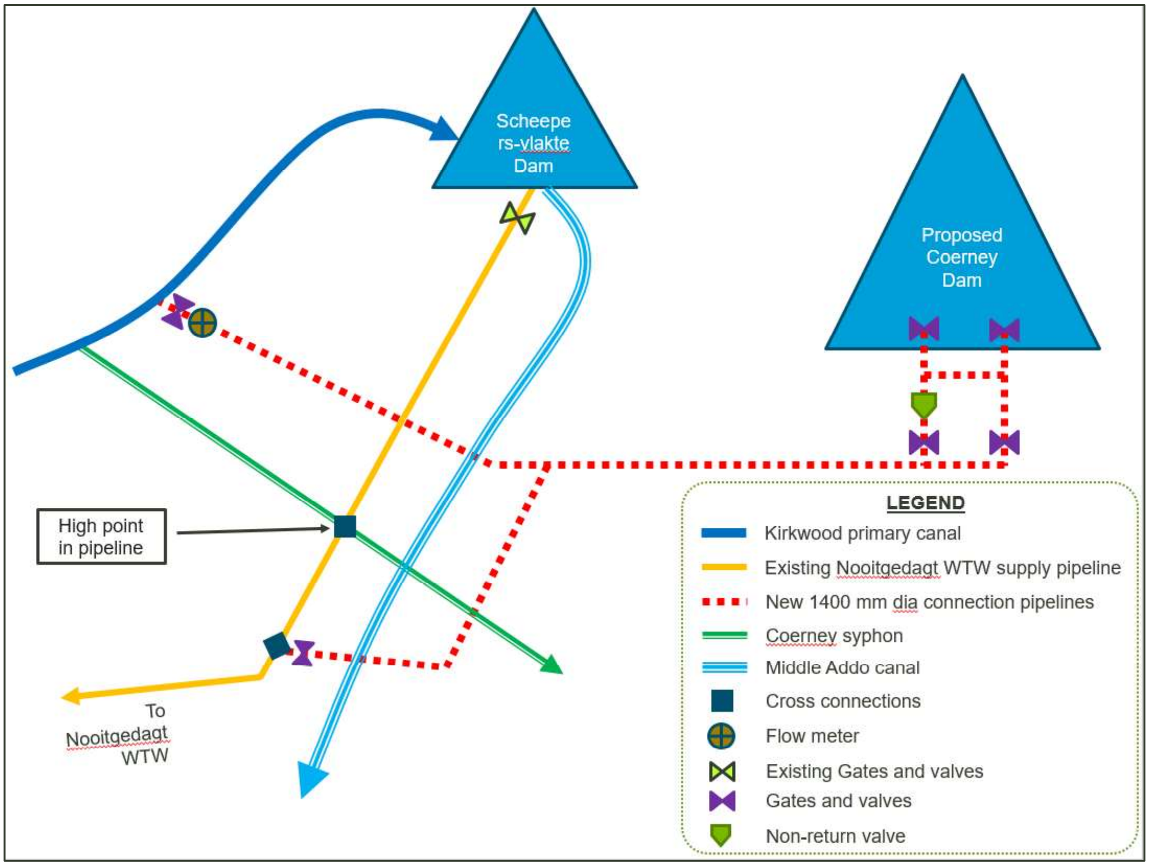

Figure E1: Schematic layout of the proposed new dam and connecting pipelines

The main advantages of the proposed scheme are that the proposed Coerney Dam would increase the raw water storage capacity of NMBM. The high point in the existing Nooitgedagt WTW gravity main would be bypassed, to increase the hydraulic capacity during periods with low water levels in the dam.

The hydraulic calculations of both pipelines are based on a design capacity of 280 Mℓ/d (3.24 m^3/s) and the Coerney Dam water levels at a minimum operating level of 86 masl and a full supply level of 98.2 masl. The Hazen-Williams equation was used to determine the operating level required for a flow of 280 Mℓ/d. The results were compared against the Depth-Storage Curve for the dam to compare the percentage storage versus the minimum water level required to discharge the maximum flow of 280 Mℓ/d. A storage capacity of only 17% would be required for a DN 1400 pipeline to deliver this required maximum flow. A flow of 106.6 Mℓ/d (1.85 m^3/s) can be discharged through a DN 1400 pipeline with the dam level at the minimum operating level, i.e. almost 40% of the maximum flow rate.

Based on the hydraulic gradient lines it would be possible to discharge 280 Mℓ/d from the Kirkwood Canal to the Coerney Dam, even when the dam is at full supply level. A residual pressure of approximately 3 m would be available at the tie-in point to the existing Nooitgedagt WTW supply pipeline.

Glass reinforced polyester (GRP), ductile iron and steel pipes were considered as suitable pipe materials, based on the pipeline diameter and expected working pressures. Given the advantages of steel pipes, it is proposed that this be considered as the preferred pipe material for the proposed pipelines.

A preliminary wall thickness calculation was undertaken based on limited geotechnical information, hydraulic analyses and external loads. Based on the assumptions and calculations the proposed pipelines will be DN 1400, Grade X52 steel with a yield strength of 358 MPa and a recommended wall thickness of 10 mm. The maximum soil cover of 3.4 m will have to be adhered to during the detailed design of the vertical alignment of the pipelines. A wall thickness of more than 10 mm might be required if the E-value of the native soil is worse than expected or if the E-value of the bedding material is lower than anticipated.

Connections and associated impacted infrastructure

The proposed dam will be supplied from the Kirkwood primary canal through a DN 1400 pipeline, which will also be used to release water from the dam to the tie-in point on the existing Nooitgedagt WTW pipeline. The pipe for supplying water to and from the dam will bifurcate into an inlet and outlet branch at the outlet chamber at the downstream toe of the embankment. The inlet branch will have an isolation valve for shutting off supply when the dam is full, and the outlet branch will be fitted with a non-return valve and an isolation valve upstream and downstream.

The offtake from the Kirkwood primary canal will be located downstream of the Coerney syphon intake, and just upstream of the long weir, which will provide head to the new intake. It is proposed that the new offtake comprises an adjustable weir that would allow regulating of the flow that could be discharged from the canal to the WTW or the Coerney Dam.

A connection will be made into the existing Nooitgedagt WTW supply pipeline downstream of the cross connection with the Scheepersvlakte pipeline, and downstream of the existing high point in the existing supply pipeline.

The Middle Addo canal will have to be crossed at two locations. It is proposed that the pipeline be installed over the canal by means of a pipe bridge, not to impact the integrity or operation of the canal, and to facilitate easier maintenance.

The proposed Coerney Dam spillway will have to be crossed if the spillway is constructed on the right abutment. The existing Nooitgedagt WTW supply pipeline will also have to be crossed with the proposed pipeline.

An additional syphon under the Sundays River on the existing Nooitgedagt WTW supply pipeline is proposed. The purpose is to reduce the risk of supply failure and to mitigate the risk of the new balancing storage being located on the opposite side of the river, relative to the WTW. It is proposed that the new syphon be located upstream and separate from the existing syphon. Apart from doubling the syphon it is also recommended that an adequate stockpile of replacement pipes be kept on site, to enable quick repair of the pipeline in case of failure.

Recommendations

The recommendations from the feasibility design of the conveyance infrastructure are summarised as follows:

- A ground centreline survey should be done along the final proposed pipeline route.
- A geotechnical investigation should be undertaken along the proposed pipeline route and chambers. This investigation should include a soil resistivity survey and testing for sulphate reducing bacteria.
- Estimate the volume of imported bedding material required and locate suitable sources.
- Confirm wall thickness calculations with additional geotechnical information.
- Confirm the pipeline route after landowner and authorities' discussions.
- Decide on lining and coating requirements for the steel pipelines.
- Verify exact positions of all connections and impacted associated infrastructure during the detailed design of the pipelines.
- Independent quality control inspections of the pipes, at the factory and on site, must be included in the construction tender documents.
- Obtain as-built drawings and/or information of the existing syphon under the Sundays River.
- Determine the position of the new syphon, upstream of the existing syphon.

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Abbreviations

3LPE	Trilaminate polyethylene coating
AWWA	American Water Works Association
DN	Nominal diameter
DWS	Department of Water and Sanitation
EWR	Ecological water requirements
FSL	Full supply level
GRP	Glass Reinforced Polyester
GWS	Government Water Scheme
HGL	Hydraulic gradeline
HW	Hazen-Williams friction coefficient
ID	Internal diameter
LSRGWS	Lower Sundays River Government Water Scheme
LSRWUA	Lower Sundays River Water User Association
m	metre
masl	Metres above mean sea level
Mℓ	Megalitre
Mℓ/d	Megalitre per day
mm	millimetre
MOL	Minimum operating level
MPa	Megapascal
NMBM	Nelson Mandela Bay Municipality
PI	Plasticity Index
SANS	South African National Standards
WTW	Water Treatment Works

1 Introduction and Background

1.1 Study Objective

The objective of the Feasibility Component of the *Support of the Water Reconciliation Strategy for the Algoa Water Supply System* study is to:

- limit risks of shortfall in supply to the Nelson Mandela Bay Municipality (NMBM) and the Lower Sundays River Government Water Scheme (LSRGWS),
- remove potential operating system constraints for the sustainable delivery of bulk Orange River water supply to the LSRGWS and NMBM, for water requirements up to 2040, and
- reduce operational risks to acceptable levels.

The focus of the investigation is to provide adequate balancing storage for supply to the NMBM, thereby limiting risks of shortfall in supply.

1.2 Purpose of this Sub-report

The purpose of this sub-report is to describe the design parameters, assumptions and feasibility design of the conveyance infrastructure associated with the proposed balancing dam. This will form a Chapter/s of the Feasibility Design Report.

1.3 Background

Following the expected completion of the Nooitgedagt Water Treatment Works (WTW) Phase 3 in 2022, the WTW will have a maximum capacity of 210 Mℓ/day with the conveyance infrastructure supply to the WTW having a maximum capacity of 280 Mℓ/day. The scheme has been designed to cater for peak/back-up supplies from the Nooitgedagt WTW at times when the older infrastructure, which is fed from sources to the west of Port Elizabeth, will require maintenance or emergency repairs.

The Lower Coerney Dam site has been identified as the preferred balancing dam site and has been recommended for feasibility design, in the *Options Analysis Report*

(P WMA 15/N40/00/2517/3). Refer to the *Feasibility-level Engineering Design - Balancing Dam* sub-report for detail on the proposed balancing dam.

The proposed dam is referred to as 'Coerney Dam' in this sub-report, and future reports, as there is no Upper Coerney Dam.

1.4 Content of this Report

The various chapters in this report and their content are briefly described hereunder.

Chapter 1: Introduction and Background

Provides a brief introduction and background to the project.

Chapter 2: Survey Data

Describes the topographical survey undertaken.

Introduction and Background**Chapter 3: Geotechnical Investigations**

Describes the geotechnical and materials investigations undertaken to date.

Chapter 4: Pipeline design

Provides details of the hydraulic parameters used in the design, the hydraulic calculations, choice of pipe materials and preliminary wall thickness calculations.

Chapter 5: Connections:

Describes the operational philosophy of the scheme and provides details of the various offtakes and connections between the existing and proposed pipelines.

Chapter 6: Legislative Considerations and Authorisations:

Briefly identifies the various legislative considerations required for the conveyance infrastructure and the status of each process.

Chapter 7: Conclusions

Summarises the conclusions from the feasibility design.

Chapter 8: Recommendations

Lists the recommendations from the feasibility design.

2 Survey Data

A topographical survey was completed by Survey Services: Southern Operations (National Water Resource Infrastructure) of DWS for the Lower Coerney and Upper Scheepersvlakte Dams in May 2018. The results are reported in the relevant survey reports: *Upper Scheepersvlakte Dam, Contour Survey* (EC004/2018) and *Coerney Dam Contour Survey* (EC 003/2018).

The contours of the existing 1 m contour plans from 1977 and 1984, which were compiled from aerial photography for the design of the LSRGWS, were digitised. Nine test sections were surveyed for the Lower Coerney site, to compare and verify the digitised data to the actual ground data, which resulted in a good match.

In August 2018, the survey was updated and expanded to include the immediate surrounding infrastructure, which is reported on in the *Scheepersvlakte Contour and Detail Survey Report* (EC026/2018).

The available survey data is considered sufficient to undertake the feasibility, preliminary and detailed designs of the proposed infrastructure. It is, however, recommended that a ground centreline survey be done along the finally chosen pipeline centreline, prior to construction commencing. This will serve as a final check on the pipelines' vertical alignment and soil cover depths.

3 Geotechnical Investigation

Geotechnical investigations for the options analysis comparison between the Upper Scheepersvlakte and Lower Coerney dam sites were conducted in 2018. These investigations were conducted to inform the selection of the preferred dam site. It included geophysical surveys (resistivity), test pitting using a tractor-loader-backhoe (TLB), in-situ field testing including standard penetration tests (SPT), sampling and laboratory testing, as well as rotary core drilling and water loss (Lugeon) testing. The findings of this investigation, relevant to the Lower Coerney Dam site, are reported in the *Lower Coerney Dam Geotechnical Survey* Report (Report no P WMA 07/N40/00/2619/2).

With the selection of the preferred site (Lower Coerney) a more detailed test pit investigation was conducted at the site using a tracked excavator, with the aim of collecting supplementary and supportive data. Findings of this investigation are reported in the *Lower Coerney Dam Supplementary Geotechnical Survey* Report (Report no P WMA 07/N40/00/2619/3). Note that this report is a stand-alone geotechnical report as it incorporates all data and findings from the first geotechnical report.

Generally, the underlying geology comprises alluvium, colluvium, reworked terrace gravels (mixed origin), thin grey sandstones, siltstones and mudrocks of the Sundays River Formation of the Uitenhage Group; part of a collection of sedimentary strata within the structurally controlled Algoa Basin.

The geotechnical investigation was limited to the dam sites with no test pits undertaken along the pipeline route. The following is worth noting from the results for the dam site to inform the feasibility design of the pipeline:

- The test pits indicated that the likelihood of encountering shallow bedrock in the trench excavations is low.
- The laboratory tests indicated that the material excavated from site might not be suitable as pipe bedding material, due to the Plasticity Index (PI) not conforming to the SANS 1200 LB specifications. Some of the excavated material does however comply with the DWS 1110 Type A requirements. This means that part of the bedding material might need to be imported from commercial sources.

- Groundwater was encountered at depths of 8 m and deeper.

It is recommended that a geotechnical investigation be undertaken along the proposed pipeline routes and at the proposed chamber locations to inform the detailed design. The geotechnical investigation should also include a soil resistivity survey and testing for sulphate reducing bacteria, to inform the coating selection and the need for cathodic protection.

4 Pipeline Design

4.1 Description of pipelines

The proposed scheme comprises two gravity pipelines, namely:

- A pipeline supplying water from the Kirkwood Primary canal to the proposed Coerney Dam, and
- A pipeline supplying water from the proposed Coerney Dam to a tie-in point on the existing Nooitgedagt pipeline that feeds the Nooitgedagt WTW.

The main advantages of the proposed scheme are that:

- The proposed Coerney Dam would substantially increase the raw water balancing storage capacity for water supply to NMBM, and
- The proposed pipeline route would bypass the high point on the existing gravity main feeding the Nooitgedagt WTW that limits the flow to the WTW. This will increase the hydraulic capacity during periods with low water levels in the dam.

The proposed horizontal pipeline alignments are shown on the layout plan drawing 112546-0000-DRG-CC-001 in **Appendix A**.

4.2 Pipeline horizontal alignments

The following factors were considered in determining the horizontal pipeline alignments:

- The pipelines should be easily accessible for future maintenance,
- The pipeline should tie into the existing Nooitgedagt pipeline downstream of the high point,
- The pipeline should be located outside the floodplain immediately downstream of the dam, and
- The pipeline should cross the proposed spillway and existing canals at optimum positions.

During the detailed design process, the pipeline route will need to be confirmed after discussions with affected land owners and authorities. Refinements may be required, depending on developments subsequent to the feasibility design.

4.3 Hydraulic input parameters

The following input parameters were used for the hydraulic calculations:

Kirkwood Primary Canal to proposed Coerney Dam Pipeline

- START : Kirkwood Primary Canal
- Kirkwood Water Levels : Long weir overflow = 105.8 masl
- END : Coerney Dam
- Coerney Water Levels : Minimum operating level (MOL) = 86 masl, Full supply level (FSL) = 98.2 masl
- Design capacity : 280 Mℓ/d (3.24 m^3/s)
- Length of section : 1 373 m

Coerney Dam to Tie-In at Nooitgedagt WTW Pipeline

- START : Coerney Dam
- Coerney Water Levels : MOL = 86 masl, FSL = 98.2 masl
- END : Nooitgedagt WTW Supply pipeline
- Design capacity : 280 Mℓ/d (3.24 m^3/s)
- Length of section : 1 573 m

The Hazen-Williams equation was used, which can be expressed as:

$$S = 6{,}84 * (v/c)^{1.85}/D^{1.167}$$

where “S” is the friction loss measured in m/m, “v” the velocity (m/s), “c” the Hazen-Williams friction coefficient and “D” the internal pipeline diameter (m). Typical Hazen-Williams friction factors for new and aged pipes are 140 and 115, respectively.

In order to determine the optimum pipeline diameter, the following calculations were performed:

- Using the MOL of 86.0 masl, the maximum flows that could be discharged for different pipe diameters were determined – refer to **Table 4-1**,
- The minimum water levels required in the Coerney Dam to discharge the maximum flow of 280 Mℓ/d (3.24 m^3/s) were also calculated for various pipeline diameters – refer to **Table 4-2**, and
- The results shown in **Table 4-2** were then compared against the Depth-Storage Curve for the dam (refer to **Figure 4-1**) to compare the percentage storage versus the minimum water level required to discharge the maximum flow of 280 Mℓ/d.

Table 4-1: Maximum flow with water level at MOL

HW=130; MOL = 86.0 masl	
Nominal Diameter (mm)	**Flow (Mℓ/d)**
1200	56.0
1300	71.7
1400	106.6
1500	138.9
1600	166.8

Table 4-2: Minimum water level required for flow of 280 Mℓ/d

HW=130; Q = 280 (Mℓ/d)		
Nominal Diameter (mm)	**Minimum water level (masl)**	**Storage capacity in dam (%)**
1200	94.4	54
1300	91.6	26
1400	89.8	17
1500	88.7	12
1600	87.9	8

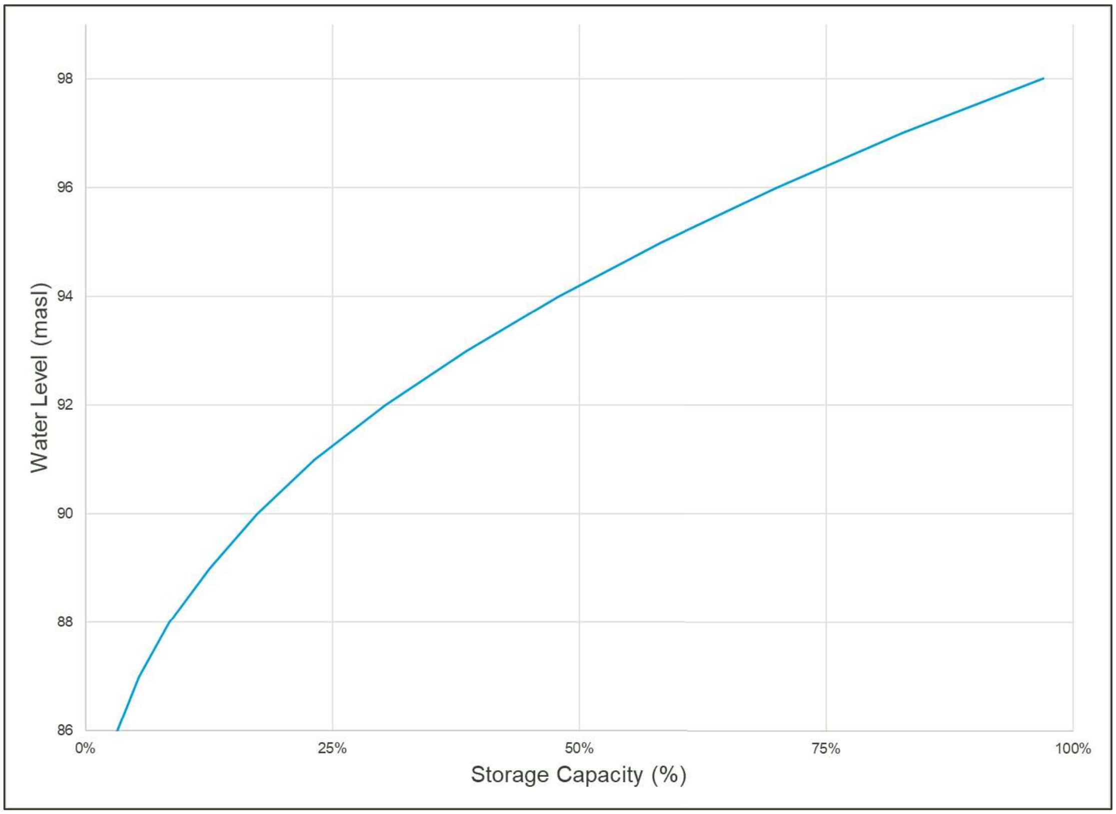

Figure 4-1: Depth-Storage Curve for Coerney Dam

It is evident from **Table 4-2** that a DN 1200 pipeline would require a minimum storage of 54% to discharge the maximum flow of 280 Mℓ/d, whereas a storage capacity of only 17% would be required for a DN 1400 pipeline. Given that the existing Nooitgedagt pipeline is a DN 1400 pipeline, and the fact that a storage capacity of only 17% would be required to discharge the design flow of 280 Mℓ/d, it is recommended that the proposed pipelines also be designed as DN 1400 pipelines. It is also evident from **Table 4-1** that a flow of 106.6 Mℓ/d can be discharged with the dam level at MOL, i.e. almost 40% of the maximum flow rate.

Table 4-3 shows the flow rates that would be achieved in a DN 1400 pipeline for different Hazen-Williams friction coefficients (i.e. 115 being an aged pipeline and 140 being a newly installed pipeline).

Table 4-3: Flow rates for different Hazen-Williams (HW) friction coefficients in DN 1400 pipeline

Water level in dam (masl)	HW = 115	HW = 130	HW = 140
	Q (Mℓ/d)	Q (Mℓ/d)	Q (Mℓ/d)
86.0	94	106	115
87.0	207	234	252

Water level in dam (masl)	HW = 115	HW = 130	HW = 140
	Q (Mℓ/d)	Q (Mℓ/d)	Q (Mℓ/d)
88.0	222	251	270
89.0	236	267	288
89.8	247	280	301

It is evident from **Table 4-3** that the flows calculated with a Hazen-Williams friction coefficient of 130 would increase by approximately 8% in a newly installed pipeline and would reduce by approximately 12% in an aged pipeline.

Error! Reference source not found. shows the hydraulic gradient lines of the Kirkwood P rimary Canal to the Coerney Dam pipeline for a flow of 280 Mℓ/d and with the Coerney Dam water levels at MOL (i.e. 86 masl) and FSL (i.e. 98.2 masl).

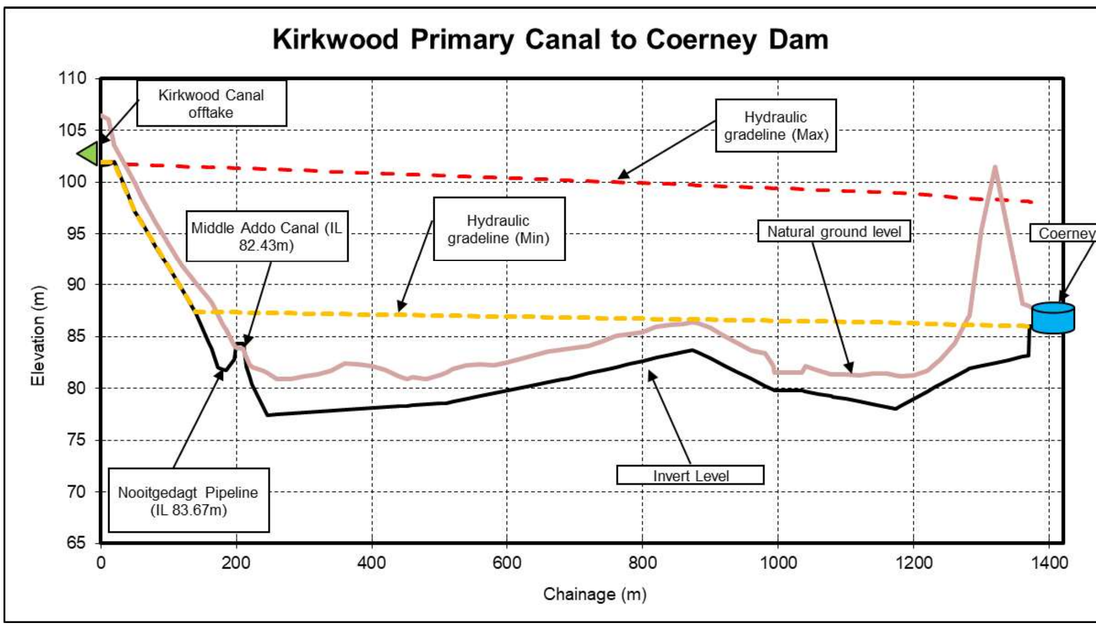

Figure 4-2: Kirkwood Canal to Coerney Dam: HGL for 280 Mℓ/d in aged DN 1400 pipeline

It is evident from **Error! Reference source not found.** that the hydraulic gradient line at the K irkwood Canal would be 102 masl when Coerney Dam is at its FSL of 98.2 masl. The floor level of the Kirkwood Canal at the offtake point is approximately 103.9 masl with the long weir having a height of 105.8 masl. It would therefore be possible to discharge 280 Mℓ/d from the Kirkwood Canal to the Coerney Dam, even when the dam is at FSL.

Figure 4-3 shows the hydraulic gradient line from the Coerney Dam to the tie-in point on the Nooitgedagt pipeline with the dam at a level of 90 masl and discharging a flow of 280 Mℓ/d.

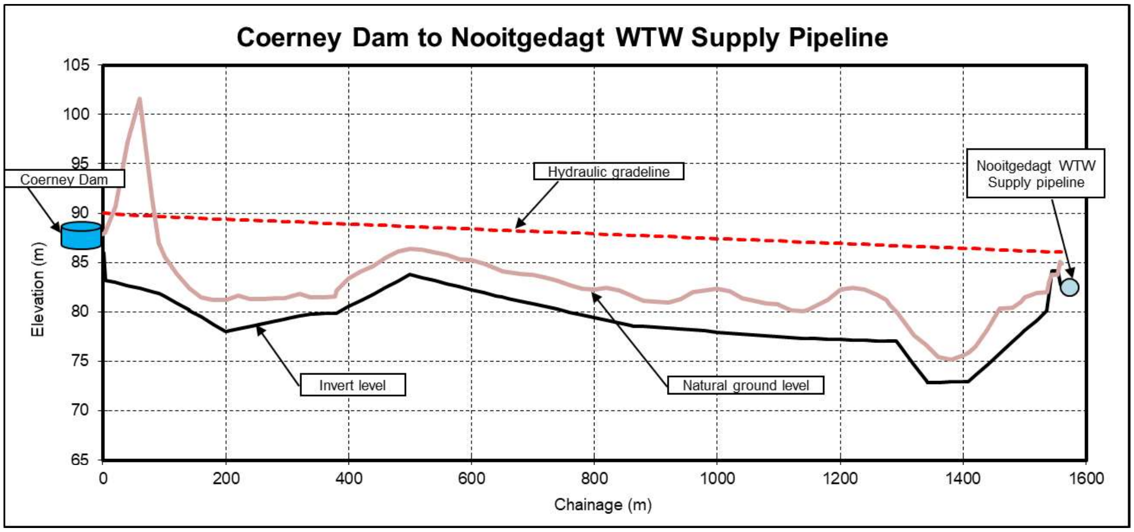

Figure 4-3: Coerney Dam to Tie-In Point: HGL for 280 Mℓ/d in aged DN 1400 pipeline

It is evident from **Figure 4-3** that a residual pressure of approximately 3 m would be available at the tie-in point.

Error! Reference source not found. shows the hydraulic gradient line from the Coerney Dam t o the Nooitgedagt WTW with the dam level at 90 masl and a discharge of 280 Mℓ/d.

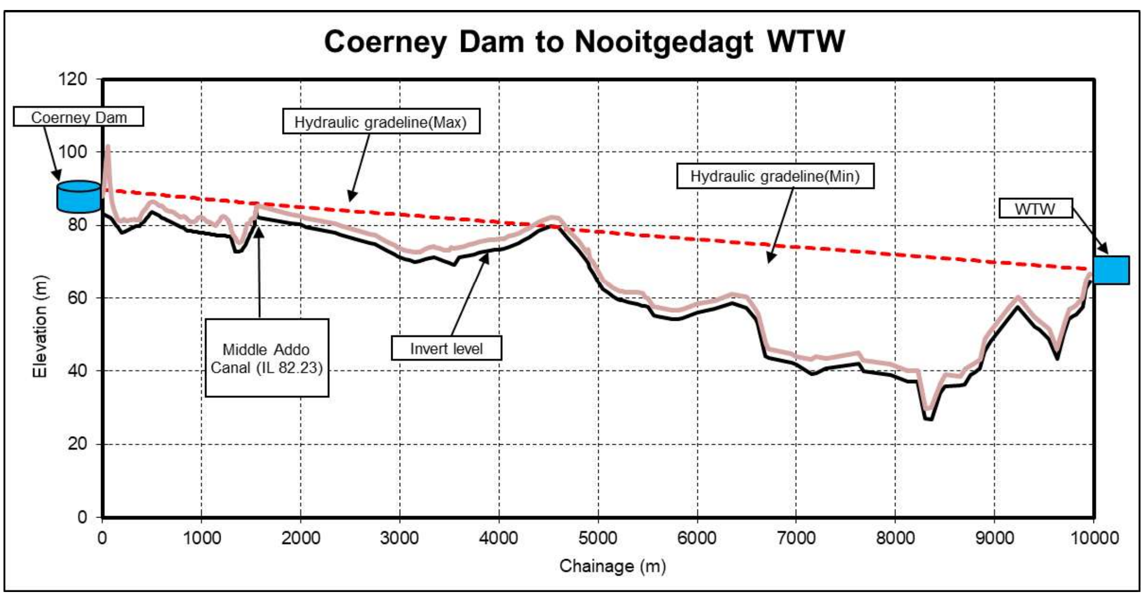

Figure 4-4: Coerney Dam to WTW: HGL for 280 Mℓ/d in aged DN 1400 pipeline

It is evident from **Error! Reference source not found.** that the high point located at chainage 4 500 m would create a hydraulic control, meaning that a short section of the existing pipeline would flow partially full immediately downstream of this high point. The proposed pipeline from Coerney Dam is therefore connected to the existing pipeline downstream of this high point.

4.4 Pipe material selection

It is evident from Error! Reference source not found. and **Figure 4-3** that maximum working p ressures would not exceed 30 m in the new pipelines. Given the pipeline diameter and expected working pressures, it would be possible to consider the following as suitable pipe materials:

- Glass Reinforced Polyester (GRP),
- Ductile Iron, and
- Steel.

Each of these materials has advantages and disadvantages with respect to hydraulic capacity, price, ease of installation, need for corrosion protection, ease of repairs, etc.

GRP pipes would most likely be the preferred pipe material based on (a) cost, (b) no need for cathodic protection, and (c) lowest internal roughness. The GRP pipes are, however, prone to damage during the construction phase of the project. They require utmost care when laying, both in the quality of the bedding material and the compaction. Special care must also be taken when connecting GRP pipes to other pipe materials or at structures, as differential settlement can result in the cracking of the pipes. Large anchor/thrust blocks would also be required at bends.

Steel pipes are typically more economical than ductile iron pipes when used in low pressure applications due to the thinner wall thicknesses. Steel pipes also have the benefit that no anchor/thrust blocks would be required. Steel pipes are also preferred due to the ease with which connections to existing pipelines can be made and the flexibility to make site-specific changes by mitring of bends. The potential negative aspect of the steel pipes is that cathodic protection would most likely be required.

Given the advantages of steel pipes, it is proposed that this be considered as the preferred pipe material for the proposed pipelines.

Consideration should be given during the detailed design to the following aspects:

- Internal lining - whether the pipelines should be cement-mortar or epoxy lined.

- External coating - a choice must be made between polyurethane, medium density polyethylene (i.e. Sintakote), 3LPE and polymer modified bitumen.
- Quality inspection at the factory of the pipes, including lining and coating, is essential.
- Further quality inspection of the pipes on site, before and after installation is required.
- An external inspector, independent of the pipe manufacturer is required.

4.5 Preliminary wall thickness calculation

Based on the limited geotechnical information available, an assumption was made that the minimum E-value of the native material would be in the order of 6 MPa. Imported bedding material would be required along the majority of the pipeline route and would therefore have an E-value of at least 12 MPa. This will provide a combined Modules of Soil Reaction of 7.20 MPa in accordance with AWWA M11's guidelines.

The recommended pipeline diameters and wall thicknesses are based on the hydraulic analyses and external loads. The following assumptions were also made in the calculations:

- A live wheel load of 80 kN
- Maximum working pressure = 30 m
- Maximum surge pressure = 40 m (assumed)
- Maximum water table at 100 mm below natural ground level
- Minimum soil cover on pipe = 1 m
- Maximum soil cover on pipe = 3.4 m
- Grade X52 steel will be used
- Factor of safety for working pressures = 1.67 (based on DWS guidelines)
- Factor of safety for surge pressures = 1.67 (based on DWS guidelines)
- Factor of safety for combined stresses = 1.65 (based on DWS guidelines)
- Maximum deflection due to cement-mortar lining = 3%.

The existing gravity supply pipeline to Nooitgedagt is a DN 1400, 11 mm Grade B steel pipe. Based on the assumptions and calculations above the proposed pipelines will be DN 1400, Grade X52 steel with a yield strength of 358 MPa and a recommended wall thickness of 10 mm. The maximum soil cover of 3.4 m will have to be adhered to during the detailed design of the vertical alignment of the pipelines.

Thicker wall thickness might be required if the E-value of the native soil is worse than expected or if the E-value of the bedding material is lower than anticipated.

It is proposed that further geotechnical investigations be undertaken to verify the E-value of the native soil. The wall thickness provided above is therefore only preliminary wall thickness, which should be verified once the additional geotechnical information becomes available.

5 Connections and associated impacted infrastructure

5.1 Control narrative of scheme

The proposed connecting pipework for the new dam to the existing infrastructure is shown schematically in **Figure 5-1**.

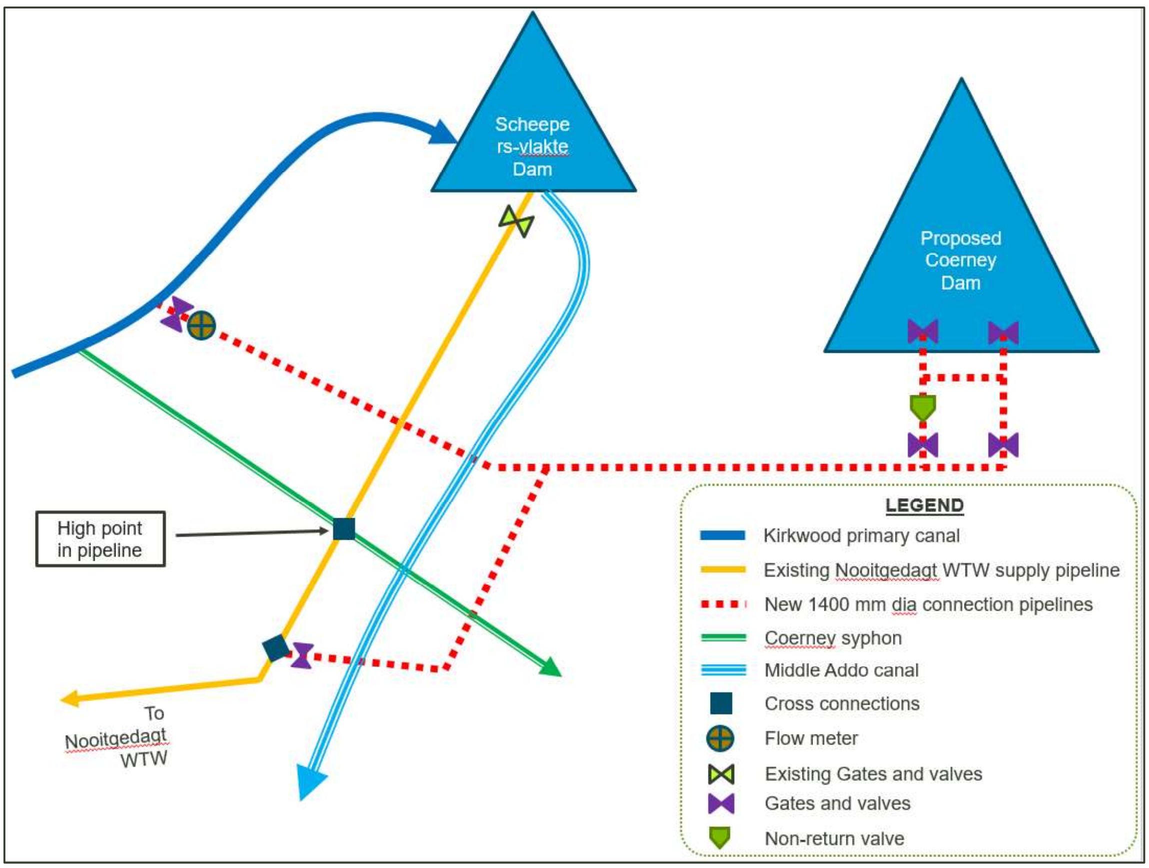

Figure 5-1: Schematic layout of the proposed new dam and connecting pipelines

The proposed Coerney Dam will be supplied with water from the Kirkwood primary canal, through a new 1400 mm diameter steel pipeline. The pipeline will abstract water from a new offtake on the canal. The proposed intake is located at the end of the Kirkwood primary canal, between the Coerney syphon inlet and the long weir, just upstream of the Scheepersvlakte Dam. Locating the intake just upstream of the long weir will provide head from the weir.

Under normal operating conditions, the existing valve on the pipeline immediately downstream of the Scheepersvlakte Dam will be closed with all the other valves shown in **Figure 5-1** being open. Water will be abstracted from the Kirkwood primary canal and fed directly into the Nooitgedagt pipeline, except that surplus water will flow into the Coerney Dam. In the event that the demand of the Nooitgedagt WTW exceeds the supply from the Kirkwood primary canal, the shortfall will be supplied from the Coerney Dam.

Should the Coerney Dam reach its full supply level, the inlet valve on the supply pipeline to the dam will be closed. The outlet pipeline, which is fitted with a non-return valve to prevent inflow into the dam, will remain open to supply the WTW with water as required.

Given that the system is downstream controlled (i.e. at the inlet to the WTW), the flow into and from Coerney Dam would automatically adjust, based on the contribution from the Kirkwood primary canal and demand from the WTW.

Once the Coerney Dam is in operation, the Scheepersvlakte Dam will function as a balancing dam for irrigation only. Its connecting pipework will be isolated, but will remain in place with a connection to the Coerney Dam for emergency supply to the WTW.

5.2 New offtake at Kirkwood primary canal

The proposed offtake from the Kirkwood primary canal will be located downstream of the Coerney syphon intake, and just upstream of the long weir, which will provide head to the new intake.

It is proposed that the new offtake comprises an adjustable weir that would allow for regulating of the flow that could be discharged from the canal to the WTW or to the Coerney Dam. At the offtake location, the canal has a floor level of 103.9 masl with the top of the long weir at a level of 105.8 masl. The length of the adjustable weir (or sluice gate) must therefore be such that the head required would be less than the overflow level of the long weir.

Table 5-1 shows the head required for different weir widths to discharge different flows, e.g. for a weir width/length of 1.0 m, a discharge head of 1.426 m would be required for a flow of 250 Mℓ/d.

Table 5-1: Kirkwood canal offtake: Flow depths for different flows and weir widths

Width of weir (m)	Flow (Mℓ/d)					
	50	100	150	200	250	280
0.5	0.774	1.229	1.610	1.950	2.263	2.441
1.0	0.488	0.774	1.014	1.229	1.426	1.537
1.5	0.372	0.591	0.774	0.938	1.088	1.173
2.0	0.307	0.488	0.639	0.774	0.898	0.969
2.5	0.265	0.420	0.551	0.667	0.774	0.835
3.0	0.234	0.372	0.488	0.591	0.685	0.739

It is proposed that the floor level be raised at the off-take to a level of 104.2 masl to mitigate the risk of sediment being transported from the bottom of the canal to the pipeline. This leaves 1.6 m as the maximum head available to discharge a flow of 280 Mℓ/d, meaning that a 1.5 m weir length would still allow just over 400 mm of freeboard.

The water from the off-take will discharge into a wet well that will be piped through a magnetic flow meter. The display from the flow meter will be positioned next to the adjustable sluice gate, which will allow the weir to be adjusted to discharge a certain flow.

The proposed offtake configuration is shown on drawing 112546-0000-DRG-CC-101 in **Appendix A** and in **Figure 5-2.**

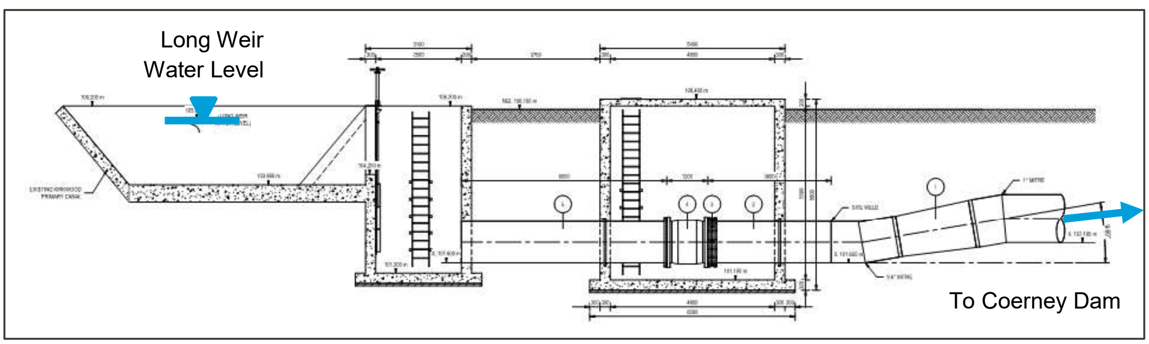

Figure 5-2: Section view of Offtake at Kirkwood Canal

5.3 Coerney Dam Inlet/Outlet Chamber

The proposed dam will be supplied from the Kirkwood primary canal with a DN 1400 pipeline, which will also be used to transfer water to the tie-in point on the existing Nooitgedagt pipeline.

The pipe for supplying water to and from the dam will bifurcate into an inlet and outlet branch at the outlet chamber at the downstream toe of the embankment. The inlet branch will have an isolation valve for shutting off supply when the dam is full; this is to prevent spilling canal water. The outlet branch will be fitted with a non-return valve and an isolation valve upstream and downstream. The non-return valve will ensure that water can be 'automatically' supplied from the dam in the event where the inlet has been shut to avoid spilling of the dam when it is full. The isolation valves will ensure that the non-return valve can be serviced while the inlet pipe remains in operation.

The inlet and outlet pipe branches will reduce from DN 1400 to DN 1200 at the bifurcation and reduce from DN 1200 to DN 1000 after the cross connection before passing through the embankment in a concrete encasement. Both pipes will connect to a wet well outlet tower in the dam basin.

The Inlet/Outlet chamber is shown on drawing 112546-0000-DRG-CC-100 in **Appendix A** and in **Figure 5-3**.

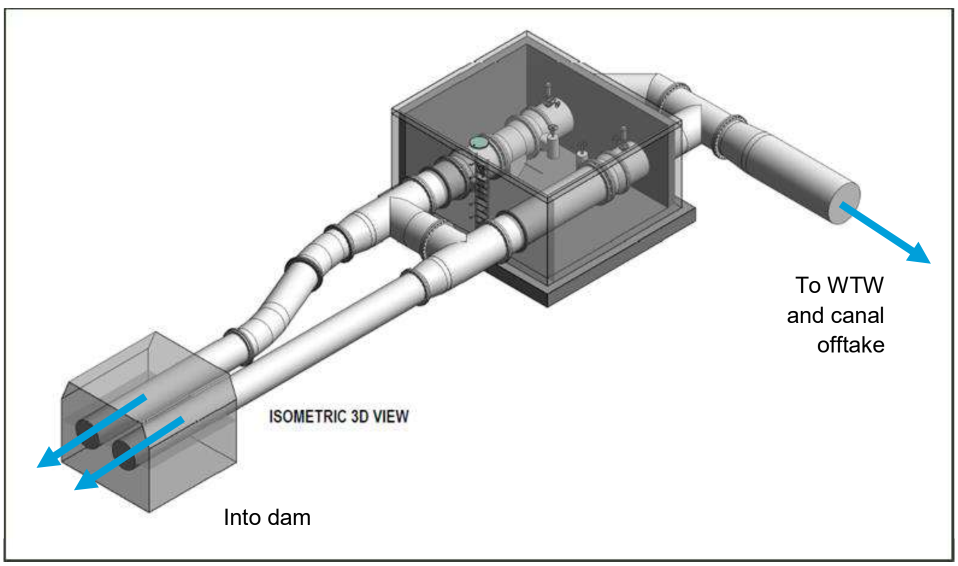

Figure 5-3: Isometric view of Coerney Dam Inlet/Outlet Chamber

5.4 Tie in to existing Nooitgedagt WTW supply pipeline

A connection needs to be made into the existing 1400 mm diameter Nooitgedagt supply pipeline. The existing pipeline is manufactured from Grade B steel with a cement-mortar lining and bitumen fibreglass coating, and has a 11 mm wall thickness at the connection point. The tie in will be located downstream of the cross connection with the Scheepersvlakte syphon and downstream of the existing high point in the existing supply line.

The tie in will comprise a 1400 mm x 1400 mm equal tee that will be cut into the existing pipeline. The branch of the tee will be fitted with an isolation valve to close the Coerney Dam's supply should maintenance be required on this pipeline. The tie-in drawing is shown on 112546-0000-DRG-CC-102 in **Appendix A** and in **Figure 5-4**.

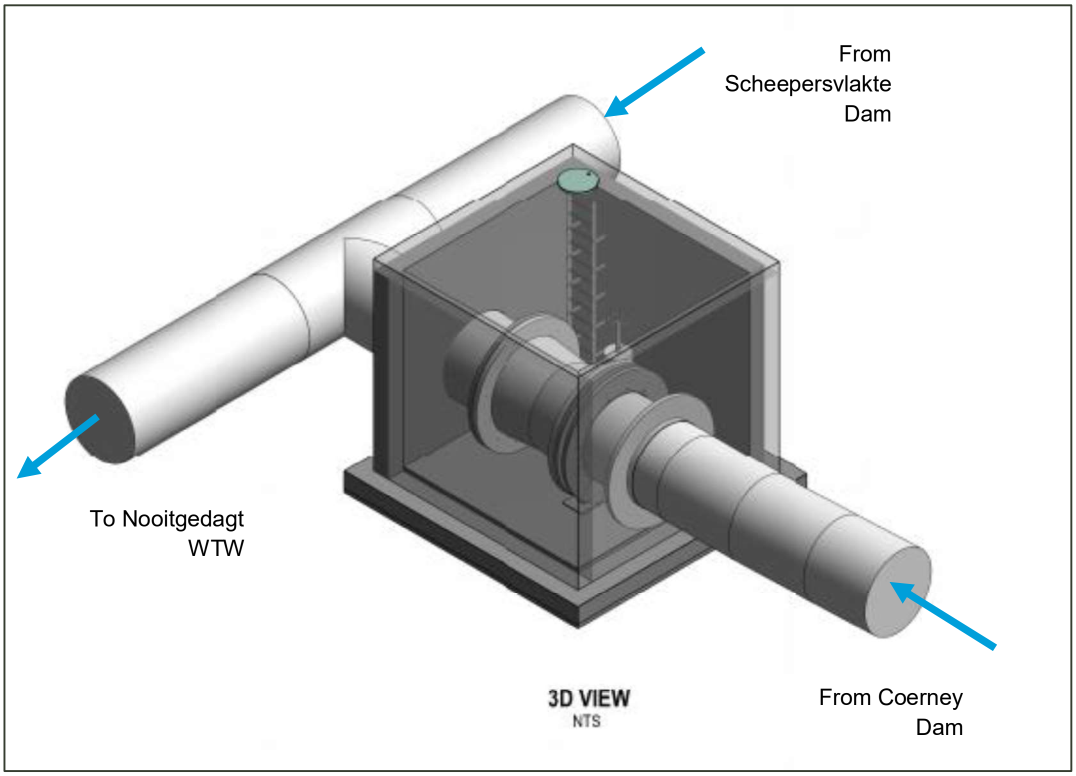

Figure 5-4: Isometric view of Tie-in to Existing Nooitgedagt Supply Pipeline

5.5 Middle Addo Canal Crossings

The new supply pipeline to the Coerney Dam and the bypass pipeline will need to cross the Middle Addo canal. The approximate elevations and width of the canal at the points of crossing are indicated in **Table 5-2**.

Table 5-2: Middle Addo Canal details

Canal details	New Supply Pipeline to Lower Coerney Dam	Bypass Pipeline to WTW
Canal width	5.35 m	5.35 m
Centre line canal	82.43 masl[1]	82.23 masl[1]
Left Bank canal	83.91 masl[1]	83.73 masl[1]

[1] Levels are approximate

The exact positions of the Middle Addo canal crossing must be verified during the detailed design of the pipelines.

It is proposed that the pipeline be installed over the canal (above ground) not to impact the operation or integrity of the canal, and to facilitate easier maintenance, if required. The 1400 mm diameter steel pipe will serve as the pipe bridge with concrete supports on either side of the canal. An air valve will have to be installed at the high point created by the canal crossing. The air valve will also serve as an access point into the pipeline for maintenance purposes. Additional protection of the exposed pipe may be required.

A typical detail of the pipe bridge is shown in **Figure 5-5**.

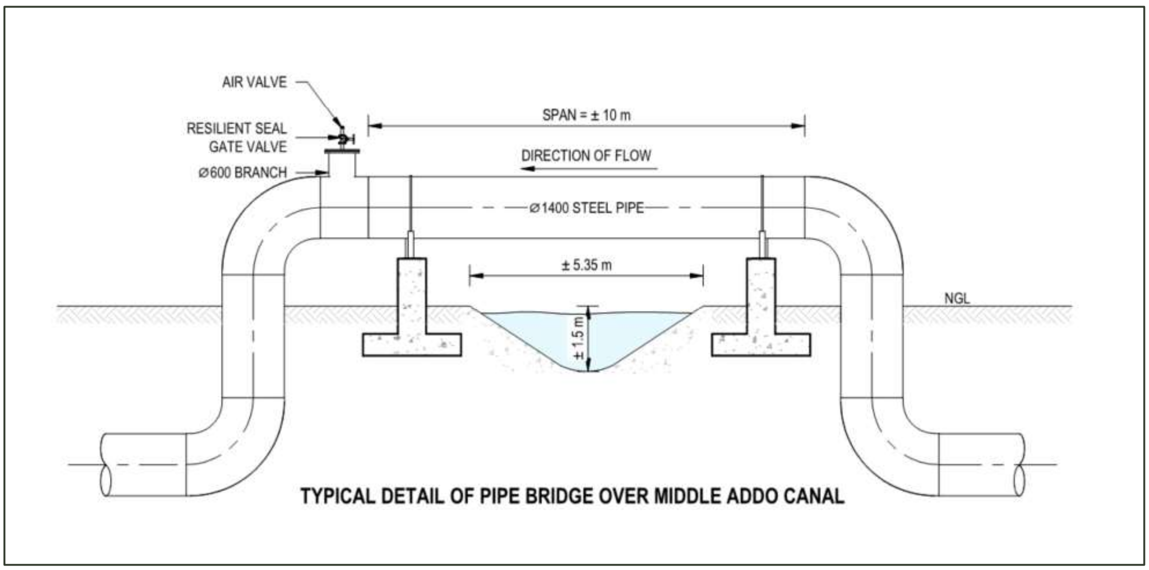

Figure 5-5: Typical detail of pipe bridge over Middle Addo Canal

5.6 Proposed Coerney Dam spillway crossing

The position of the Coerney Dam spillway is not yet finalised. If the spillway is constructed on the left, it will have no impact on the proposed pipeline. If the Coerney Dam spillway is positioned on the right the proposed DN 1400 pipeline will need to cross it, in which event it is proposed that the pipeline crosses under the spillway just downstream of the stilling basin as shown in **Figure 5-6.** The pipeline will most likely be encased as part of the stilling basin's end sill.

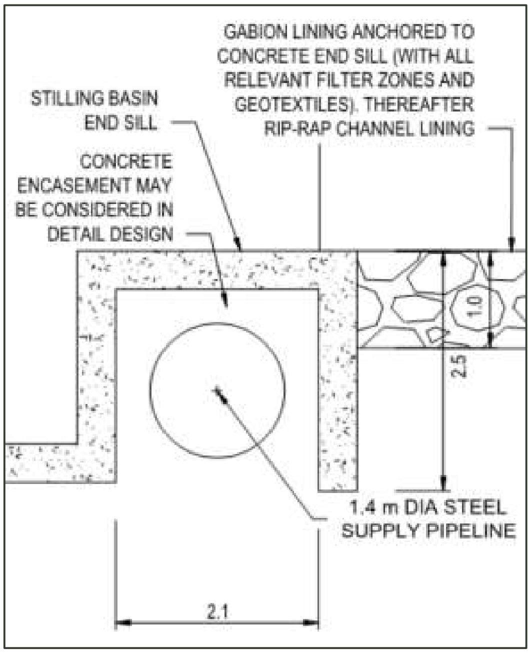

Figure 5-6: Typical detail of pipe underneath spillway

5.7 Existing Nooitgedagt WTW supply pipeline crossing

The proposed pipeline from the Kirkwood primary canal to the Coerney Dam will have to cross the existing Nooitgedagt WTW supply pipeline.

The proposed pipeline would need to cross under the existing Nooitgedagt pipeline due to the limited soil cover on the existing pipeline at the point of crossing. The invert level at the proposed crossing is approximately 83.7 masl. The new pipeline will have a 300 mm clearance between the invert of the existing pipeline and the crown of the new pipeline. The existing pipeline will have to be excavated by hand to confirm the exact levels during the construction phase of the project and to ensure that no damage is done to the existing pipeline.

5.8 Syphon under Sundays River

An additional syphon under the Sundays River on the existing Nooitgedagt WTW supply pipeline is proposed to:

- Reduce the risk of supply failure in the event of damage to the existing syphon; and
- Mitigate the risk due to the new balancing storage being located on the opposite side of the river, relative to the WTW.

The additional syphon under the Sundays River will be concrete encased. The top of the reinforced pipe encasement should be below riverbed level. The length of the encasement is assumed to be approximately 105 m (the same as the existing pipeline).

It is proposed that the new syphon be located upstream of the existing syphon at a suitable point to cross the river. The new syphon should be separate from the existing syphon at a suitable distance upstream. The additional syphon will potentially also be on private property and landowner discussions will need to be initiated.

An air valve chamber and a scour valve chamber will have to be installed, and tie-ins made into the existing pipeline. The air valve will also serve as an access point into the new pipeline for maintenance purposes. The tie-ins will comprise 1400 mm x 1400 mm equal tees that will be cut into the existing pipeline and installed on the new syphon pipeline. Isolating valves will be provided so that the new syphon can be isolated, as it will only be used if the existing syphon is damaged or when maintenance is required.

As-built drawings and/or information will have to be obtained on the existing syphon during the detailed design phase of the project.

Apart from doubling the syphon it is also recommended that an adequate stockpile of replacement pipes be kept, to be able to quickly repair the pipeline in case of failure.

6 Legislative Considerations and Authorisations

6.1 Environmental Impact Assessment

The environmental impact assessment (EIA) process is expected to commence in 2020, as soon as DWS has appointed an Environmental Assessment Practitioner. This will be further dealt with in the *Implementation Support Sub-Report*.

6.2 Water use licence

A water use licence will need to be obtained for storing water and affecting and altering the banks of a river (Section 21 (b), (c) and (i), National Water Act, 1998). This licence application is included in the scope of work for the EIA study (refer also to the *Implementation Support Sub-Report)*.

6.3 Land ownership

The portion of land upon which the dam is to be located is known as Portion 7 of Scheepers Vlakte, which is owned by Scheepersvlakte Farms Pty Ltd. The affected land and infrastructure are discussed in further detail in the *Affected Land and Infrastructure Sub-Report* (DWS, 2019).

It is recommended that a 15 m wide servitude be registered along the proposed pipeline and that the proposed pipeline be positioned 6 m away from the one edge of the servitude.

During the construction phase, it is proposed that provision be made for a 40 m wide working width (temporary servitude) along the proposed pipeline routes.

6.4 Wayleave

Wayleave applications will be submitted to all the relevant service authorities to (a) obtain information on the location of their existing services, (b) comment on the proposed pipeline alignments, and (c) to obtain their requirements that must be adhered to during construction.

This process should be undertaken during the detailed design phase of the project.

7 Conclusions

The feasibility-level design of the conveyance infrastructure associated with the proposed balancing dam has concluded the following:

a) The proposed scheme comprises of two gravity pipelines.

b) The main advantages of the proposed scheme are that the proposed Coerney Dam would increase the raw water storage capacity of NMBM and the high point in the existing Nooitgedagt WTW gravity main would be bypassed.

c) The hydraulic calculations of both pipelines are based on a design capacity of 280 Mℓ/d (3.24 m^3/s) and Coerney Dam water levels at MOL of 86 masl and a FSL of 98.2 masl.

d) A storage capacity of only 17% would be required for a DN 1400 pipeline to deliver the design flow rate of 3.24 m^3/s. A flow of 106.6 Mℓ/d can be discharged through a DN 1400 pipeline with the dam level at MOL, i.e. almost 40% of the maximum flow rate.

e) Based on the hydraulic gradient lines it would be possible to discharge 280 Mℓ/d from the Kirkwood Canal to the Coerney Dam.

f) It is proposed that steel pipes be considered as the preferred pipe material for the proposed pipelines.

g) Based on the preliminary wall thickness calculations, the proposed pipelines will be DN 1400, Grade X52 steel with a yield strength of 358 MPa and a recommended wall thickness of 10 mm.

h) The proposed dam will be supplied from the Kirkwood primary canal through a DN 1400 pipeline, which will also be used to transfer water to the tie-in point on the existing Nooitgedagt pipeline.

i) The offtake from the Kirkwood primary canal will be located downstream of the Coerney syphon intake, and upstream of the long weir. It is proposed that the new offtake comprises an adjustable weir that would allow regulating of the flow that could be discharged from the canal to the WTW or the Coerney Dam.

j) A connection will be made into the existing Nooitgedagt WTW supply pipeline downstream of the cross connection with the Scheepersvlakte syphon, and downstream of the existing high point in the existing supply pipeline.

k) The Middle Addo canal will have to be crossed at two locations by means of a pipe bridge.
l) The proposed Coerney Dam spillway will need to be crossed by the DN 1400 pipeline, if the spillway is constructed on the right abutment of the dam. There will be no impact on the pipeline if the spillway is constructed on the left abutment.
m) An additional syphon under the Sundays River on the existing Nooitgedagt WTW supply pipeline is proposed. The purpose is to reduce the risk of supply failure and to mitigate the risk of the new balancing storage being located on the opposite side of the river, relative to the WTW.
n) It is proposed that the new syphon be located upstream and separate from the existing syphon. Apart from doubling the syphon it is also recommended that an adequate stockpile of replacement pipes be kept on site, to enable quick repair of the pipeline in case of failure.

8 Recommendations

The following recommendations are applicable to the detailed design and construction phases of the project:

a) A ground centreline survey should be done along the final chosen pipe centreline route, prior to construction commencing. This will serve as a final check on the pipeline vertical alignment and soil cover depths.

b) A geotechnical investigation should be undertaken along the proposed pipeline routes and at the proposed chamber locations to inform the detailed design. The geotechnical investigation should also include a soil resistivity survey and testing for sulphate reducing bacteria to inform the coating selection and the need for cathodic protection.

c) An estimate is required of the volume of suitable pipeline bedding material that will need to be imported, as well as locating suitable sources.

d) The wall thickness calculations of the proposed pipelines should be confirmed once the additional geotechnical information becomes available.

e) During the detailed design, the pipeline route will need to be confirmed after discussions with affected land owners and authorities. Some refinements to the routes may be required due to developments subsequent to the feasibility design.

f) A decision is required on the preferred lining system (i.e. cement mortar or epoxy) and coating system (i.e. polyurethane, medium density polyethylene (i.e. Sintakote), 3LPE and polymer modified bitumen) to be used.

g) The exact positions of all connections and impacted associated infrastructure must be verified during the detailed design of the pipelines.

h) Independent quality control inspections of the pipes, at the factory and on site, must be included in the construction tender documents.

i) As-built drawings and/or information of the existing syphon under the Sundays River will need to be obtained during the detailed design phase of the project.

j) The position of the new syphon, upstream of the existing syphon, needs to be determined.

References

Department of Water and Sanitation, South Africa 2018. Coerney Dam Contour Survey (EC 003/2018). Survey Services: Southern Operations (National Water Resource Infrastructure).

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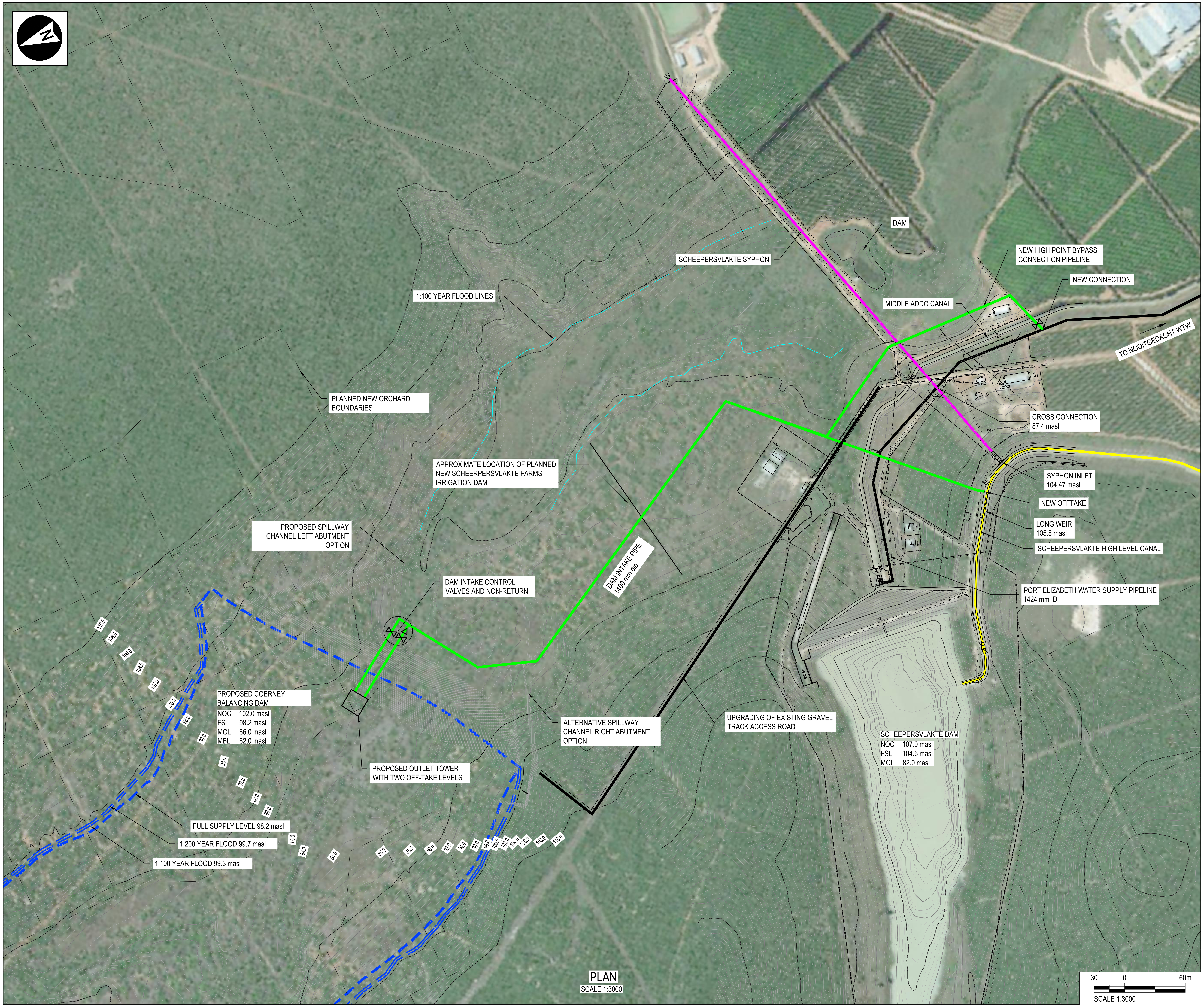
Department of Water and Sanitation, South Africa 2019, Options Analysis. Report number P WMA 15/N440/00/2517/3. Prepared by Aurecon South Africa (Pty) Ltd as part of the Support of the Water Reconciliation Strategy for the Algoa Water Supply System.

Department of Water and Sanitation, South Africa 2019, Layout and Affected Land and Infrastructure Sub-Report. Prepared by Aurecon South Africa (Pty) Ltd as part of the Support of the Water Reconciliation Strategy for the Algoa Water Supply System.

Department of Water and Sanitation, South Africa 2019, Options Analysis. Report number P WMA 15/N440/00/2517/3. Prepared by Aurecon South Africa (Pty) Ltd as part of the Support of the Water Reconciliation Strategy for the Algoa Water Supply System.

Department of Water and Sanitation, South Africa 2019, Layout and Affected Land and Infrastructure Sub-Report. Prepared by Aurecon South Africa (Pty) Ltd as part of the Support of the Water Reconciliation Strategy for the Algoa Water Supply System.

Appendix A: Drawings



REFERENCE DRAWINGS

DRAWING No.	TITLE / DESCRIPTION

LEGEND

- FUTURE ORCHARD BOUNDARIES
- PE WATER SUPPLY PIPELINE
- MIDDLE ADDO CANAL
- SCHEEPERSVLAKTE SYPHON
- SCHEEPERSVLAKTE HIGH LEVEL CANAL
- PROPOSED PIPELINE

NOTES

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REV	DATE	REVISION DETAILS	APPROVED
A	08/2019	FOR INFORMATION	E. V. D. BERG
B	02/2020	FOR INFORMATION	E. V. D. BERG
C	02/2020	FOR INFORMATION	E. V. D. BERG
D	03/2020	FOR INFORMATION	E. V. D. BERG

SCALE: AS SHOWN
SIZE: A1
FOR INFORMATION

DRAWN: P. NDLOVU
DESIGNED: O. HUMAN
CHECKED: M. SHAND
APPROVED
DATE

PROJECT
SUPPORT OF THE WATER RECONCILIATION STRATEGY OF THE ALGOA WATER SUPPLY SYSTEM

TITLE
COERNEY BALANCING DAM LAYOUT PLAN

DRAWING NUMBER

PROJECT No.	WBS	TYPE	DISC	NUMBER	REV
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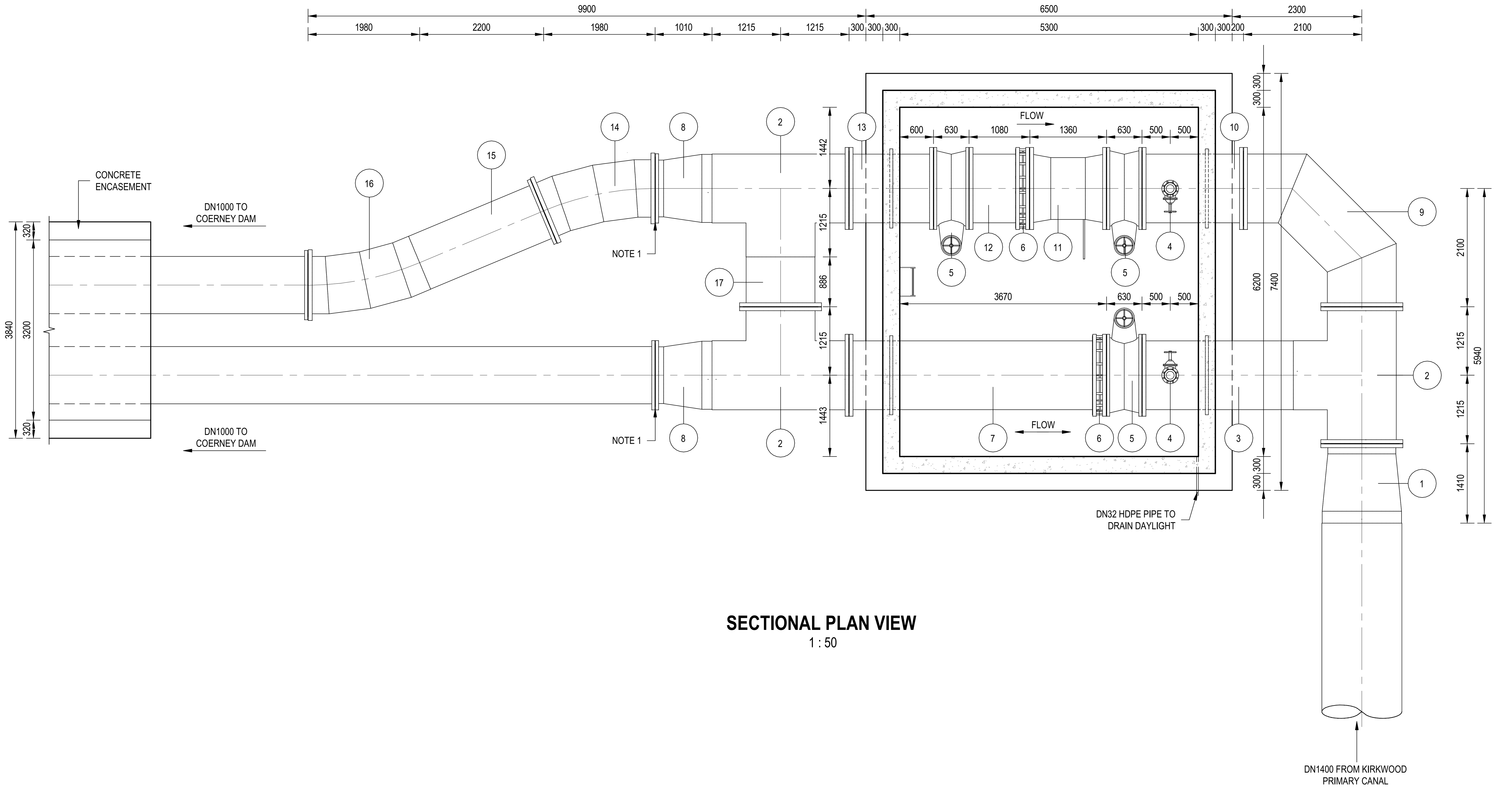
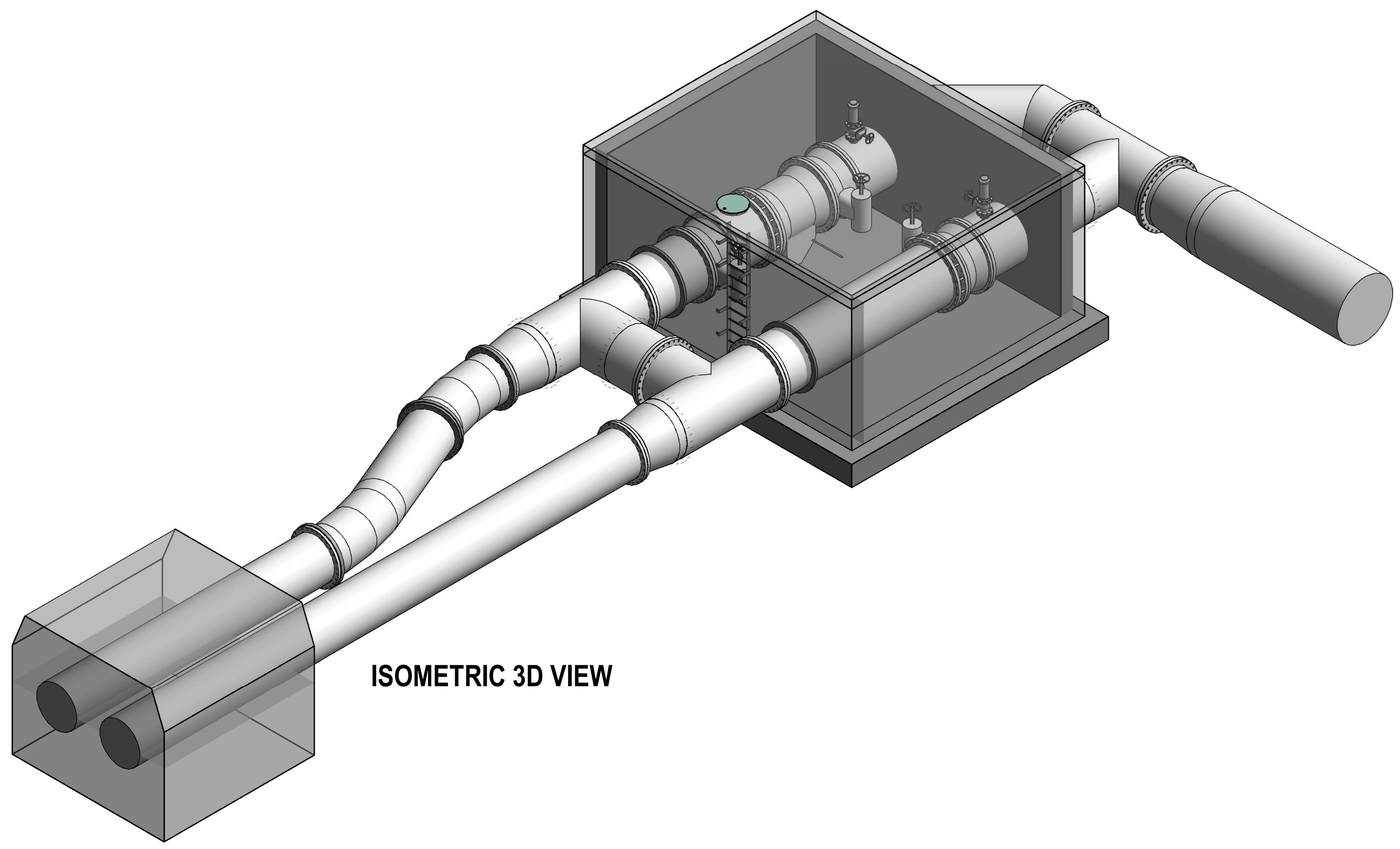


SECTIONAL PLAN VIEW
1 : 50



ISOMETRIC 3D VIEW

NOTES:

1. FLANGES LOCATED OUTSIDE CHAMBER CAN BE REPLACED WITH SITE WELDS.

MATERIALS LIST

ITEM	QTY	DESCRIPTION
1	1	DN 1400 x DN 1200 REDUCER; FLANGED ONE END
2	3	DN 1200 FLANGED EQUAL TEE; ONE END PLAIN
3	1	DN 1200 PUDDLE PIPE; FLANGED ONE END; 2685mm F/F
4	2	DN 150 STUB; 1070mm C/F; WITH DN 150 GATE VALVE AND DN 150 AIR VALVE
5	3	DN 1200 FLANGED BUTTERFLY VALVE
6	2	DN 1200 RESTRAINED FLANGE ADAPTOR
7	1	DN 1200 FLANGED PUDDLE PIPE; 4570mm F/F
8	2	DN 1200 x DN 1000 PLAIN ENDED REDUCER
9	1	DN 1200 PLAIN ENDED 90° BEND (1 x D)
10	1	DN 1200 PUDDLE PIPE; FLANGED ONE END; 1800mm F/F
11	1	DN 1200 FLANGED NON-RETURN VALVE
12	1	DN 1200 PIPE FLANGED ONE END; 1080mm F/F
13	1	DN 1200 FLANGED PUDDLE PIPE; 1500mm F/F
14	1	*DN 1000 FLANGED 22.7° BEND
15	1	DN 1000 PIPE; FLANGED ONE END; 2385mm F/F
16	1	*DN 1000 22.7° BEND; FLANGED ONE END
17	1	DN 1000 PIPE; FLANGED ONE END; 885mm F/F

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B	03/2020	FOR INFORMATION	

SCALE	SIZE
AS INDICATED	A1

FOR INFORMATION

APPROVED

DATE

DRAWN: B. MCCAROGHER

DESIGNED: M. WAHL

REVIEWED: S. KLEYNHANS

PROJECT

SUPPORT OF THE WATER RECONCILIATION STRATEGY OF THE ALGOA WATER SUPPLY SYSTEM

TITLE

LOWER COERNEY DAM INLET/OUTLET CHAMBER

DRAWING NUMBER

PROJECT No	WBS	TYPE	DISC	NUMBER	REV
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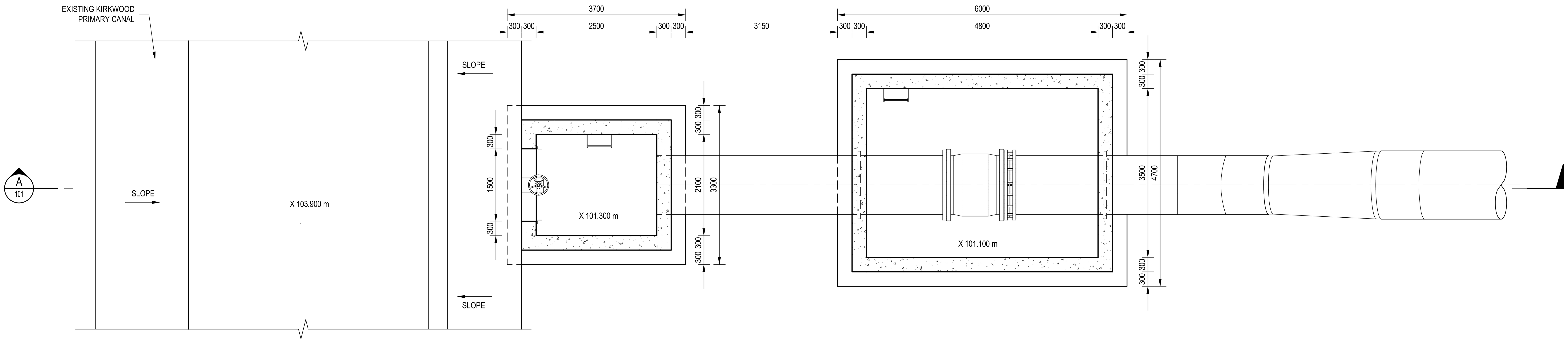
Plot Date: 3/4/2020 6:23:36 AM Office: ZAWAT Filename: P:\Projects\112546 Algoa Recon Support\03 Prj Delivery\12 Feasibility Design\04 Pipeline design\Drawings\Revit\112546-0000-DRG-CC-100.rvt



SECTIONAL PLAN VIEW

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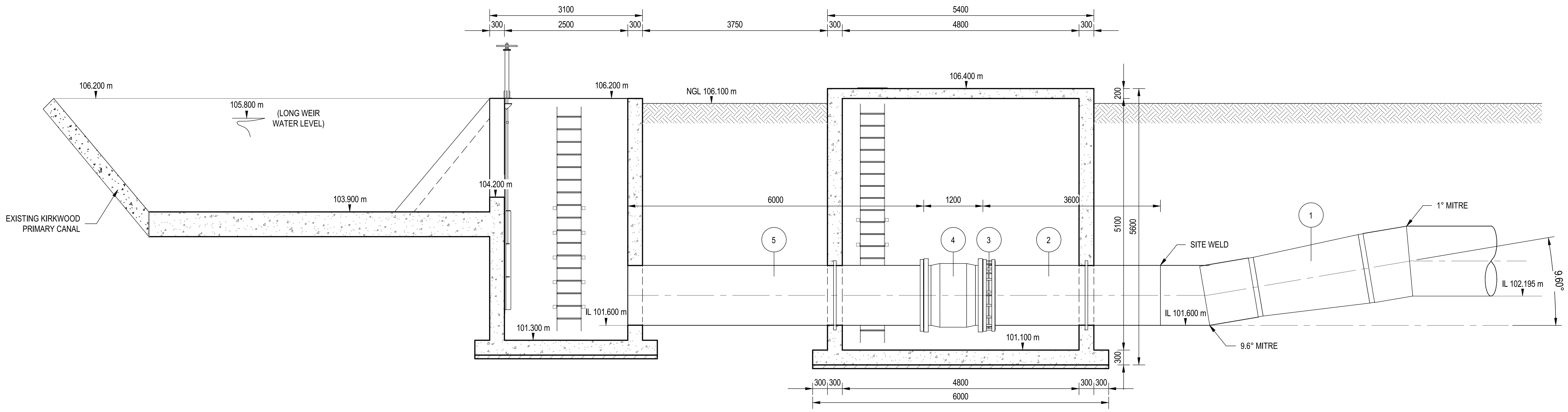

SECTION A

1 : 50 (101)

MATERIAL LIST		
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2	1	DN 1200 PUDDLE PIPE; FLANGED ONE END; 3600mm F/F
3	1	DN 1200 RESTRAINED FLANGE ADAPTOR
4	1	DN 1200 FLANGED ELECTRO-MAGNETIC FLOW METER
5	1	DN 1200 PUDDLE PIPE; FLANGED ONE END; 6000mm F/F

Plot Date: 3/4/2020 6:50:30 AM Office: ZAWAT Filename: P:\Projects\112546 Algoa Recon Support\03 Prj Delivery\12 Feasibility Design\04 Pipeline design\Drawings\Revit\112546-0000-DRG-CC-101.rvt

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A	02/2020	FOR INFORMATION	

SCALE	SIZE
AS INDICATED	A1

FOR INFORMATION

DRAWN: B. MCCAROGHER

DESIGNED: M. WAHL

REVIEWED: S. KLEYNHANS

APPROVED

DATE

PROJECT

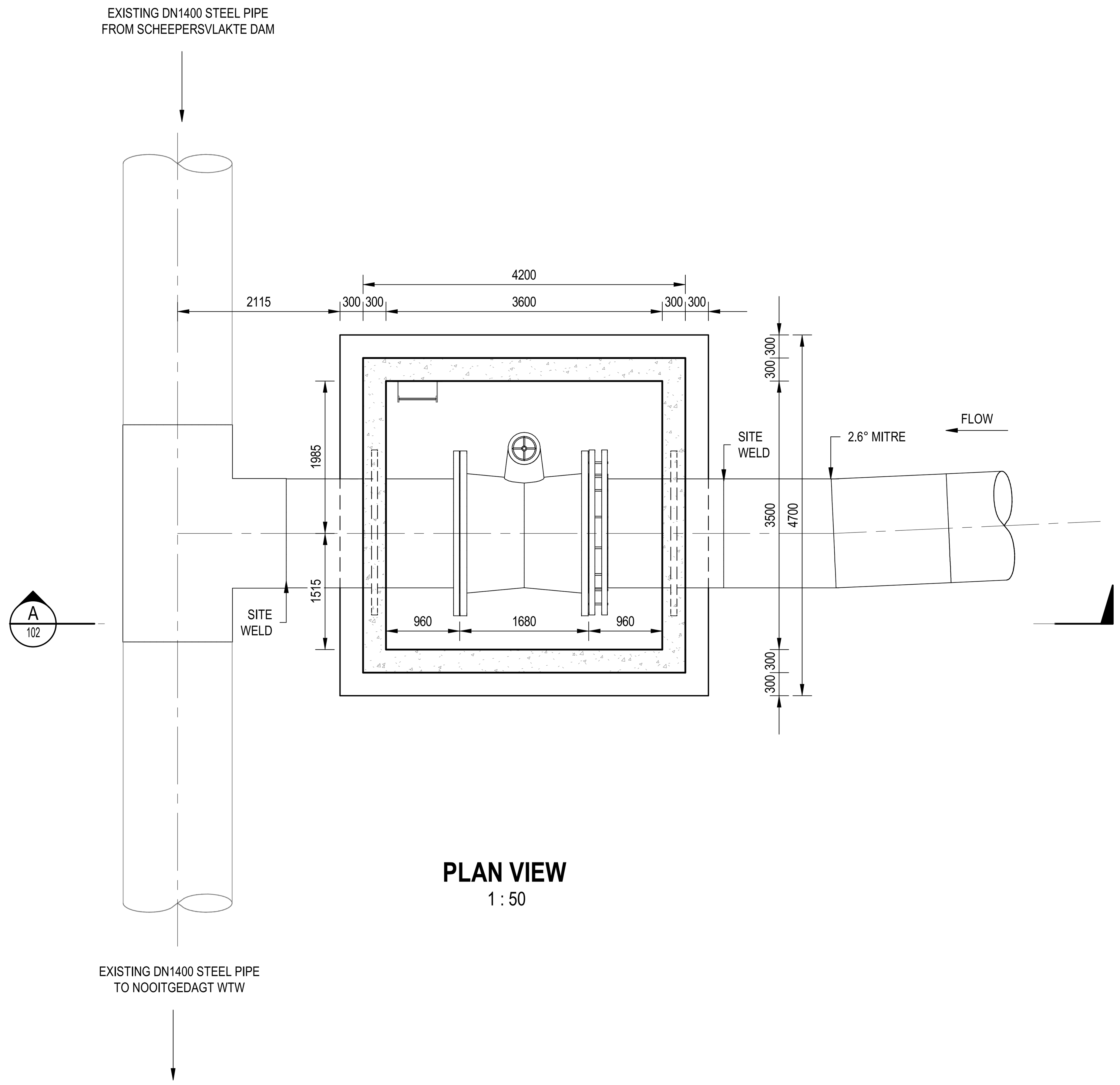
SUPPORT OF THE WATER RECONCILIATION STRATEGY OF THE ALGOA WATER SUPPLY SYSTEM

TITLE

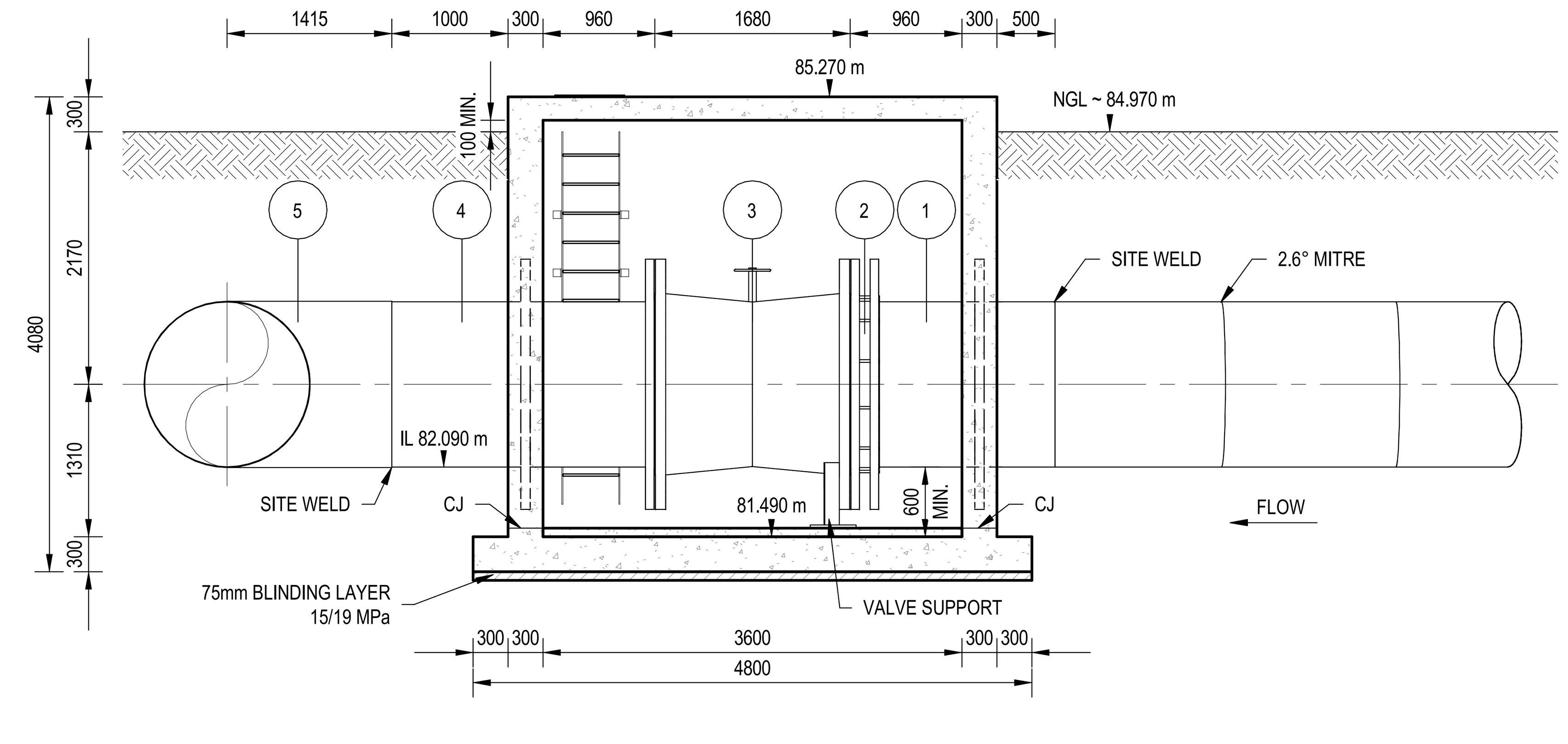
OFFTAKE AT KIRKWOOD PRIMARY CANAL

DRAWING NUMBER

PROJECT No	WBS	TYPE	DISC	NUMBER	REV
112546	0000	DRG	CC	101	A



PLAN VIEW
1 : 50



SECTION A
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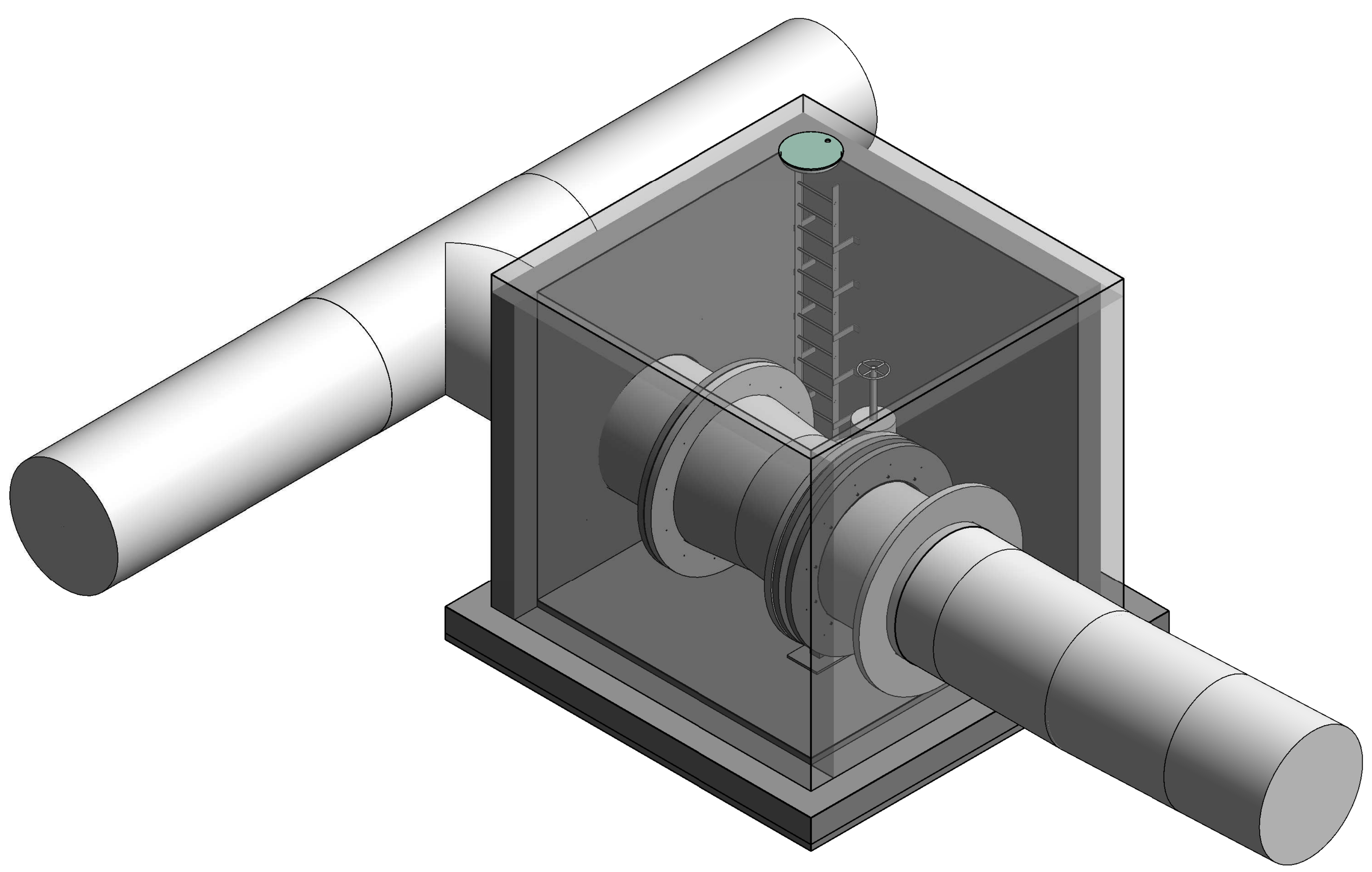
102



3D VIEW
NTS

MATERIALS LIST

ITEM	QTY	DESCRIPTION
1	1	DN 1400 PLAIN ENDED PUDDLE PIPE; 1760mm F/F
2	1	DN 1400 RESTRAINED FLANGE ADAPTOR
3	1	DN 1400 FLANGED BUTTERFLY VALVE
4	1	DN 1400 PUDDLE PIPE; FLANGED ONE END; 2260mm F/F
5	1	DN 1400 PLAIN ENDED EQUAL TEE

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REV	DATE	REVISION DETAILS	APPROVED
A	02/2020	FOR INFORMATION	

SCALE	SIZE
AS INDICATED	A1

FOR INFORMATION

DRAWN
B. MCCAROGHER

DESIGNED
M. WAHL

REVIEWED
S. KLEYNHANS

APPROVED
DATE

PROJECT
SUPPORT OF THE WATER RECONCILIATION STRATEGY OF THE ALGOA WATER SUPPLY SYSTEM

TITLE
TIE-IN TO EXISTING NOOITGEDAGT SUPPLY PIPELINE

DRAWING NUMBER

PROJECT No	WBS	TYPE	DISC	NUMBER	REV
112546	0000	DRG	CC	102	A

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