Feasibility Study for Foxwood Dam (WP10580)

Water Quality Report

Final Issue

DWS Report Number: **P WMA 15/Q92/00/2113/10**

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STUDY REPORTS

The Water Quality report assesses the water quality within the Koonap River, the potential impact of damming the river and the suitability of the quality of water for potable and irrigation use. An assessment of the existing Water Treatment Works in Adelaide is also included.

Feasibility Study for Foxwood Dam: Inception Report	**P WMA 15/Q92/00/2113/1**
Feasibility Study for Foxwood Dam: Preliminary Study Report	**P WMA 15/Q92/00/2113/2**
Feasibility Study for Foxwood Dam: Environmental Screening	P WMA 15/Q92/00/2113/3
Feasibility Study for Foxwood Dam: Geotechnical Reconnaissance	P WMA 15/Q92/00/2113/4
Feasibility Study for Foxwood Dam: Alternative Water Supply Options	P WMA 15/Q92/00/2113/5
Feasibility Study for Foxwood Dam: Feasibility Study Main Report	**P WMA 15/Q92/00/2113/6**
Feasibility Study for Foxwood Dam: Koonap River Hydrology	P WMA 15/Q92/00/2113/7
Feasibility Study for Foxwood Dam: Water Requirements	P WMA 15/Q92/00/2113/8
Feasibility Study for Foxwood Dam: Agro-Economic Study Report	P WMA 15/Q92/00/2113/9
Feasibility Study for Foxwood Dam: Water Quality	P WMA 15/Q92/00/2113/10
Feasibility Study for Foxwood Dam: Geotechnical Investigation	P WMA 15/Q92/00/2113/11
Feasibility Study for Foxwood Dam: Dam Feasibility Design	P WMA 15/Q92/00/2113/12
Feasibility Study for Foxwood Dam: Project Feasibility Costing	P WMA 15/Q92/00/2113/13
Feasibility Study for Foxwood Dam: Economic Impact Assessment	P WMA 15/Q92/00/2113/14
Feasibility Study for Foxwood Dam: Record of Implementation Decisions	P WMA 15/Q92/00/2113/15
Feasibility Study for Foxwood Dam: Book of Maps	P WMA 15/Q92/00/2113/16
Feasibility Study for Foxwood Dam: Public Participation (Queries & Responses Report)	P WMA 15/Q92/00/2113/17

REPORT REFERENCE

This report is to be referred to in bibliographies as:

Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Water Quality Report, P WMA 15/Q92/00/2113/10

Note on Departmental name change

In 2014, the Department of Water Affairs (DWA) changed its name to the Department of Water and Sanitation (DWS). This occurred during the course of this study and as a result some reporting which was commenced and/or approved prior to the name change may still refer to DWA. References herein to DWA and DWS should be considered one and the same.

EXECUTIVE SUMMARY

The Department of Water and Sanitation is investigating the feasibility of developing a multi-purpose dam on the Koonap River near Adelaide in the Eastern Cape. The project is being considered for implementation as a strategic initiative to mobilize the water resources in the area as a stimulus for socio-economic development in this rural, economically depressed region. This initiative would support the objectives of the National Development Plan (NDP) and is consistent with the National Water Resource Strategy 2 (NWRS2).

The purpose of this report is to review the quality of water within the Koonap River and assess any likely required treatment for use of the water for potable or irrigation purposes. The report also reviews the condition of the existing water treatment works and makes recommendations regarding the dam design to optimize impact on water quality resulting from construction and operation of the dam.

The assessment has reviewed the quality of water in the Koonap River in the context of proposed use for potable water and irrigation water. A review of the existing water treatment works has been carried out at Adelaide to review any possible need for upgrading / modification for treating water supplied from the dam. Key findings are:

- The historical record for the Koonap River water quality confirms that the water is suitable for treatment and is able to provide Class 0 drinking water for more than 75% of the time. The construction of the proposed Foxwood Dam will alter the water quality to the works in that there will be less seasonal variation (and possibly an increase in the availability of Class 0 Water for more than 95% of the time). However the size of the impoundment might result in summer stratification of the water column and there are possible risks in terms of anaerobic water and nutrient release during overturn events (generally in autumn).

- It is recommended that the off-take structure be provided with draw-offs at regular intervals to 25 m below top water level. The top highest outlet should be 5 – 8 m below full supply level with two further outlets at regular intervals down to a level of approximately 25 m below full supply level.

- One shortcoming of the water quality data is the limited data on the turbidity and suspended solids for Koonap River. As both parameters can impact on the siltation, storage reduction and treatment requirements it is recommended that, in the event that the project proceeds beyond feasibility study, consideration be given to weekly sampling of the Koonap River to determine the seasonal silt loads and to confirm water quality upstream of Adelaide.

- While it is possible to operate the current treatment works to produce potable water that complies with the drinking water requirements (DWS requirements), it will be necessary to have operators that are well trained and committed to their work. If it is intended that this facility become a regional supply point it would be wise to consider upgrading or replacing the existing water treatment plant with a modern, correctly constructed and equipped facility. If replacement of the plant cannot be considered then it is recommended that significant upgrading of the treatment units take place in a systematic manner.

- There is a concern that organic matter could promote anaerobic conditions in the deep sections of the dam. For that reason, it would be preferred if the vegetation within the dam basin was removed prior to filling.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

LIST OF ACRONYMS

ACRONYM	
ADM	Amathole District Municipality
AW	Amatola Water
DWS	Department of Water and Sanitation
MAR	Mean Annual Run-off
Nxuba	Nxuba Local Municipality
PSP	Professional Service Provider
WSA	Water Service Authority
WSP	Water Service Provider
WTW	Water Treatment Works

LIST OF UNITS

MEASURE	UNIT
Area	m^2, ha or km^2
(Water) Conductivity	mS/m
Distance	m or km
Dimension	mm, m
(Water) Hardness	mg/l
Percentage	%
Volume (storage)	m^3, million m^3
Yield	million m^3/a

1 INTRODUCTION

The Department of Water and Sanitation is carrying out an investigation into the feasibility of developing a multi-purpose dam on the Koonap River outside of Adelaide in the Eastern Cape. The proposed site is known as the Foxwood Dam site. Investigations into the potential development of the water resource within the Koonap River Valley date back to the 1960's. The project is once again being considered due to the potential for the development of the water resource in this area to provide stimulus for development in the region in line with the objectives of the National Development Plan and the National Water Resource Strategy 2. Development of a dam at the Foxwood Dam site could provide additional assurance of water supply to improve resilience of domestic water supply within the region. In addition, development of a dam at the Foxwood site could provide additional assurance of supply of water for irrigation development in the region which may provide stimulus for socio-economic development when combined with agriculture and land reform policies.

The Foxwood Dam site is located immediately upstream of Adelaide (coordinates 32˚40'30"S, 26˚16'0"E) in the Koonap River catchment shown in Figure 1 below. The Koonap River catchment has a catchment area of 3 334 km^2, is situated in the Eastern Cape Province and lies within the Fish to Tsitsikamma Water Management Area (WMA).

Adelaide current is supplied with potable water via an off-channel canal from the Koonap River that feeds a storage dam to the north of the town. This system is backed-up by a transfer pipeline from the Fish River (installed as an emergency intervention during historic times of drought) and municipal boreholes. Comprehensive details on the existing water supply infrastructure are provided in the Alternative Supplies Report (DWA, 2015)

The location of Foxwood Dam within the context of Adelaide and showing current water supply infrastructure is shown in Figure 2. Adelaide is located within Nxuba Local Municipality (Nxuba) within the Amathole District Municipality (ADM). ADM is the Water Service Authority (WSA) responsible for water services in the Nxuba and Amatola Water (AW) is the Water Service Provider (WSP).

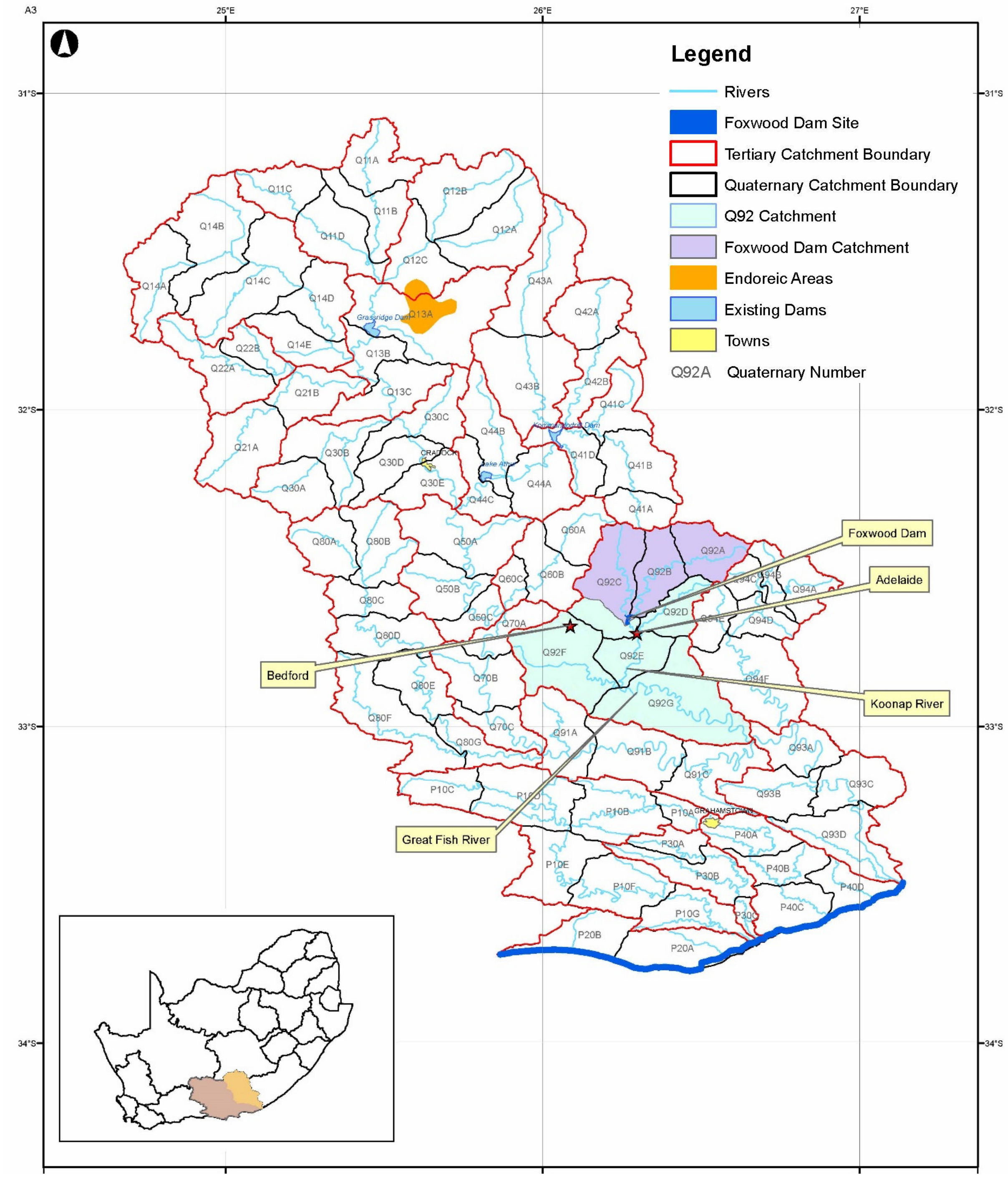


Figure 1: Fish River Catchment with Koonap River Sub-catchment

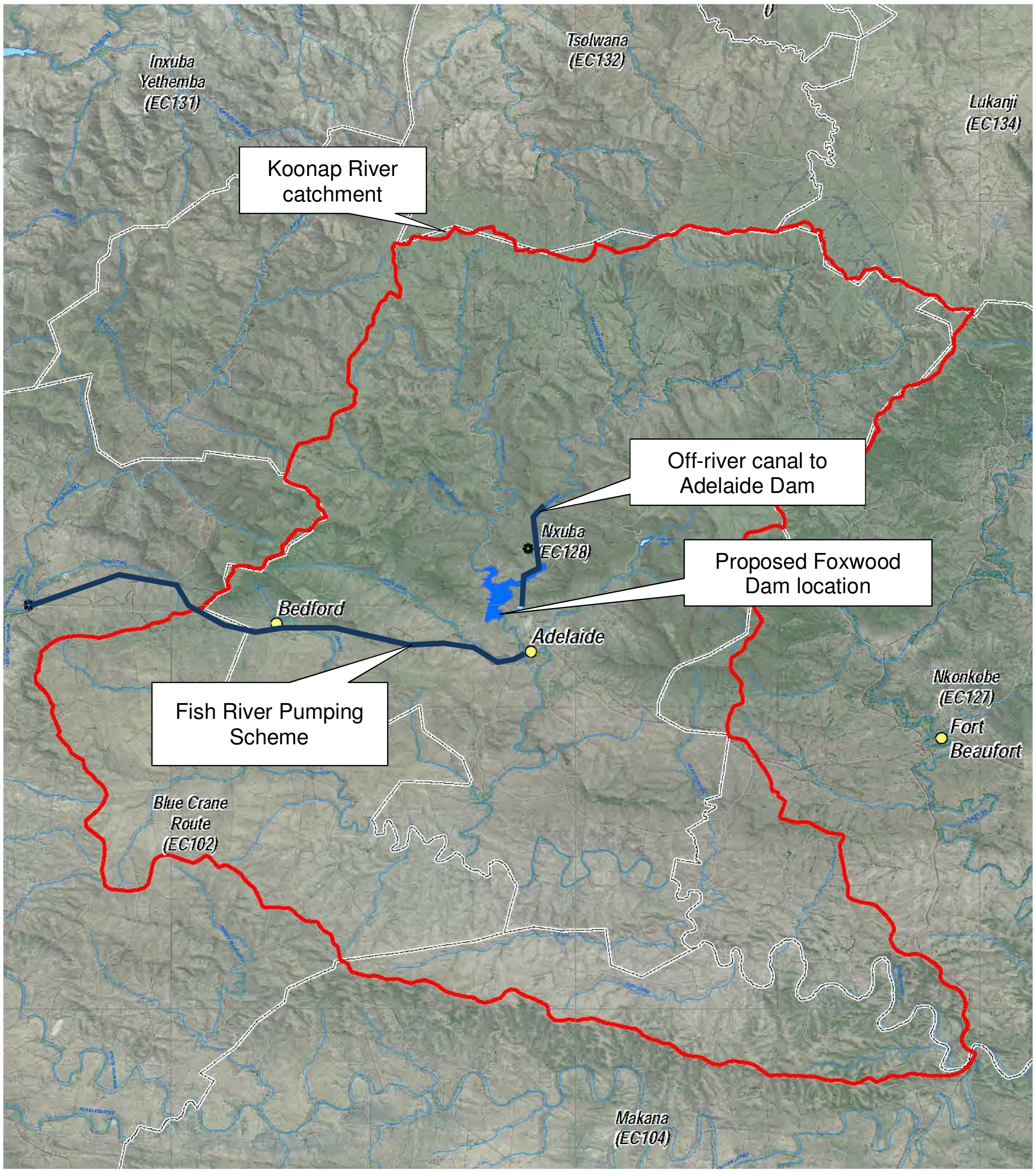


Figure 2: Adelaide location within Koonap River catchment, showing water supply infrastructure

1.1 Objectives of the Water Quality report

The purpose of this report is to review the quality of water within the Koonap River and assess any likely required treatment for use of the water for potable or irrigation purposes. The report also reviews the condition of the existing water treatment works and makes recommendations regarding the dam design to optimize impact on water quality resulting from construction and operation of the dam.

1.2 Structure of the report

The Water Quality report is structured into the following main sections

- **Existing water quality** – an assessment of the existing water quality of the Koonap River based on historic DWS records as well as additional ‘grab’ samples taken as part of this study.
- **Water treatment** – a summary of typical water treatment required to achieve potable water quality from the Koonap River water.
- **Adelaide water treatment works** – an assessment of the current condition of the existing water treatment works and recommendations for improvements.
- **Dam design considerations** – recommendations regarding the dam design to minimize impact on the quality of water supplied from the dam.

2 EXISTING WATER QUALITY

2.1 Review of historic DWS records

Historical water quality data for the period 29 August 1971 to 19 June 2012 were obtained from the DWS water quality database. Three sample locations have been referenced. Their location is shown in Figure 3 below and their details are provided in Table 1 below:

Table 1: Water quality monitoring points on the Koonap River

Monitoring Point Name	Latitude	Longitude	Number of samples
Q9H014Q01 Koonap River at Frisch Gewaagd/Groenkop	-32.4647	26.51083	191
Q9H016Q01 Koonap River at Schurftekop	-32.4992	26.36556	343
Q9H002Q01 Koonap River at Adelaide	-32.7139	26.29667	595

These data sets are readily available from the DWS web site and additional updates (going forward) are made available from time to time. The primary site for the Koonap River at Adelaide is located on the outskirts of the town and has a DWS Reference (or Station) Number of Q9H002Q01 (-32.7139 S, 26.29667 E). Given the length of the data record the information is suitable for determining trends and ranges but often does not provide the detail, or the parameters, that are useful for assessing the treatability of the raw water.

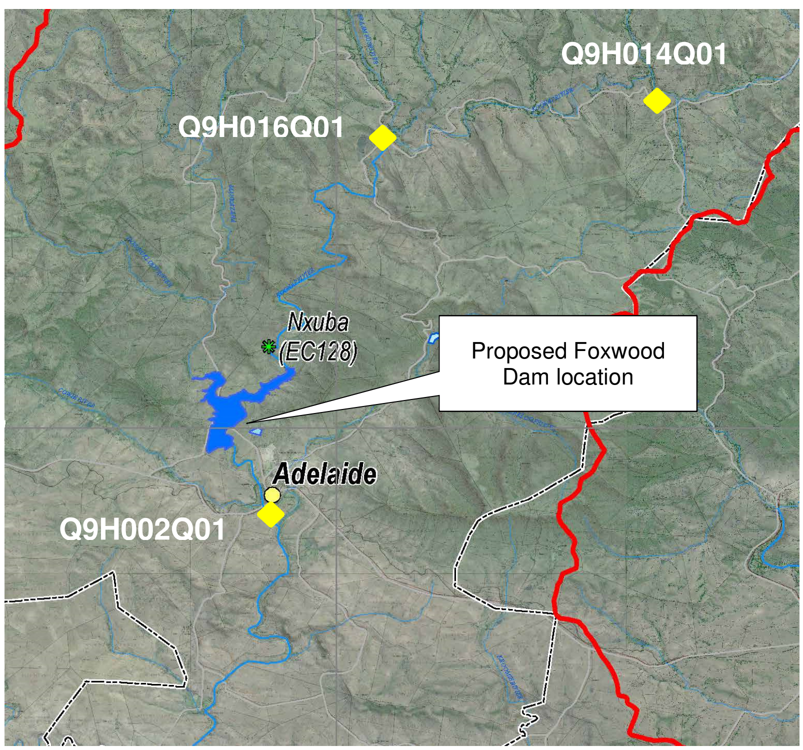


Figure 3: DWS water quality sample locations on the Koonap River

In an attempt to assess the suitability of the Koonap River water for drinking purposes the data set was ranked and the range (minimum and maximum) for each parameter determined. In addition the 25, 50 (median value), and 75 percentile were calculated and the summary data is presented in summary in Table 2 below. The full statistics for all three monitoring locations are provided in the Appendix A to this document along with graphs illustrating the trends for data from the three locations.

When considering the historical data no screening or validation took place and it was noted that the original data set had a number of very high, and very low, reported concentrations for some of the variables. These are considered to either be incorrect, or outliers, and have limited impact on the water quality available. For this reason the water Class has been assessed on the 25^{th} percentile and the 75^{th} percentile. It is expected that the high or low concentrations are the result of sampling at non-regular river flows and noted that where a large impoundment, such as a dam construction, is developed, such values have negligible impact on the overall water quality.

Table 2: Classification of the water quality variables in the Koonap River for the DWS database to June 2012

Koonap River at Adelaide		
Parameter	25th percentile	75th percentile
pH	Class 0	Class 0
Total Alkalinity	Not classified	Not classified
Conductivity	Class 0	Class 1
Turbidity	Treatment required	Treatment required
Total Hardness	Class 0	Class 1
Calcium	Class 0	Class 0
Magnesium	Class 0	Class 0
Sodium	Class 0	Class 0
Potassium	Class 0	Class 0
Chloride	Class 0	Class 0
Sulphate	Class 0	Class 0
Phosphate	Not classified	Not classified
Overall Class	Class 0	Class 1

In the context of the above table only the Conductivity and Hardness fall into a Class 1 classification (Class 1 corresponds to the required parameter limits for drinking water, and are 150 mS/m for electrical conductivity and 300 mg/l for total hardness). It is probable that both of these extreme values were recorded during a drought cycle (when salts would be more concentrated), and probably at low flows (or possible at a point where there was no flow in the river) is would be reasonable to conclude that when water flow is present then the raw water (after treatment) has the potential to be classified as a Class 0 drinking water for more than 75 % of the time. In any event Class 1 drinking water is considered a “good” water quality)

In the context of this investigation, the proposal is to establish a dam at the Foxwood site, and the dam would store water during wet cycles. It would therefore be expected that the water quality in the dam would generally be a Class 0 water. It is also possible that for a significantly greater period of time the incidence of higher conductivity and hardness in the raw water storage reservoir would be limited to extreme drought conditions, and then only when the dam was drawn down to very low levels.

2.2 Water quality for irrigation

With regard to irrigation, the main water quality issues are salinity and total hardness. Many crops cannot tolerate high salt levels and scaling resulting from water hardness impacts on irrigation infrastructure. An initial review of water generally indicates that water quality within the Koonap River is acceptable for irrigation. Calculated from the sodium, calcium and magnesium, Sodium Absorption Ration of the water is within acceptable limits.

Further detailed water quality testing should be carried out in conjunction with soil testing at the specific proposed locations for irrigation development due to the importance of the relationship between water and soil quality in conjunction for crop development. It is noted that the WARMS database has registered abstractions of 12 million m^3/a for irrigation with the Koonap River catchment with the majority of this being from run-of-river.

2.3 Additional sampling and review

To assist with the additional water quality requirement for the preliminary assessment a reconnaissance survey of the existing raw water supply from the Adelaide Dam and the proposed Foxwood Dam site took place and samples were collected on 30 January 2013. Additional testing of the Koonap River at the proposed Foxwood Dam site (refer Monitor Laboratories Report of 6 February 2013 in Appendix B) confirmed the suitability of the river water for treatment to achieve a Class 0 water after appropriate treatment. The buffering (or integrating) effect of a dam would reduce the variability of the raw water quality to the treatment works.

One shortcoming of the water quality data is the limited data on the turbidity and suspended solids for Koonap River. As both parameters can impact on the siltation, storage reduction and treatment requirements it is recommended that, in the event that the project proceeds beyond feasibility study, consideration be given to weekly sampling of the Koonap River to determine the seasonal silt loads and to confirm water quality upstream of Adelaide.

A concern is that the suspended sediments might negatively impact on the treatability of the raw water. On the other hand the less clear water may reduce light penetration and, as a consequence, algal build-up may be reduced. It is for this reason that we would recommend that weekly samples for sediment and turbidity be collected in the vicinity of the proposed dam for a period of at least 24 months. If such an investigation were to proceed it would be prudent to include additional testing as required.

3 WATER QUALITY CONSIDERATIONS FOR FOXWOOD DAM

To consider the possible impact on water quality, a 1 MAR dam size has been considered with a height of 38 m. It would be expected that, in dams of greater than 20 metres depth, in the summer months sections of the dam would develop a thermocline. The consequence of this is that there will be a segregation of the upper 20 to 25 metres of the dam with warmer water, while the base layers will be significantly colder. At the end of summer the water column will destabilize and chemical changes could be expected following overturn. At this stage it is not possible to predict if oxygen levels will drop in the hypolimnion (bottom layer), but if they do nutrients will be redistributed into the water column. For this reason it is recommended that the off-take structure be provided with draw-offs at regular intervals to 25 m below top water level. The top highest outlet should be 5 – 8m below full supply level with two further outlets at regular intervals down to a level of approximately 25 m below full supply level.

Any abstractions points deeper than 25 m below crest should only be available for use in winter months and during periods of drought (when these off-takes are less than 20 m below water surface). A bottom outlet will be provided for scouring. There is a concern that organic matter could promote anaerobic conditions in the deep sections of the dam. For that reason, it would be preferred if the vegetation within the dam basin was removed prior to filling.

The existing Adelaide dam is useful in that it provides a means of reducing the silt loads to the treatment works. It would be desirable to have the flexibility within the raw water supply system to be able to use the Adelaide dam as an off-channel storage facility. The Eastern Cape DWS office have indicated that their preference is to maintain the existing gravity canal water supply system and Adelaide dam.

4 WATER TREATMENT

The historical water quality data and the confirmatory grab samples and testing conducted during the assessment give no indication that the water from the Koonap River is difficult to treat. The current water treatment works appears to be able to produce a potable water from both the Fish and Koonap River supplies with limited equipment and expertise at the water treatment works. No reliable final water quality assessments for the water treatment works were available and grab sampling of the town supply was the only basis for assessing the actual water quality achieved. It is expected that the building of an in-stream dam will result in a more stable raw water quality with smaller seasonal variation.

Based on experience within the general area, and observations at the existing water treatment works, a standard configuration water treatment works would be able to provide a Class 0 quality water for 95 % of the time provided that the works was adequately designed, operated and maintained.

The primary components of such a works would be:

- Adequate and consistent water supply and quality
- Flocculant dosing and coagulation
- Sedimentation of flocs
- Removal of sediment
- Filtration of the settled water
- Disinfection and sterilization of the final water
- Safe storage and distribution

In addition such a works will require qualified personnel to operate and maintain the works and to conduct the necessary process control and confirmatory testing.

5 ADELAIDE WATER TREATMENT WORKS (WTW)

The existing water treatment works was originally established in about 1957 and has been modified in at least 3 contracts since then. During January 2013 the works was inspected and observations made on the operation and performance of the current works. The water quality assessment was limited to the raw and final water. A detailed assessment report is included in Appendix D and the key issues are discussed here.

5.1 Introduction

The design capacity of the works is the subject of some debate as the District Municipality suggests that the works has a capacity in excess of 7 000 m^3 per day while a KV3 assessment (post 2000) refers to a design capacity of 240 m^3 per hour (5 700 m^3 per day). Current raw water inflows to the WTW (Stephen Nash (ADM): 2013 records) suggest that the works is processing 850 000 m^3 per annum (equivalent to 2 330 m^3 per day or 97 m^3 per hour) of raw water. As determined in the Water Requirements report (DWS 2015b).

5.2 Configuration of the existing works

The existing works set up conforms to the general requirement to treat the raw water received at the works and the general layout of the works is described in the annotated image of the site. (Figure 4) below. There is a concern that the 'fit' of the components is not suitable for reliable operation of the facility. These concerns are listed below:

- Inlet structure - There is no facility to monitor the incoming water and adequately control the flow rate.

- Chemical dosing – There is no flexibility to change or combine different dosing regimes to cope with changes in water quality. There is no permanent storage for chemicals or equipment on the site and this can adversely affect the plants ability to produce consistent quality potable water.

- Flocculation and coagulation – The length and configuration of the flocculation channel is such that the floc build is destroyed, or lost, in the channel due to too long a retention time and unmatched channel profiles.

- Sedimentation – The initial separation of the feed-water results in the destruction of any remaining flocs while the launder appears to short-circuit and 'dump' solids at the launder site. This might be a function of poor operational procedures on the site but in any event the desludging system is unable to shift the settled sludge adequately. The overflow launders entrain solids and need to have a reduced velocity to improve water quality (solids) to the filtration system.

- Sand filtration – An evaluation of the filter sand (Appendix C) shows that the Uniformity Coefficient exceeds 2 and the grading needs to be improved. At the same time the operation of the filters results in media being displaced into the inflow channels suggesting that the filters are not operated within the design range.

- Chlorination – at the time of the evaluation (2013) there was not a reliable means of dosing chlorine at the works. The installation of a gas dosing system could have improved the reliability but there are concerns about the adequate contact periods and buffering of the final water. The security (integrity) of the storage system may also compromise quality of the water prior to distribution.

- Sludge handling – No reasonable facilities exist on site for the removal of sludge from the sedimentation tanks or the settlement and dewatering of this waste stream. The units put forward as the facilities are impractical to use and dangerous.

- Filter backwash – It is evident that the filter backwash water is stored in an open reservoir and water is either recycled to the inlet works or used for backwash. Neither of these uses are desirable at the works because the algal growth in the reservoir can negatively impact on the treatment of the water or the state of the filter media. This can affect the quality of potable water produced.

- Site facilities – The site does not have the necessary facilities to store equipment or chemicals for continued operation of the plant. There is a lack of office and laboratory space and equipment to provide for the basic requirements of the site.

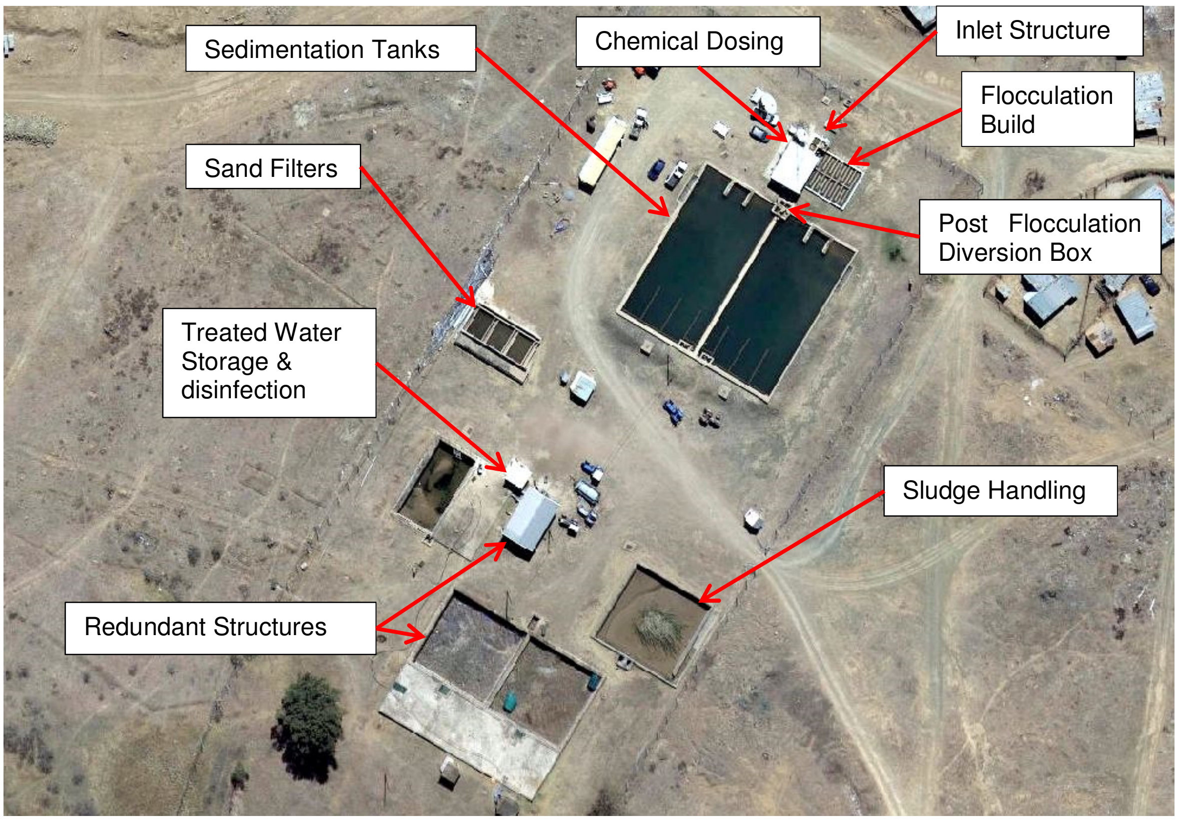


Figure 4: Adelaide Water Treatment Works Layout (October 2013 Aerial Imagery)

Based on the forgoing it is considered surprising that the plant is able to produce water that chemically complies with the requirements for drinking water for domestic purposes. There appears to be little commitment from the operators to carry out the basic monitoring or daily maintenance at the works, and questioning of the routine followed on site did not yield satisfactory answers. It is probable that a well trained and experienced operator would be able to 'tweak' the works and maintain operation (and water quality) for the majority of the time. The configuration and current state of the works would not make this an easy task.

On the basis of location and accessibility of the works to competent support, there are real risks to failure at the site, and at the very least the works will need a major overhaul and alteration to consistently be able to produce a compliant potable water quality from the site.

5.3 Proposed upgrades

Considering the list of identified concerns recorded in Section 5.2 above it is difficult know how the works could be modified or rehabilitated to reliably produce a fully compliant water quality in terms of SANS 0241- 2011 on a consistent basis. In terms of water production, a revised inlet structure, chemical dosage and storage facilities and improved sedimentation and sludge disposal infrastructure are required. In terms of storage of water the reservoirs need to be secured and the disinfection system operated and maintained on a continuous basis. To be more specific about the actions required would require detailed assessments of each of the works components and an evaluation of the ability of the works operators to manage the system over an extended period, and this falls outside of the scope of this preliminary assessment.

The current works configuration is the product of numerous revisions and retro-fitting and further alterations are unlikely to be the most effective means of improving the works ability to produce potable water. It is therefore probable that, given the relative size of the works required, consideration should be given to designing and installing a compact, appropriately designed water treatment works to meet the water demand from the Adelaide community.

6 CONCLUSION

As part of the feasibility study into the proposed Foxwood Dam, an assessment of the water quality in the Koonap River has been carried out. The assessment has reviewed the quality of water in the Koonap River in the context of proposed use for potable water and irrigation water. A review of the existing water treatment works has been carried out at Adelaide to review any possible need for upgrading / modification for treating water supplied from the dam. Key findings are:

- The historical record for the Koonap River water quality confirms that the water is suitable for treatment and is able to provide Class 0 drinking water for more than 75 % of the time. The construction of the proposed Foxwood Dam will alter the water quality to the works in that there will be less seasonal variation (and possibly an increase in the availability of Class 0 Water to more than 95 % of the time). However the size of the impoundment might result in summer stratification of the water column and there are possible risks in terms of anaerobic water and nutrient release during overturn events (generally in autumn).

- It is recommended that the off-take structure be provided with draw-offs at regular intervals to 25 m below top water level. The top highest outlet should be 5 – 8 m below full supply level with two further outlets at regular intervals down to a level of approximately 25 m below full supply level.

- One shortcoming of the water quality data is the limited data on the turbidity and suspended solids for Koonap River. As both parameters can impact on the siltation, storage reduction and treatment requirements it is recommended that, in the event that the project proceeds beyond feasibility study, consideration be given to weekly sampling of the Koonap River to determine the seasonal silt loads and to confirm water quality upstream of Adelaide.

- While it is possible to operate the current treatment works to produce potable water that complies with the drinking water requirements (DWS requirements), it will be necessary to have operators that are well trained and committed to their work. If it is intended that this facility become a regional supply point it would be wise to consider upgrading or replacing the existing water treatment plant with a modern, correctly constructed and equipped facility. If replacement of the plant cannot be considered then it is recommended that significant upgrading of the treatment units take place in a systematic manner.

- There is a concern that organic matter could promote anaerobic conditions in the deep sections of the dam. For that reason, it would be preferred if the vegetation within the dam basin was removed prior to filling.

7 BIBLIOGRAPHY

DWA, 2015 Department of Water Affairs, 2015. Feasibility Study for Foxwood Dam: Alternative Water Supply Options, P WMA 15/Q92/00/2113/5

DWS, 2015b Department of Water and Sanitation, 2015. Feasibility Study for Foxwood Dam: Water Requirements, P WMA 15/Q92/00/2113/8

APPENDIX A:EVALUATION OF THE WATER QUALITY RECORDS FROM THE DEPARTMENT OF WATER AND SANITATION DATABASE

APPENDIX A: EVALUATION OF THE WATER QUALITY RECORDS FROM THE DEPARTMENT OF WATER AND SANITATION DATABASE.

Physical Water Quality – Koonap River at Adelaide

Historical record from Department of Water and Sanitation for station Q9H002Q01 for the period 29 August 1971 to 19 June 2012.

Note 1 - The water quality guideline information for potable use refers to the Assessment guidelines published by Water Research Commission (TT101/98) where:
Blue (B) represents ideal water quality (Class 0),
Green (G) represents good water quality (Class 1),
Yellow (Y) represents marginal water quality (Class 2),
Red (R) represents poor water quality (Class 3),
Purple (P) represents unacceptable water quality (Class 4).

Note 2 - A level placed in brackets reflects the reasonable upper level. The stated level may be an outlier.

Variable : pH			Unit = pH	N=491
Minimum	25 % tile	Median	75% tile	Maximum
4.53	7.74	8.05	8.32	9.69

Water quality guidelines for potable use: no effects YBBBY

Variable : Total Alkalinity			Unit = mg/l	N=474
Minimum	25 % tile	Median	75% tile	Maximum
5.8	109	180	267	431

Water quality guidelines for potable use: not specified

Variable : Electrical Conductivity			Unit = mS/m	N=535
Minimum	25 % tile	Median	75% tile	Maximum
8.6	34.1	56	87	156

Water quality guidelines for potable use: no effects BBBGY

Variable : Turbidity			Unit = NTU	N=39
Minimum	25 % tile	Median	75% tile	Maximum
0.5	6	14	64	530 (150)

Water quality guidelines for potable use: Treatment required before use

Cations

Variable : Calcium			Unit = mg/l	N=475
Minimum	25 % tile	Median	75% tile	Maximum
5.9	22.2	33.6	46.5	67.7

Water quality guidelines for potable use: no effects BBBBB

Variable : Magnesium			Unit = mg/l	N=476
Minimum	25 % tile	Median	75% tile	Maximum
2.2	10.4	17.7	28.4	48

Water quality guidelines for potable use: no effects BBBBG

Variable : Sodium			Unit = mg/l	N=475
Minimum	25 % tile	Median	75% tile	Maximum
6.2	26.9	48.1	84.4	192.5

Water quality guidelines for potable use: no effects BBBBG

Variable : Potassium			Unit = mg/l	N=472
Minimum	25 % tile	Median	75% tile	Maximum
0.7	1.7	2.2	2.7	12.3

Water quality guidelines for potable use: no effects BBBBB

Variable : Total Hardness			Unit = mg/l	N=476
Minimum	25 % tile	Median	75% tile	Maximum
23	100	158	236	350

Water quality guidelines for potable use: no effects BBBGY

Anions

Variable : Chloride			Unit = mg/l	N=478
Minimum	25 % tile	Median	75% tile	Maximum
5.5	25.6	46.8	93.8	223

Water quality guidelines for potable use: no effects BBBBY

Variable : Sulphate			Unit = mg/l	N=476
Minimum	25 % tile	Median	75% tile	Maximum
0.5	9.7	14.3	22.7	107.9

Water quality guidelines for potable use: no effects BBBBB

Variable : Phosphate			Unit = mg/l	N=485
Minimum	25 % tile	Median	75% tile	Maximum
0.003	0.017	0.027	0.045	1.473

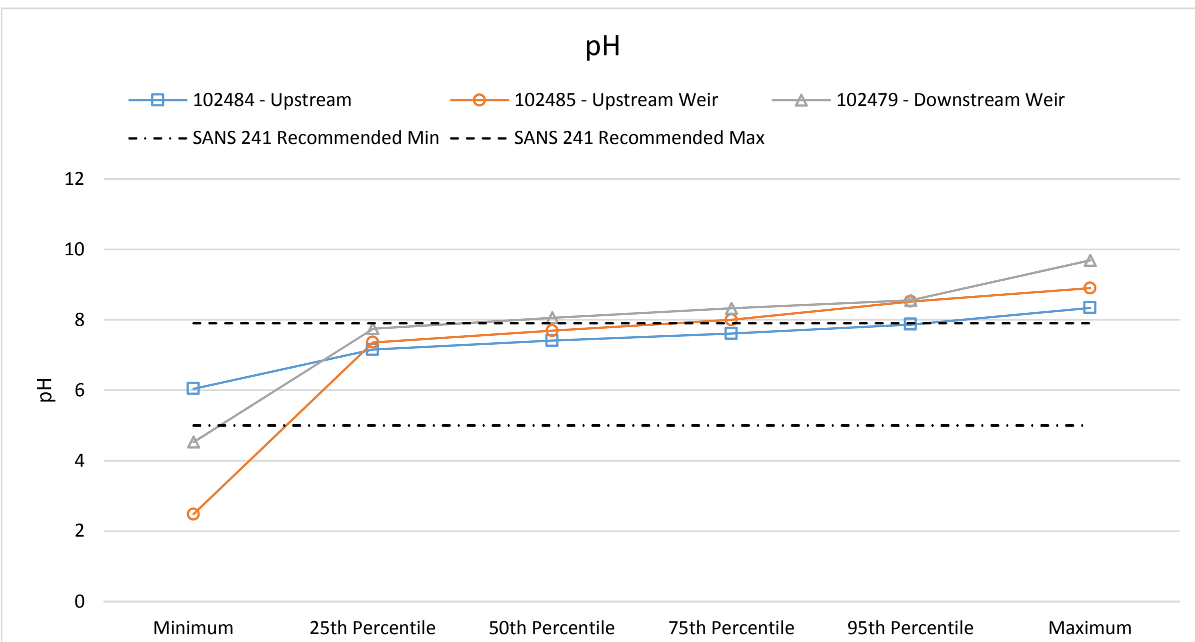
Water quality guidelines for potable use: not specified

References

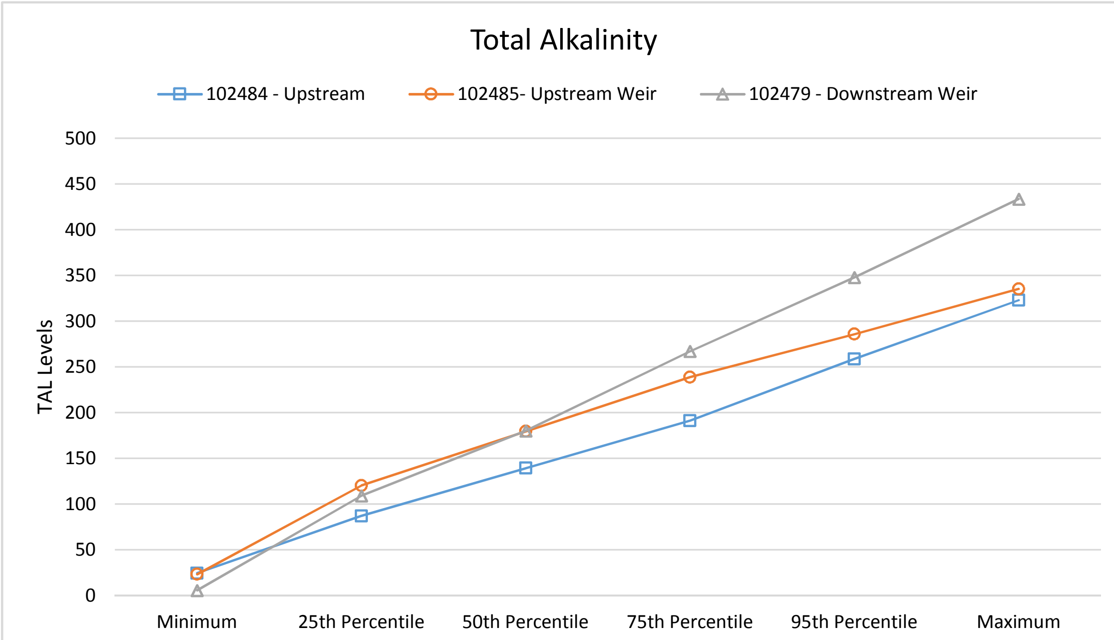
1 SANS 241:2011
2 General and Special Standards: Requirements for the purification of waste water or effluent by the Government Gazette (1984)
3 Process design manual for small wastewater works by DJ Nozaic & SD Freese (2009)

Koonap River Water Quality Sampling Points				
Identification	Name	Latitude	Longitude	Number of samples
102484 - Upstream	Q9H014Q01	-32.4647	26.51083	191
102485 - Upstream Weir	Q9H016Q01	-32.4992	26.36556	343
102479 - Downstream Weir	Q9H002Q01	-32.7139	26.29667	595

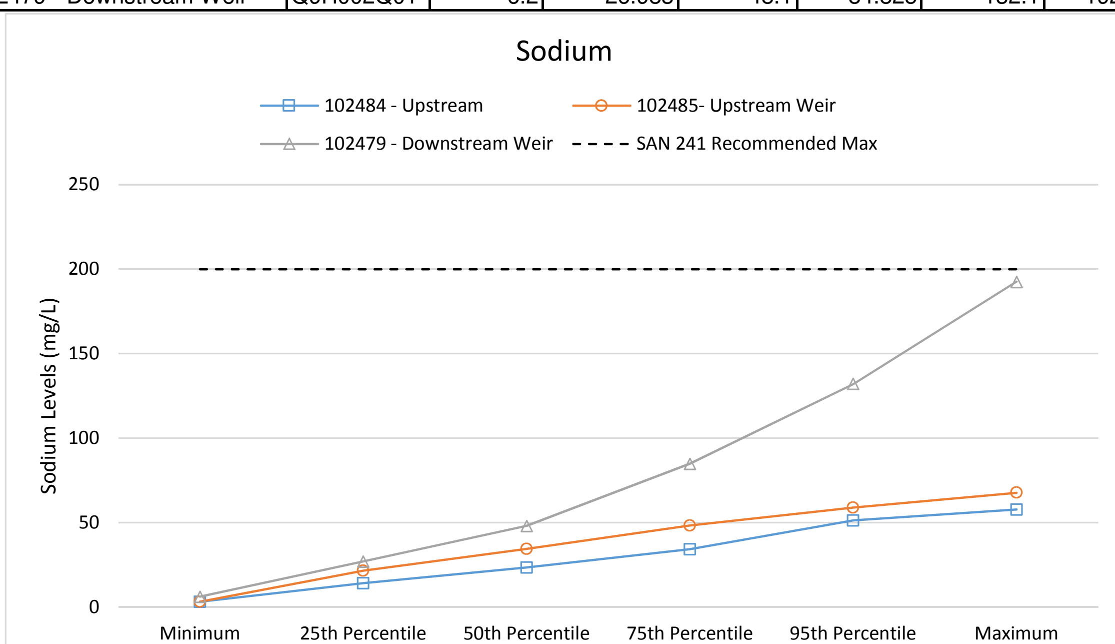
pH							
		Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
102484 - Upstream	Q9H014Q01	6.04	7.155	7.41	7.61	7.867	8.34
102485 - Upstream Weir	Q9H016Q01	2.48	7.36	7.69	8	8.519	8.9
102479 - Downstream Weir	Q9H002Q01	4.53	7.749	8.058	8.323	8.55	9.69



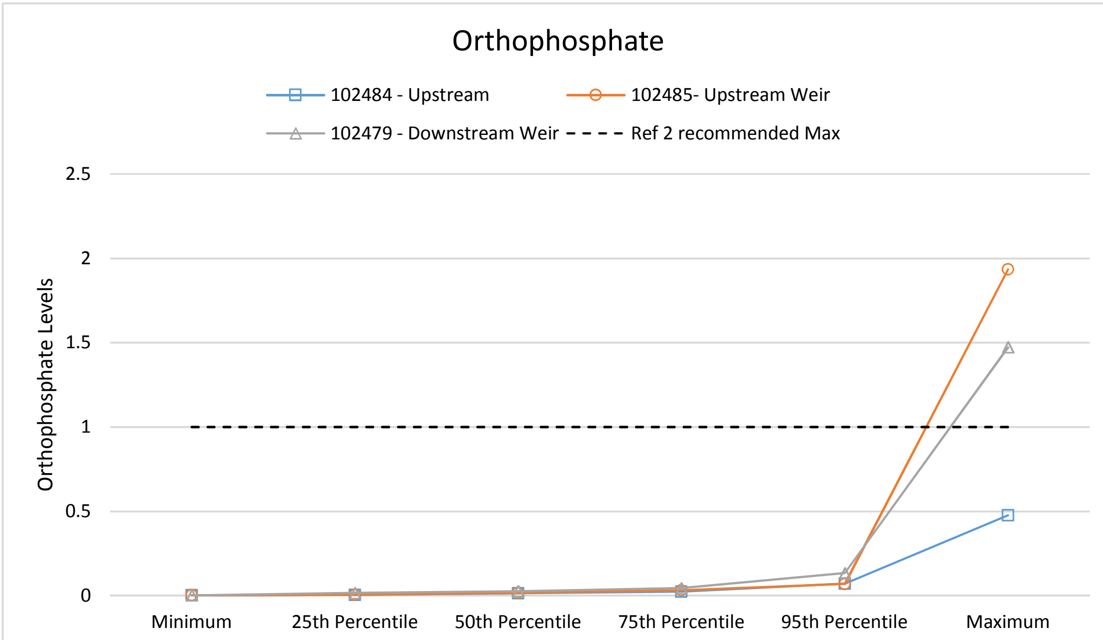
Total Alkalinity							
		Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
102484 - Upstream	Q9H014Q01	24.6	87	139.4	191.2	258.85	323
102485- Upstream Weir	Q9H016Q01	23.3	120.25	179.6	238.8	285.87	335.3
102479 - Downstream Weir	Q9H002Q01	5.8	109.05	180.2	267.041	347.825	433.6



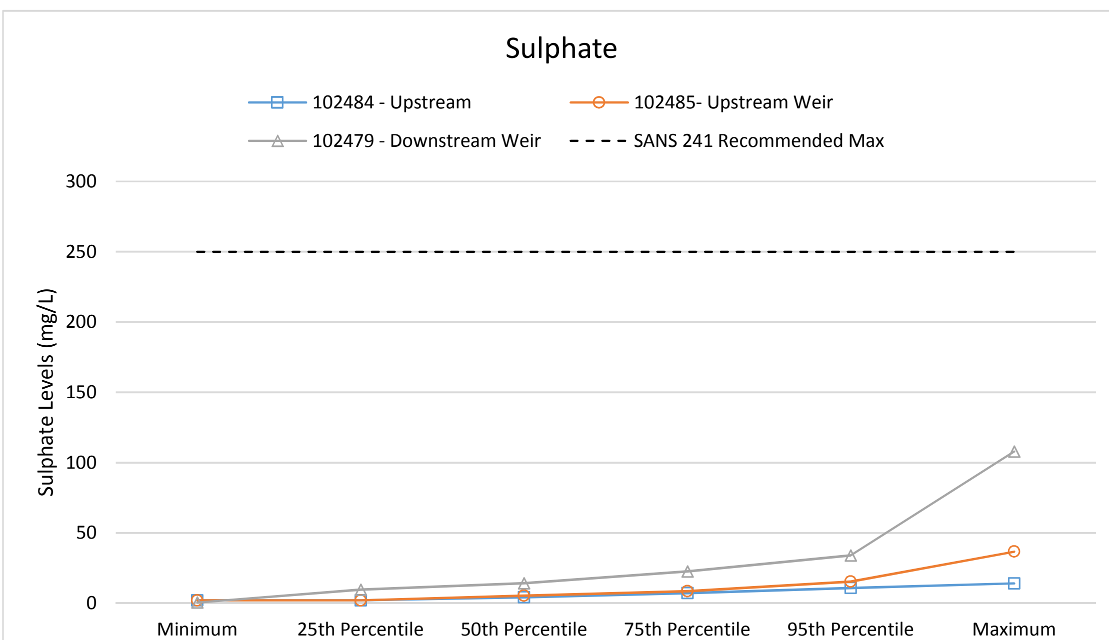
Sodium							
		Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
102484 - Upstream	Q9H014Q01	3.2	14.1	23.5	34.25	51.28	57.8
102485- Upstream Weir	Q9H016Q01	3.2	21.6	34.4	48.25	58.935	67.7
102479 - Downstream Weir	Q9H002Q01	6.2	26.983	48.1	84.825	132.1	192.526



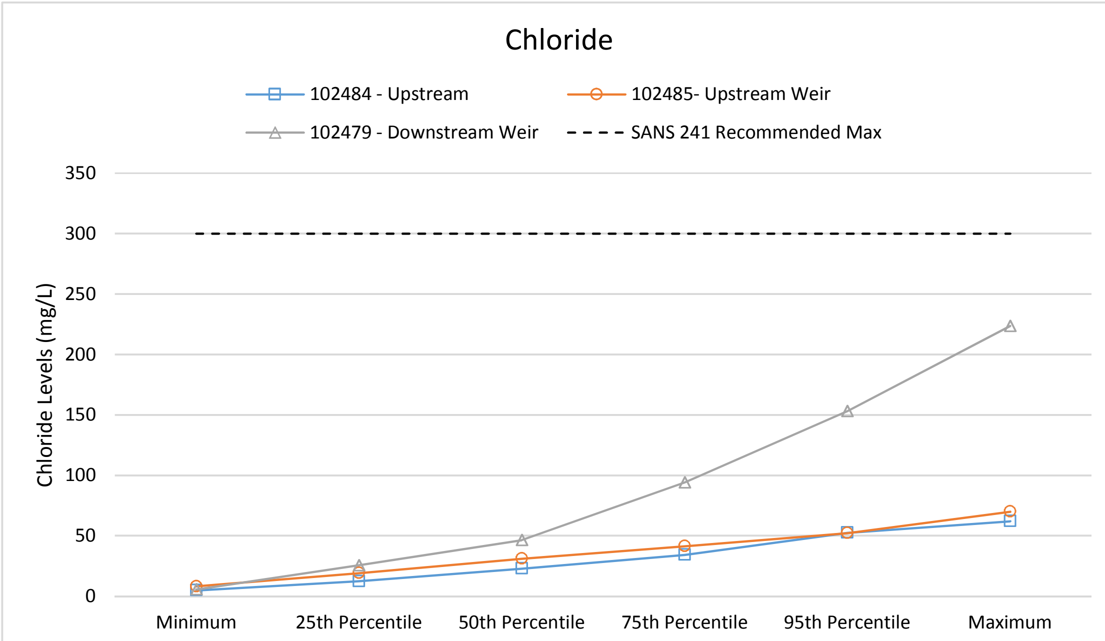
PO4-P							
		Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
102484 - Upstream	Q9H014Q01	0.003	0.006	0.014	0.025	0.071	0.477
102485- Upstream Weir	Q9H016Q01	0.003	0.006	0.016	0.031	0.069	1.935
102479 - Downstream Weir	Q9H002Q01	0.003	0.017	0.027	0.045	0.134	1.473



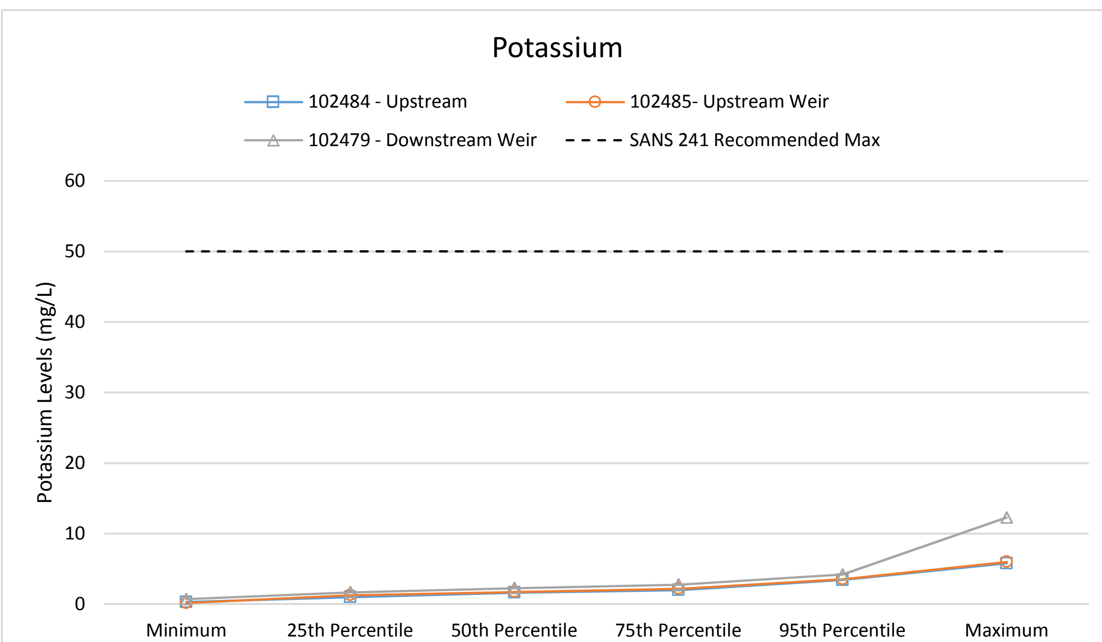
SO_4 (Sulphate)							
		Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
102484 - Upstream	Q9H014Q01	2	2	4.2	7.3	10.82	14.1
102485- Upstream Weir	Q9H016Q01	2	2	5.35	8.55	15.435	36.7
102479 - Downstream Weir	Q9H002Q01	0.5	9.785	14.3	22.7	34.03	107.865



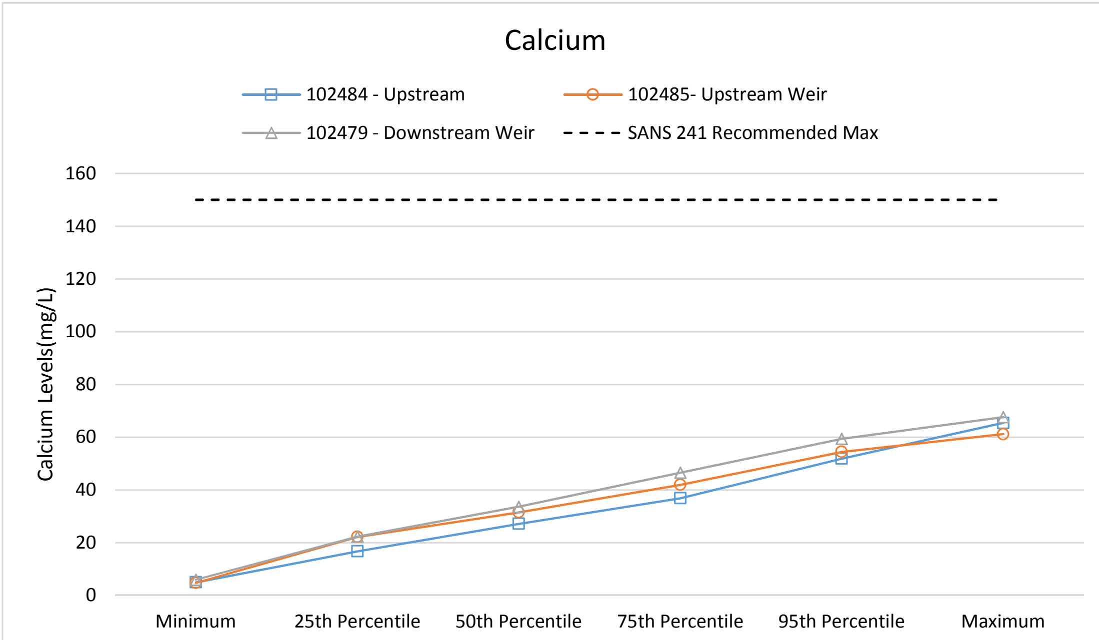
Chloride							
		Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
102484 - Upstream	Q9H014Q01	4.7	12.35	22.8	34.3	52.6	62
102485- Upstream Weir	Q9H016Q01	8.1	19.1	31.15	41.35	52.145	69.9
102479 - Downstream Weir	Q9H002Q01	5.5	25.6	46.5	94	153.1	223.663



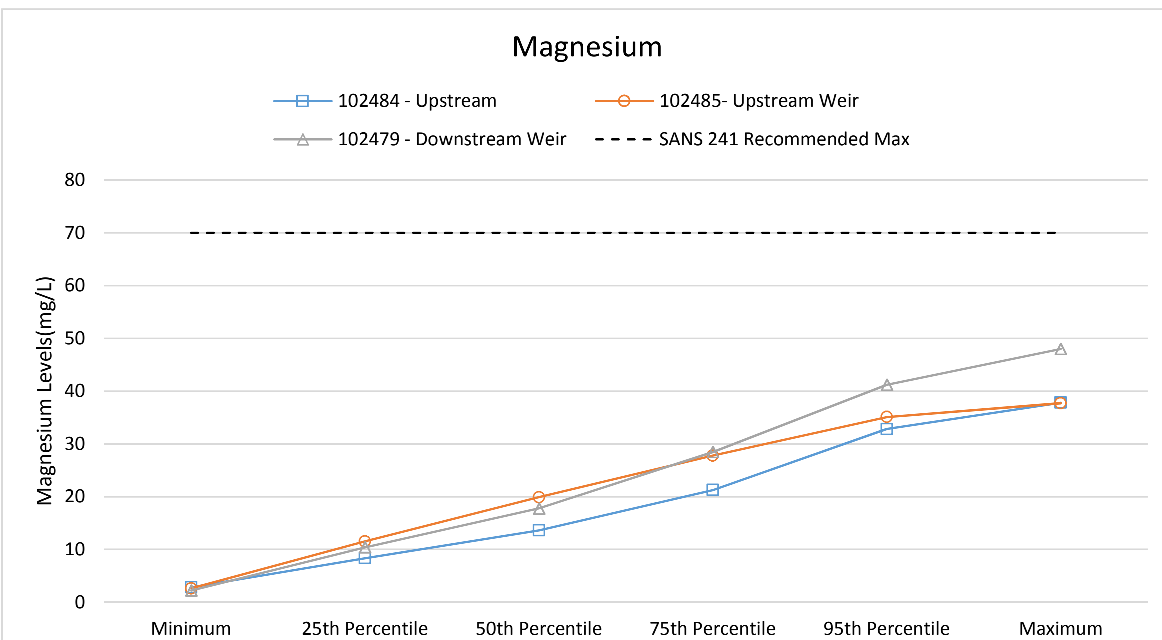
Potassium							
		Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
102484 - Upstream	Q9H014Q01	0.3	0.993	1.64	1.99	3.43	5.79
102485- Upstream Weir	Q9H016Q01	0.15	1.29	1.74	2.2	3.532	5.98
102479 - Downstream Weir	Q9H002Q01	0.71	1.7	2.26	2.764	4.205	12.28



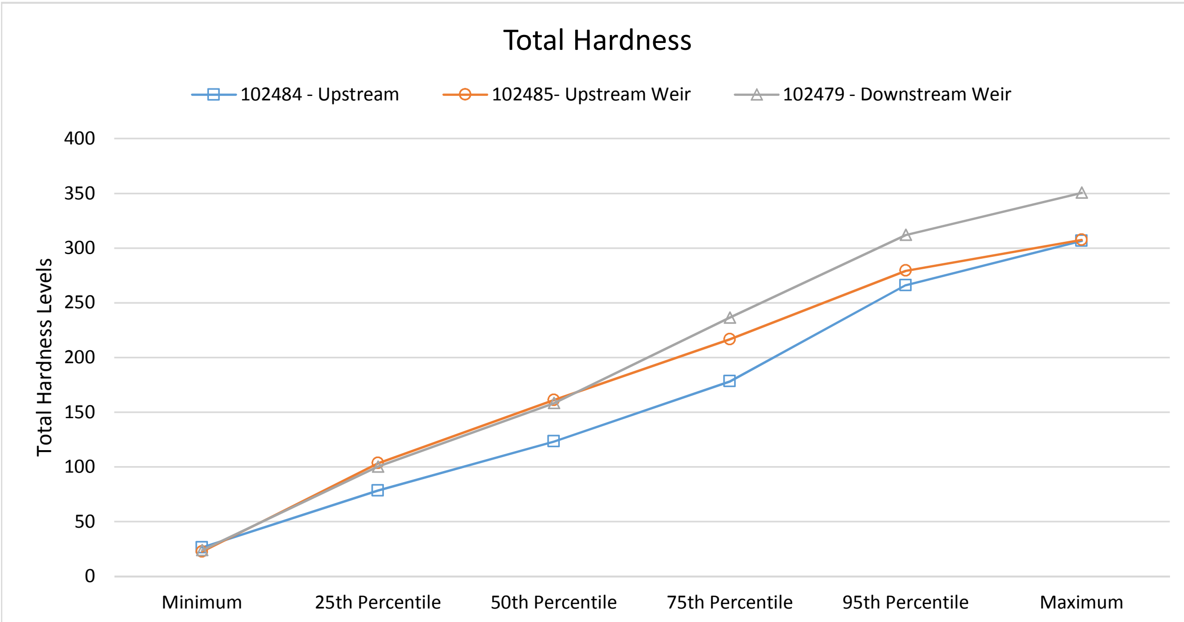
Calcium							
		Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
102484 - Upstream	Q9H014Q01	4.9	16.7	27.1	36.8	51.82	65.4
102485- Upstream Weir	Q9H016Q01	4.7	22.125	31.45	41.9	54.37	61.1
102479 - Downstream Weir	Q9H002Q01	5.9	22.282	33.6	46.5	59.4	67.6



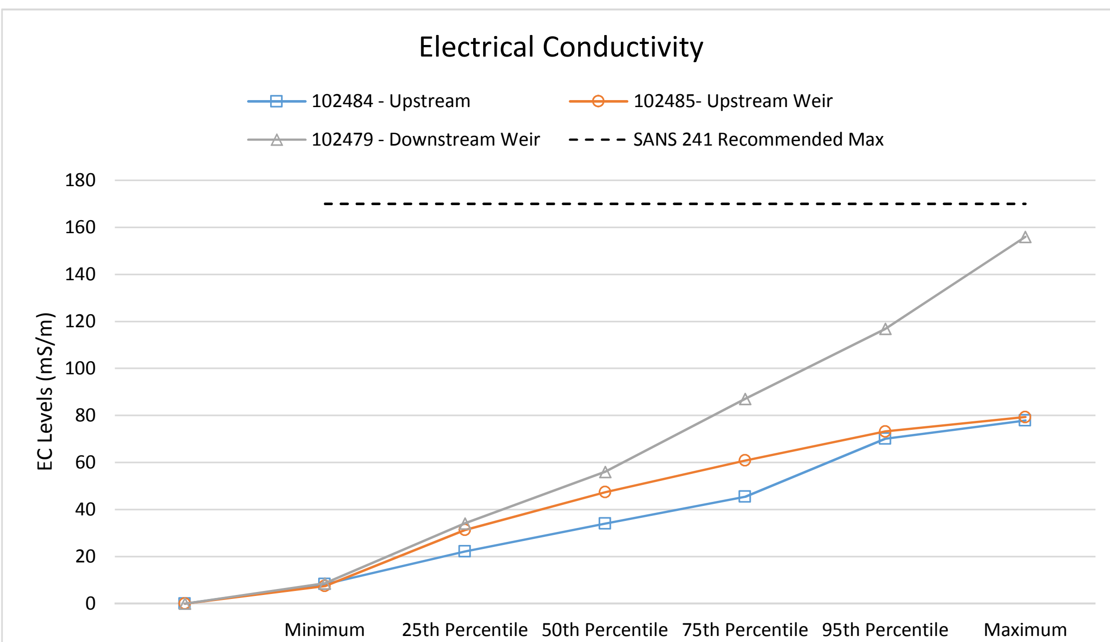
Magnesium							
		Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
102484 - Upstream	Q9H014Q01	2.8	8.35	13.6	21.25	32.8	37.8
102485- Upstream Weir	Q9H016Q01	2.6	11.525	19.9	27.775	35.1	37.7
102479 - Downstream Weir	Q9H002Q01	2.2	10.4	17.763	28.476	41.2	48



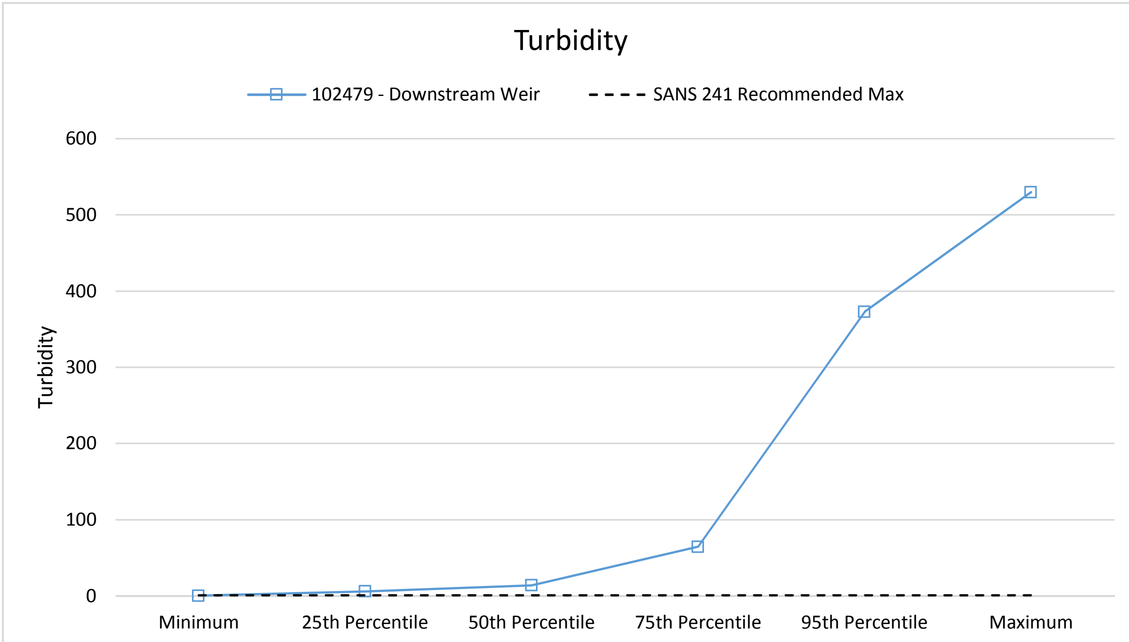
Total hardness							
		Minimum	25th Percent	50th Perce	75th Percen	95th Percen	Maximum
102484 - Upstream	Q9H014Q01	26.413	78.32	123.169	178.161	265.888	306.499
102485- Upstream Weir	Q9H016Q01	22.444	103.284	161.046	216.512	279.246	307.424
102479 - Downstream Weir	Q9H002Q01	23.794	100.264	158.233	236.403	311.859	350.494



Electrical conductivity							
		Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
102484 - Upstream	Q9H014Q01	8.3	22.15	34	45.5	70.1	77.9
102485- Upstream Weir	Q9H016Q01	7.5	31.3	47.4	60.85	73.18	79.3
102479 - Downstream Weir	Q9H002Q01	8.6	34.1	56	87.1	116.88	156



Turbidity							
		Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	Maximum
102479 - Downstream Weir	Q9H002Q01	0.5	6	14	64.5	373	530



APPENDIX B: WATER SAMPLING RESULTS

APPENDIX B: WATER SAMPLING RESULTS

MONITOR LABORATORIES

Water, Soils and Microbiology

28 Elton Street
SELBORNE
5201

P O Box 2184
BEACON BAY
5205

Tel : 043 722 6393
Fax : 086 650 5352

Date of Issue: 6 February 2013
Lab. No. 2012/2153 - 2157

CLIENT: MR W T SELKIRK	
Date delivered: 30/01/2013	Contact: Mr W T Selkirk
Sample 1	Foxwood 1. Fish River pump station 29/01/13
Sample 2	Foxwood 2a. Raw water for Adelaide WTW. 29/01/13
Sample 3	Foxwood 2b. Town water ex Eskom 29/01/13
Sample 4	Foxwood 3. Borehole supply to WTW. 29/01/13
Sample 5	Foxwood 4. Koonap River at dam site. 29/01/13

Parameter	No.1	No.2	No.3	No.4	No. 5	Class 1 - SANS 241: 2005	Units
pH	9.03	9.15	9.13	7.70	9.13	5.0 - 9.5	
Conductivity	53.9	55.5	81.1	128.4	43.8	<150	mS/m
Turbidity	220	169	0.7	1.0	8.2	<1	NTU
Total Suspended Solids	239	169	-	-	9	-	mg/l
Alkalinity	169	208	283	450	157	-	mg/l
Nitrate (as N)	0.70	0.84	0.85	0.71	<0.01	<10	mg/l
Chloride (as Cl)	20.0	24.5	52.7	123	22.7	<200	mg/l
Sulphate (as SO_4)	30	32	34	33	10	<400	mg/l
Fluoride (as F)	0.50	0.58	0.63	0.89	0.41	<1.0	mg/l
Sodium (as Na)	51.9	51.6	93.3	114	29.9	<200	mg/l
Calcium (as Ca)	28.6	41.0	43.2	107	32.2	<150	mg/l
Calcium (as $CaCO_3$)	71	102	108	267	80	-	mg/l
Magnesium (as Mg)	12.3	17.2	17.9	37.5	12.5	<70	mg/l
Magnesium (as $CaCO_3$)	51	71	74	154	51	-	mg/l
Total Hardness	122	173	182	422	132	300	mg/l
Potassium (as K)	1.96	2.23	3.85	4.16	1.96	<50	mg/l
Iron (as Fe) (Total)	2.65	2.19	0.05	0.03	0.16	<0.2	mg/l
Iron (as Fe) (Dissolved)	0.23	0.17	-	-	0.11	<0.2	mg/l

KURT VENTER
ANALYTICAL CHEMIST

WAYNE SELKIRK
TECHNICAL SIGNATORY

COMMENTS: mS/m: milli-Siemens per metre - Unit of electrical conductivity.
NTU: Nephelometric Turbidity Units.
mg/l: mg of analyte per litre of sample tested

Water Monitoring Laboratories CC Trading as Monitor Laboratories Member : W T Selkirk Registration No 2008/170738/23

APPENDIX C: SAND PARTICLE DISTRIBUTION

APPENDIX C: SAND PARTICLE DISTRIBUTION

MONITOR LABORATORIES

Water, Soils and Microbiology

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Tel : 043 722 6393
Fax : 086 650 5352

Date of issue: 12 March 2013
Lab. No 2012/2158

CLIENT: MR W T SELKIRK

Date delivered: 30/01/2013 | Contact Name: Mr W T Selkirk

Adelaide WTW Sand filter particle size fractions

Sieve (mm)	Mass retained (g)	% Retained	% Passing
2.36	0.0	0.0	100.0
1.40	157.9	21.7	78.3
1.00	338.8	46.6	53.4
0.60	208.8	28.5	3.20
0.25	19.5	2.68	0.52
0.15	1.8	0.25	0.27
0.106	0.5	0.07	0.20
0.075	0.4	0.06	0.15
Pan	1.1	0.15	

Sample mass (g) 727

Note: d_{10} = 0.65mm and d_{60} = 1.70mm. The uniformity coefficient of this sand is therefore 2.60 which falls outside the optimal range of 1 to 2.

KURT VENTER
ANALYTICAL CHEMIST

WAYNE SELKIRK
TECHNICAL SIGNATORY

COMMENTS:

APPENDIX D:ADELAIDE WATER TREATMENT WORKS DETAILED ASSESSMENT REPORT

POLLUTION CONTROL TECHNOLOGIES
Water Conservation, Wastewater and Environmental Management Specialists

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FAX: 0866899949

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5205

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FOXWOOD WATER SUPPLY PROJECT

EVALUATION OF THE ADELAIDE WATER TREATMENT WORKS

Introduction

Camdekon Engineers had undertaken a reconnaissance level inspection of the facility prior to a visit by W Selkirk on 29 January 2013. The project team had been provided with an excerpt of a report by KV3 Engineers (undated) where some facts about the treatment works were presented. In the original configuration, river water was fed from the Koornap River via a canal to the Adelaide Dam. This stored water was pumped to the treatment works above the hospital. The original Adelaide dam wall was raised in 1977 to increase storage and yeild.

Water stored in the Adelaide Dam would have had a relatively long retention time and the dam would have operated as a sediment trap. Presently there appear to be challenges to getting Koornap River water to the dam, and coupled with an extended drought, the town has a serious water shortage. It is also understood that there is a pipeline from the Fish River to Adelaide and Bedford (but only Adelaide takes this water). At the time of the inspection there was only Fish River water supply to the Works.

To provide a long term solution for water supply to the area it has been proposed that an in-stream storage dam (± 53 Million m^3) be built in the Koonap River at Foxwood.

Configuration of the existing works

A walk around the Water Treatment Works indicated that since initial establishment in about 1957, a number of upgrades and modifications have taken place. On 29 January 2013 there were contractors installing new equipment to the plant.

Inlet structure

Raw water is delivered via two bulk pipelines of nominally 315 and 200 mm diameters and the flow in each is metered. The larger pipeline (in operation) was reported to be from the local supplies while the 200 mm pipeline is thought to be the terminal point of the Fish River supply. This may not be the case as the District Municipality say that only Fish River water is being used at present. Both pipes have an open discharge to a spare receiving chamber (which acts as a stilling basin). There is an over flow to the adjacent chamber (also open to the air) which is fitted with a 200 mm 'V' notch weir.

The weir has an unrestricted discharge into a 3rd chamber. The third chamber is dosed with flocculent.

Chemical dosing

No provision is made for pH adjustment but this might not be required at the inflow as samples collected were highly alkaline (pH 9.1). Poly flocculent (Primco 735) was being dosed to the 3rd inlet chamber at a rate of 0.24 mℓ per second (7mℓ/20sec). Assuming an SG of 1.25 this equates to 0.3g Primco per second.

The Works is provided with a number of positive displacement dosing pumps but at the time of the inspection only one unit (operating at 10% of range) was working and dosing from a 210ℓ poly drum. There was also a water feed at the dosing point but this appeared to serve no purpose.

Flocculation build

After flocculent addition the raw water (plus flocculent) enters a double set of nominally 500 mm wide by 500 m deep channels with a direction change every 3.5 m. There are 15 segments each channel set. Based on observation on the day floc build was complete within 3 direction changes. Thereafter there was progressive separation of the floc with deposition at the corners (direction change) and on the base of the channel. After the torturous path the flocculated water discharges to a distribution box (to the settling basins).

Post-flocculation division box and launder

After flocculation the water enters an open division box with weirs to adjust the flow between units. In reality the weirs plates have been forced and are immoveable and the flow is accelerated through the openings with the resultant floc breakup. Each division box connects to a large diameter steel pipe (600mm) that runs the width of each sedimentation tank. The mechanics for operation could not be determined because the entire unit was covered with sludge. It was also apparent that the inflowing water is forced to the furthest point of the distribution arm, where it is probable that an escape route is provided by this accelerated flow. As a result all the benefits of floc build are lost.

Sedimentation tanks

There are two large (almost square) tanks of approximately 3 m depth. Based on the information to hand, these were originally flat bottomed tanks, but in about 2000, were retro-fitted to include sludge hoppers. Each tank has hoppers with a single discharge valve per hopper line. There also appears to be a facility to introduce air into the system (possibly for sludge dispersion). Detailed plans are not available for the hoppers, but observations on site indicate that sludge removal is not effective. Part, but no all of the problem, is that the water shortage has prompted management to direct that sludge wasting be limited to once a day only. There is however, no possibility of removing sludge over a 12m length with a single extraction point. Similarly the blocking of the launder further adds to the operational problems of the site.

The size of the sedimentation units is such that any windage results in stirring up of the suspended sediment fines in the water. Similarly the off-take launders consists of a number of 300mm steel pipes that extend into each tank. It is assumed that there are a series of 5-10 mm holes drilled in the underside of the pipe. The opening size, relative to the flow, is too small and this results in the entrainment of solids.

These launders discharge to the inlet channel of the sand filters. At this point, water from local boreholes is fed into the works at this point.

Sand filters

The Works has 3 rapid gravity sand filters with 0.8-1.4 mm silica sand in a deep bed. The filtration gallery and back wash configuration could not be determined on site. It is thought that water for back-washing is pumped from the potable water reservoir (2 units) with air injection available from 2 blower units. No information was available on the frequency of cleaning but it was evident that the backwash cycle displaces sand into the inflow launder. This means that the bed rise is too great and thus the back wash velocities (water and air) probably exceed the normal specifications for similar type filters.

Backwash water is wasted to an open tank and pumped back to the head of the Works. A concern is that this water is rich in algae and this could impact negatively on the operational state of the plant.

Treated water storage and disinfection

Two covered concrete reservoirs are used for treated water storage on the site. It is evident that HTH kibble has been used for disinfection (but the unit was not connected). On the day of the inspection a gas chlorinator and accessories was being fitted inside a building on the site.

The potable water storage units have been fabricated out of remnants of the original plant and there are latent defects on the units that could impact on the quality of water suppliedfrom the plant.

These issued include:

Unprotected ventilation openings.
Unrestricted access to the tanks.
Numerous temporary and old pipes into the tanks.

Sludge handling

As stated previously the sand filter backwash is returned to an open reservoir for recycling to the head of the works. There is a concrete open reservoir (overgrown with reeds) that is intended for sludge handling but in its current state it cannot be used. In any event, the amount of sludge, and the rate of discharge would not allow the existing unit to operate (it might be more suited for the filter back wash water). It is therefore considered prudent to consider a different approach to sludge handling and water recovery on the site.

Redundant structures

There are remnants of the old slow sand filters and various buildings that do not serve the works. It is recommended that these structured be demolished.

Site accommodation

There is a rudimentary office and no on-site laboratory. It appears as if there are containers that are made available for accommodation and storage. The general accommodation facilities on the site are inadequate for a works of this size

Staffing

There was a security guard at the gate but no visible sign of operators. During the inspection a ‘senior operator’ appeared and provided some information on the Works. When asked to attend to a blockage he summoned one of the people lounging around on the site. Neither person could provide meaningful information on the Works, and neither were dressed appropriately for the site. It would appear that the Works operates by default.

It was evident from the site visit that no routine duties are performed on the site by staff.

Conclusions

While it is possible to operate the current work to produce a potable water that complies with the drinking water requirements, it will be necessary to have operators that are well trained and committed to their work. If it is intended that this facility become a regional supply point it would be wise to consider upgrading or replacing the existing water treatment plant with a modern, correctly constructed and equipped facility.

W T Selkirk

Pollution Control Technologies
07 March 2013
(minor revisions 29 April 2014)