Luthuli Waste Water Treatment Works

Hydrological Analysis of sewer outfall watercourse crossings and effluent discharge from the WWTW

FINAL

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ABBREVIATIONS AND ACRONYMS

Ha	Hectare
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MAE	Mean Annual Evaporation
m^3/annum	Cubic metres per annum
THLM	Thembisile Hani Local Municipality
WWTW	Wastewater Treatment Works

1 INTRODUCTION

The Thembisile Hani Local Municipality (THLM) is planning a WWTW and associated main outfall sewers for the recipient area. This 6Mℓ/d treatment capacity will form Phase 1 of this project. This report serves as a specialist hydrology report requested by the DWS for the issue of environmental authorisation and a water use license for Phase 1.

A sewage outfall network is being designed to transport raw sewage to a new Waste Water Ttreatment Works (WWTW) planned for the town of KwaMhlanga in KwaNdebele north-east of Pretoria. See Figure 1.1.

IWR Water Resources were appointed by AFI Consult to carry out a hydrological analysis of the sewer watercourse crossings to assess the impact of these crossings on the flow in the watercourse as well as the impact of wastewater discharge into the water course. The preliminary design has indicated that the sewer will cross 4 watercourse and the WWTW will discharge 6 Mℓ/day into the Enkeldoornspruit.

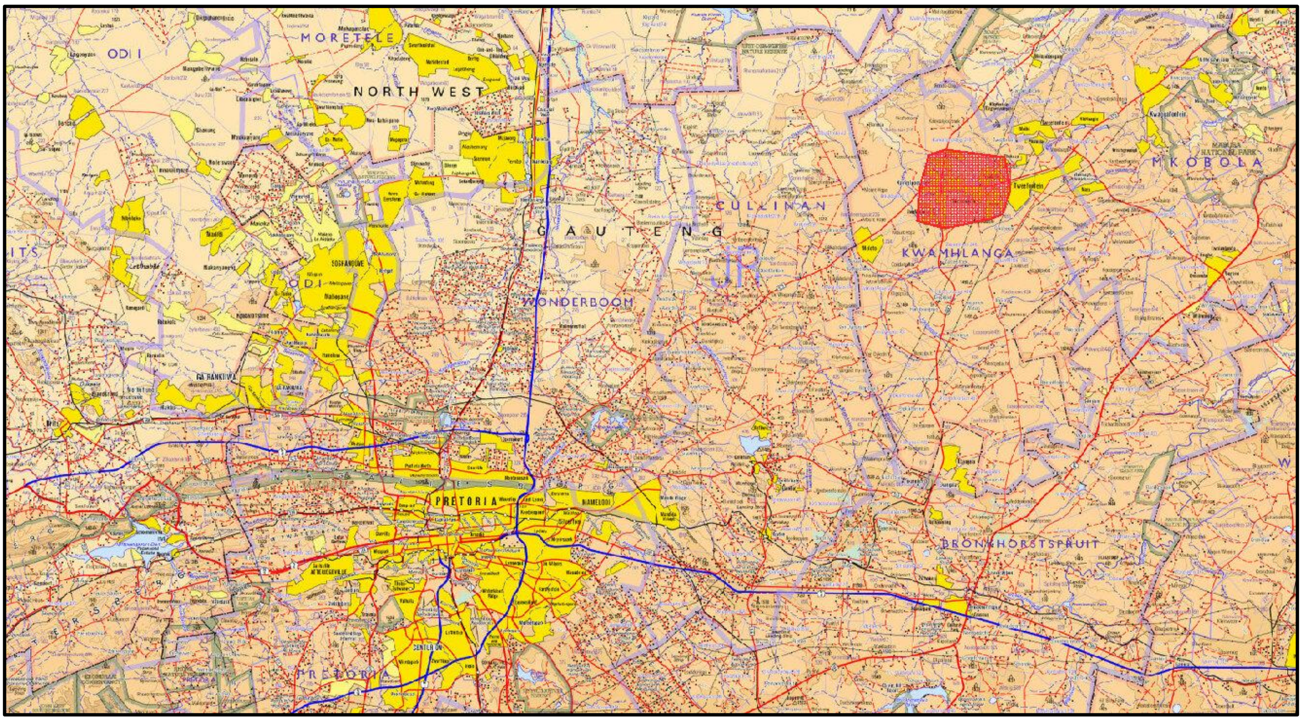

Figure 1.1: Location of KwaMhlanga

2 HYDROLOGICAL AND CATCHMENT INFORMATION

2.1 Location relative the quaternary catchments

KwaMhlanga falls mostly within the B31D quaternary catchment. See Figure 2.1 which shows that the catchment area of the sewer outfall comprises of a small part of the upper reaches of the B31D quaternary catchment. The WWTW will discharge into the Enkeldoornspruit which is a tributary of the Elands River.

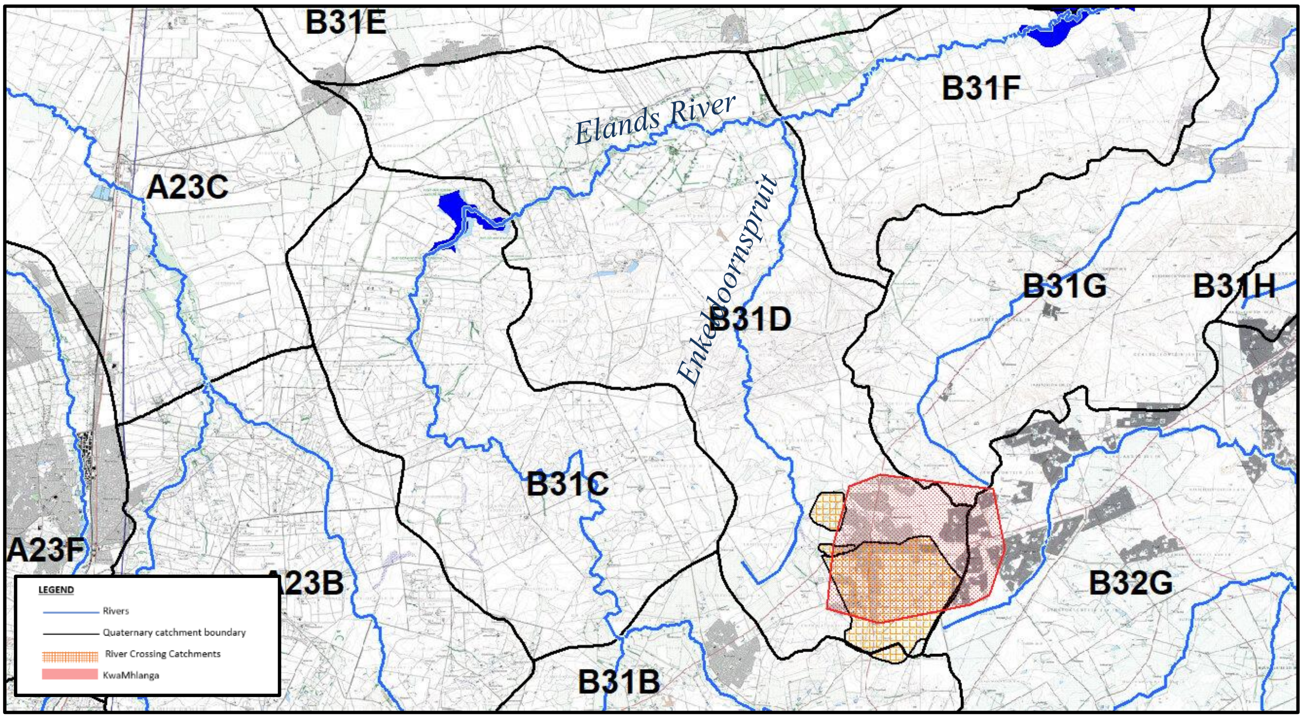

Figure 2.1: Location of sewer outfall within the B31D quaternary catchment

The hydrological information for the B31D catchment was obtained from the latest hydrological analysis of this catchment which was carried out by the Water Research Commission – referred to as the WR2012 study. (Bailey and Pitman, 2015). See Table 2.1.

Table 2.1: Summary of climate and hydrology information for the B31D quaternary catchment

Area (km^2)	Mean Annual Evaporation (mm)	Mean Annual Precipitation (mm)	Natural Mean Annual Runoff (million m^3/annum)
558	1 849	588	12.57

2.2 Watercourse Crossings

The catchments of the watercourse crossings were delineated. See Figure 2.2. The catchment area of watercourse crossing 2 is too small to delineate and hence this crossing is not significant.

The hydrological details of the catchments of the crossing are given in Table 2.2.

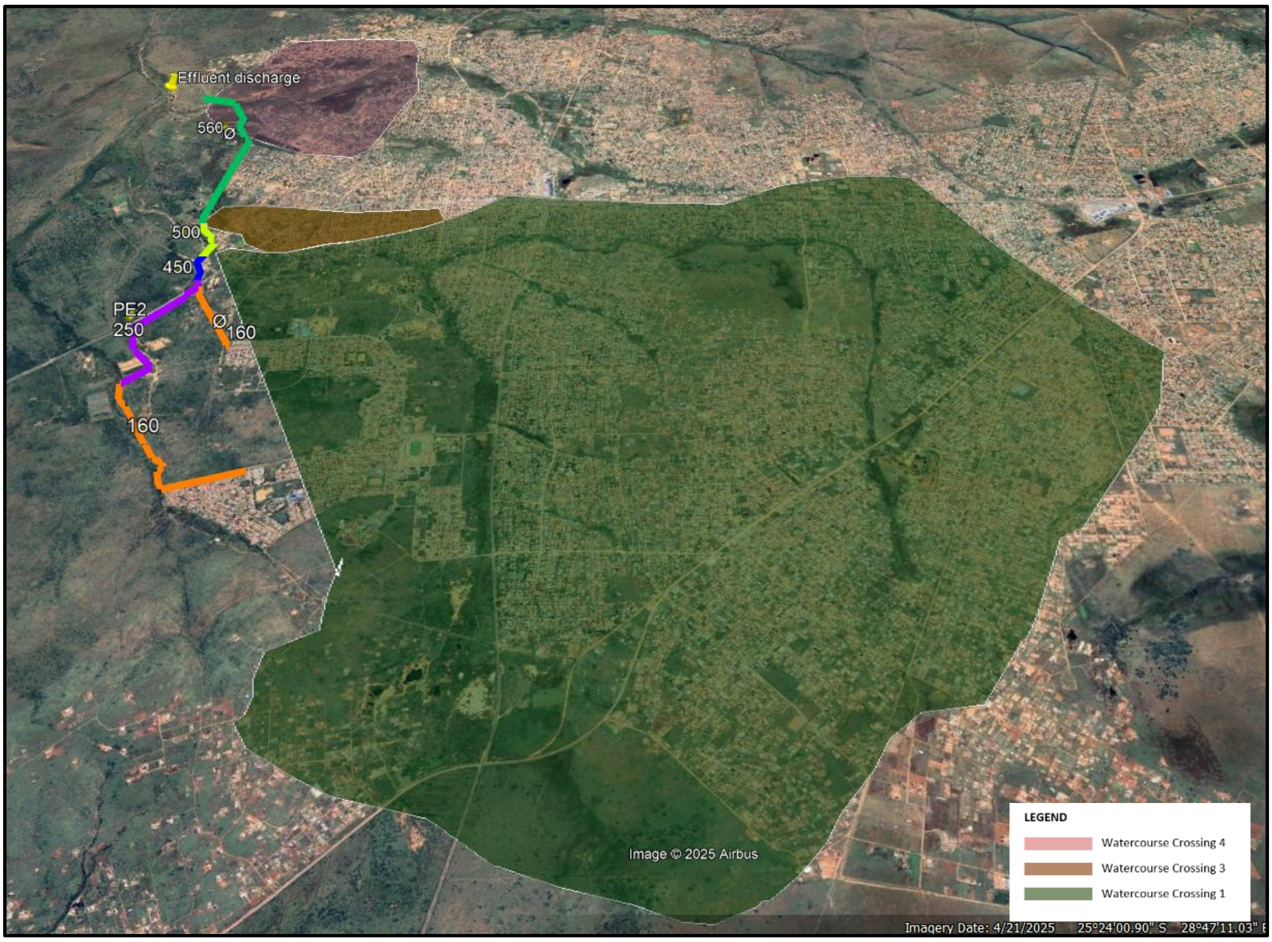

Figure 2.2: watercourse crossing catchments

Table 2.2: Summary of hydrology of the watercourse crossing catchments

Watercourse Crossing	Catchment Area (km^2)	Proportion of B31D	Natural Mean Annual Runoff (million m^3/annum)
4	3.23	0.0058	0.073
3	1.03	0.0018	0.023
2	~0	0	0
1	37.7	0.0676	0.850

The time series of the Natural Runoff from the watercourse crossings is shown in Figure 2.3 while the average monthly flow is shown in Figure 2.4.

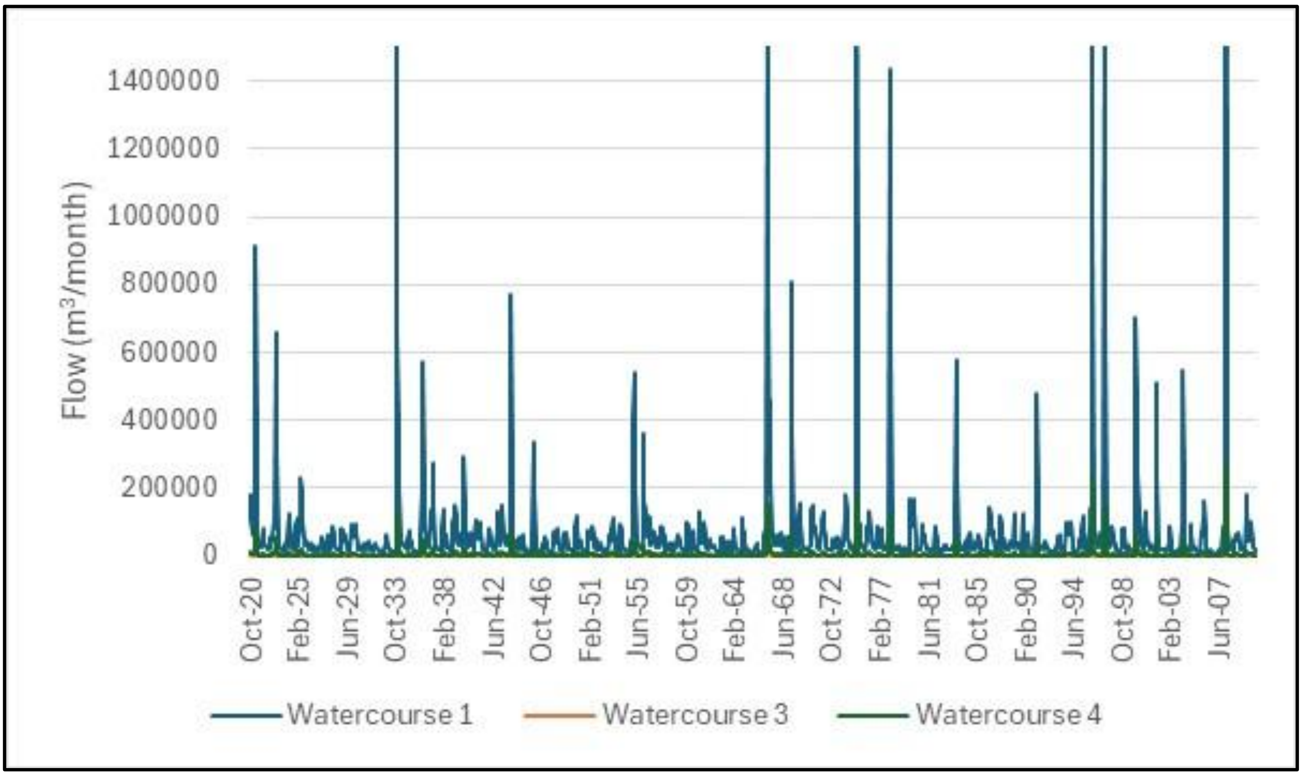

Figure 2.3: Time series of Natural flow from watercourse crossings

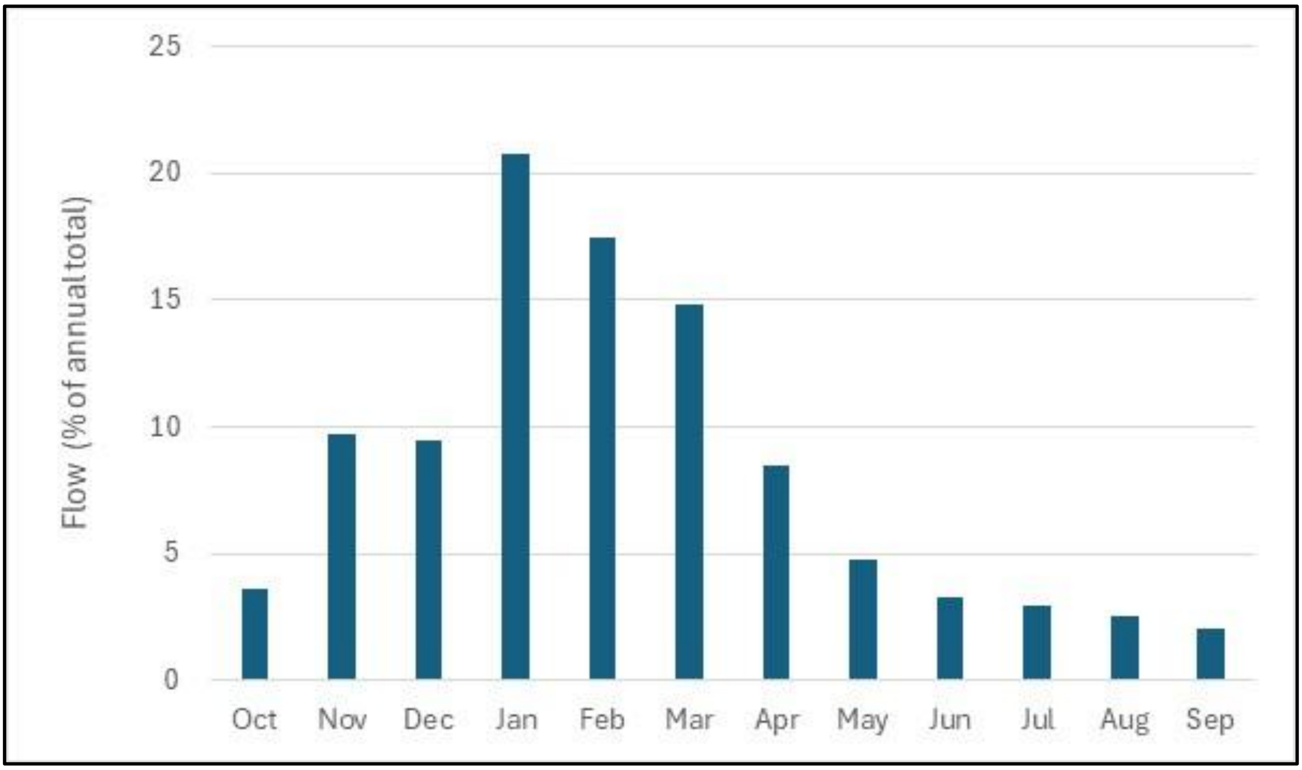

Figure 2.4: Average monthly natural flow from the watercourse crossings

The natural flow from the B31D quaternary (and hence the watercourse crossing catchments) is variable with high flow in summer and very little flow in winter.

2.3 Effluent Discharge

The catchment of the effluent discharge point is larger than the sum of the watercourse crossing catchment since it includes a tributary not affected by the watercourse crossings. See Figure 2.5.

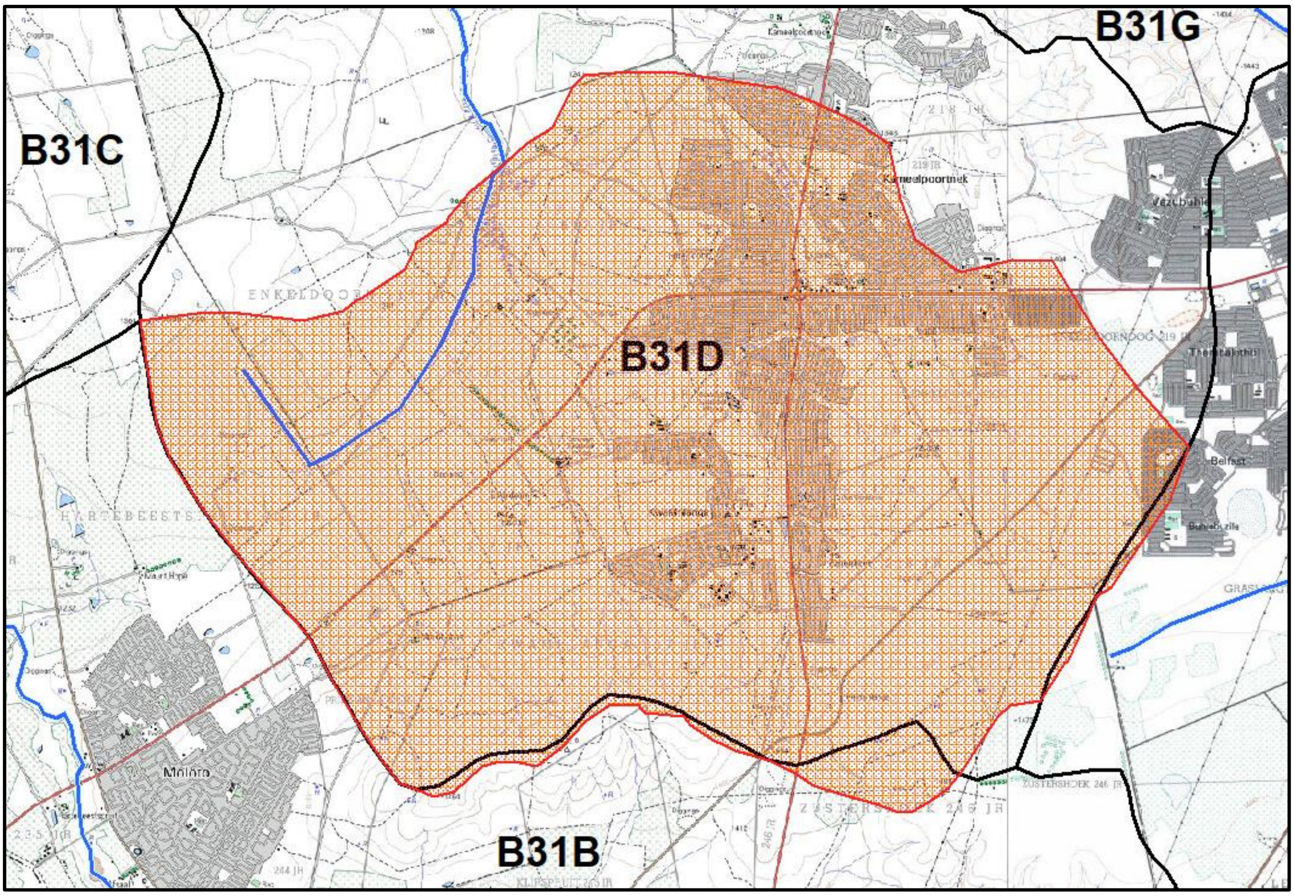

Figure 2.5: Effluent discharge catchment

The hydrological details of the catchment of the effluent discharge point in given in Table 2.3.

Table 2.3: Summary of hydrology of the effluent discharge point

Catchment Area (km^2)	Proportion of B31D	Natural Mean Annual Runoff (m^3/annum)
69.3	0.124	1.56

3 HYDROLOGICAL ANALYSIS OF WATERCOURSE CROSSINGS

3.1 Methodology

A hydrological analysis is generally carried out to assess how the flow regime changes due to proposed developments within a catchment. While these analyses usually pertain to water abstractions, the increased flow due to the discharge of effluent into the stream and changes due to sewer lines crossing the impacted watercourses are also important. Increased flow can result in channel erosion and changes in the riparian vegetation and may be an indicator that a monitoring programme needs to be instituted as part of a project to ensure timeous mitigation strategies to address these risks. There will also be an increase in flood flows due to the impervious areas of the development, for example, roofs of houses, roads, etc.

3.2 Water use in the catchment

It is important when evaluating the hydrology of a catchment and the impact of development on the flow to take into account water use in the catchment. Water use in the catchments under considerations consist of domestic use which could include some garden watering. This water is mostly supplied from outside of the catchment, although there are some boreholes and reports of Schedule 1 use from Watercourse 1. Water collected by the community from the fountain in Watercourse 1 will reduce the low flow from this watercourse.

Impervious surfaces, such as roads and roofs, result in increased runoff from urban catchments and this needs to be taken into account. The estimate impervious areas are given in Table 3.1.

Table 3.1: Impervious developed area

Catchment	Catchment Area (ha)	Develop area (ha)	% of develop area impervious
Watercourse Crossing 1	323	194	10%
Watercourse Crossing 3	103	80	30%
Watercourse Crossing 4	3 770	2830	20%

Table 3.2 summarised the increased runoff due to urban development.

Table 3.2: Increased runoff due to impervious areas in urban areas

Watercourse Crossing	Natural Mean Annual Runoff (m^3/annum)	Increased runoff due to impervious areas	Present Day Mean Annual Runoff (m^3/annum)
1	73 000	1 000	74 000
2	0	0	0
3	23 000	1 000	24 000
4	850 000	23 000	873 000

3.3 Results

Figure 3.1 shows the natural flow at each watercourse crossing expressed as duration curves while Figures 3.2 to 3.4 show the natural and present-day flows as duration curves. Note that there is slight increase in flow due to paved area.

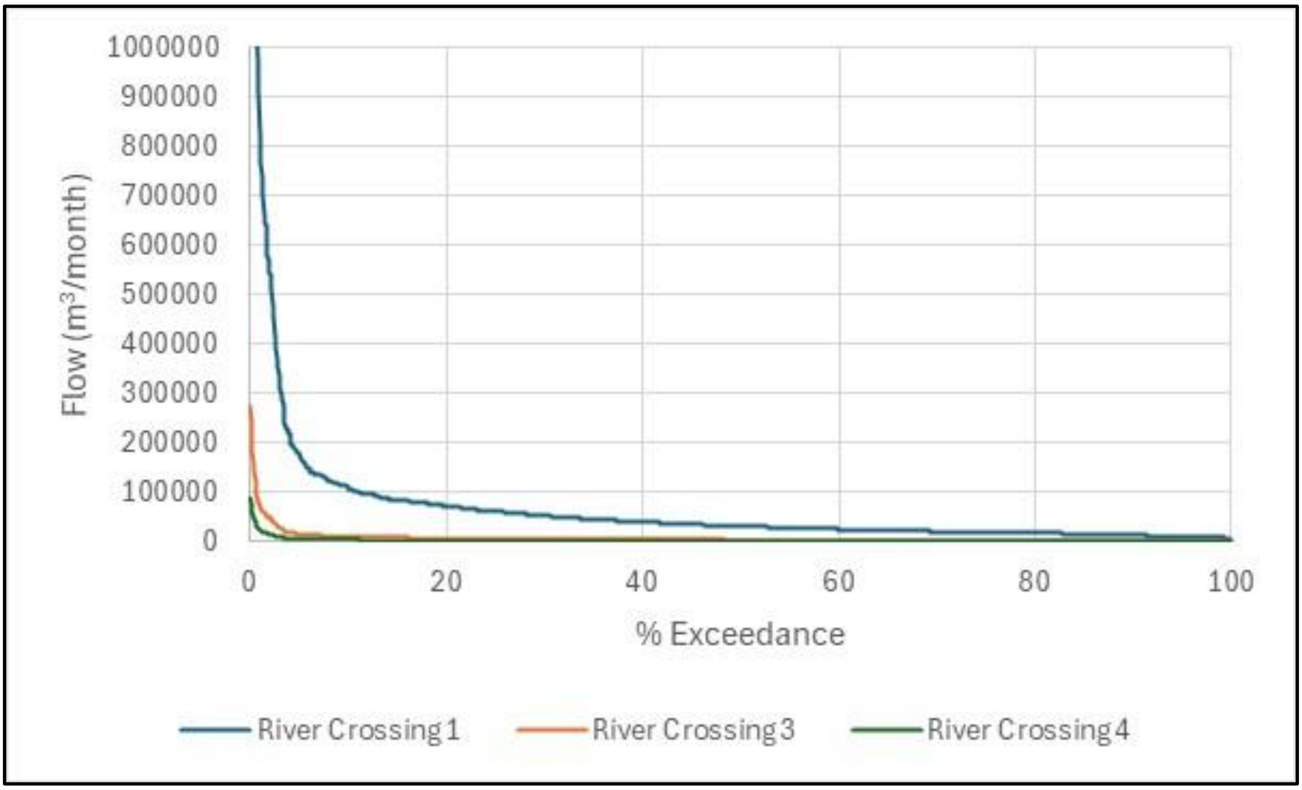

Figure 3.1: Natural flow at the watercourse crossings

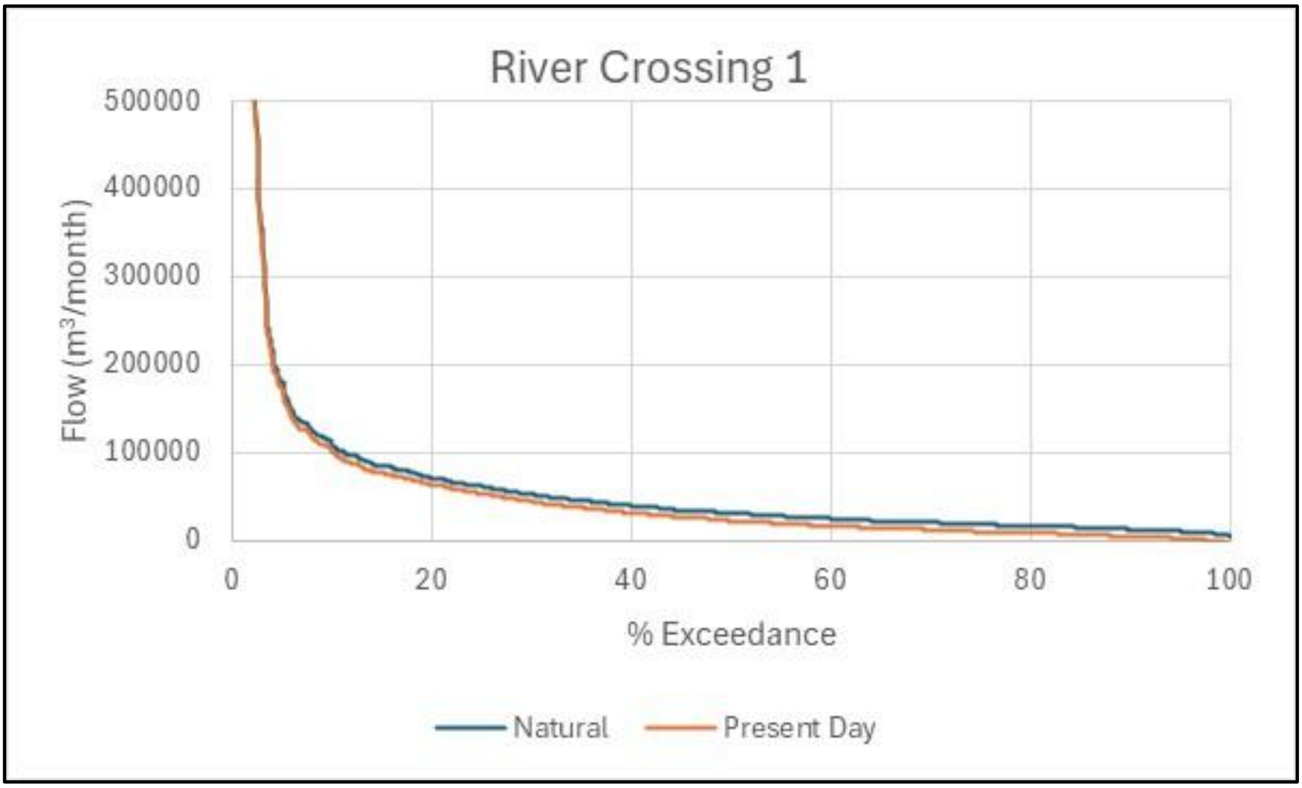

Figure 3.2: Natural and Present Day flow at the watercourse crossing 1

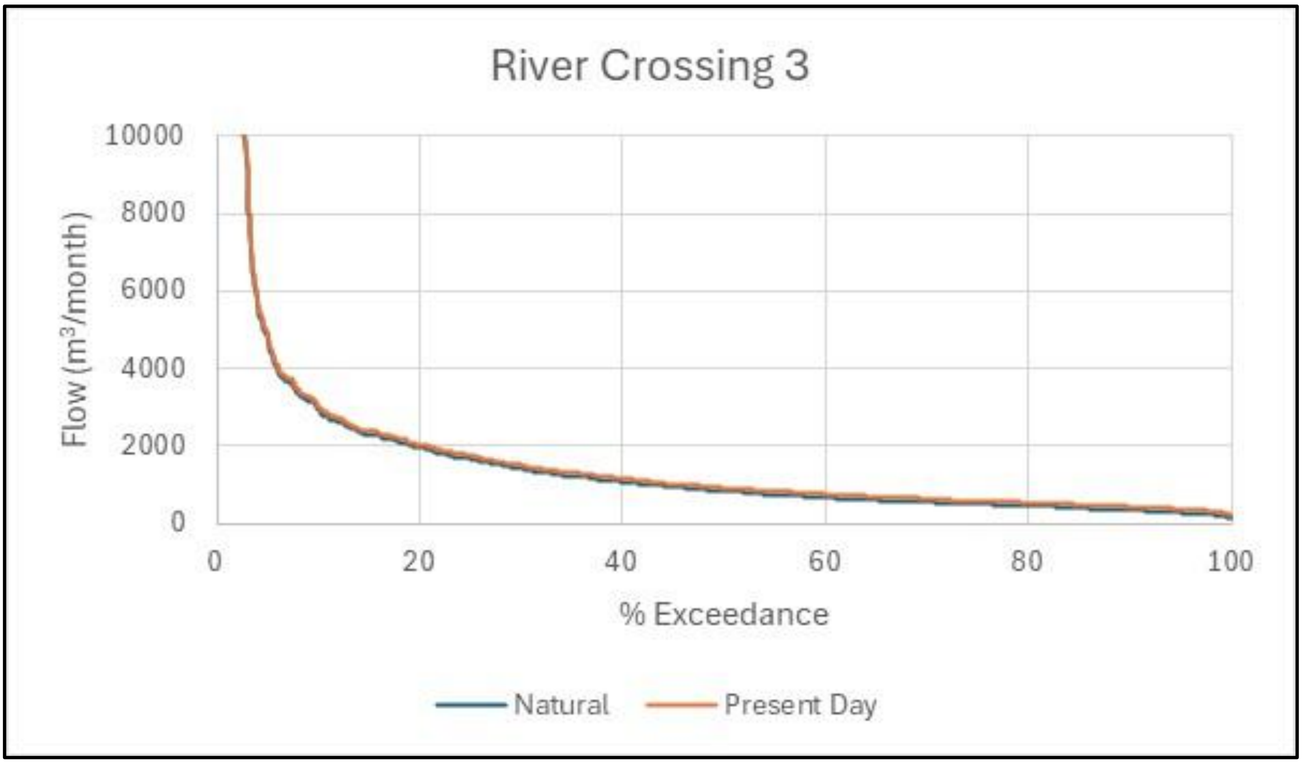

Figure 3.3: Natural and Present Day flow at the watercourse crossing 3

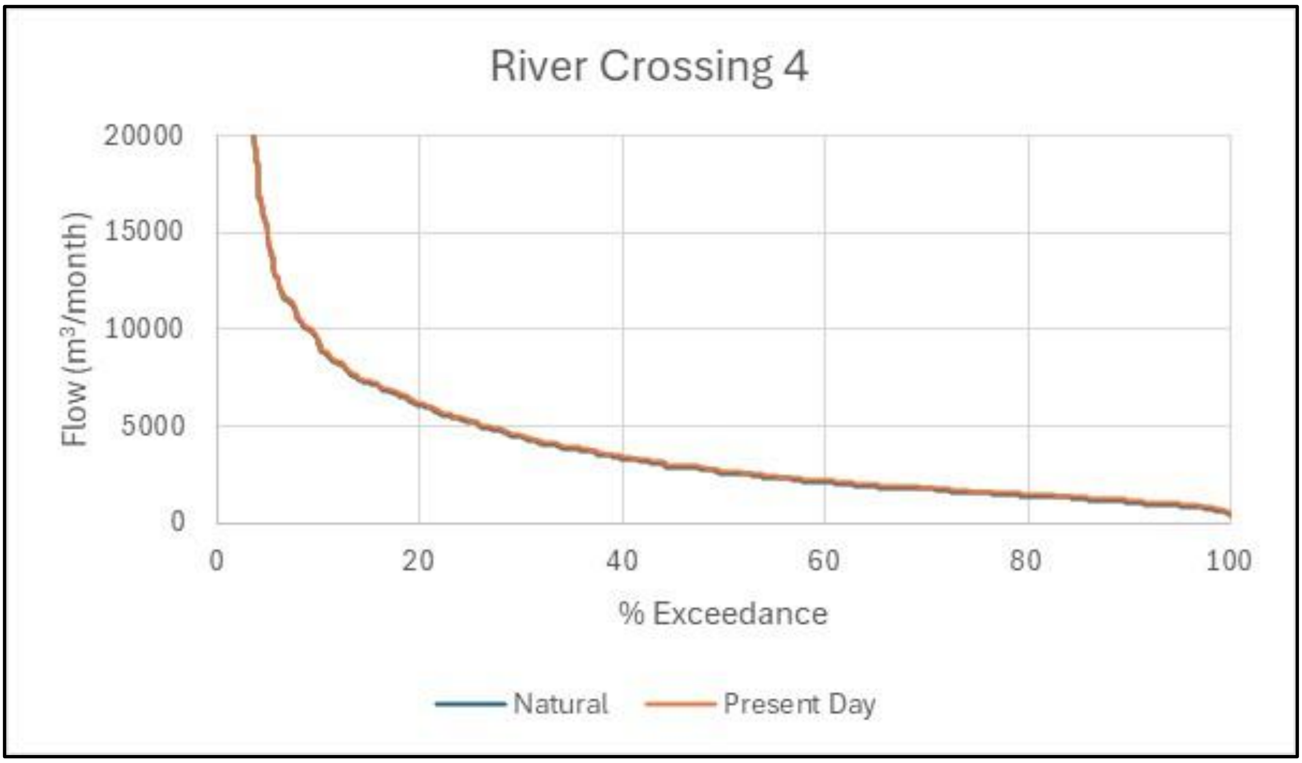

Figure 3.4: Natural and Present Day flow at the watercourse crossing 4

The paved surfaces in the urban areas upstream of the watercourse crossing result in a slight increase in the catchment runoff at all watercourse crossings.

3.4 Impacts

A review of the preliminary design of the sewer outfall revealed that there will be no discharge of effluent at the watercourse crossings. Also, the pipelines will be buried at the watercourse crossings so the flow will not be impeded in any way. It was concluded that the sewer outfall will have no impact on the watercourse flows.

There will however be a short-term local impact during the construction phase due to coffer dams that will need to be constructed at the watercourse crossings.

4 HYDROLOGICAL ANALYSIS OF EFFLUENT DISCHARGE

4.1 Methodology

The proposed WWTW will discharge treated effluent into the water course immediately to the West of the WWTW. See Figure 4.1.

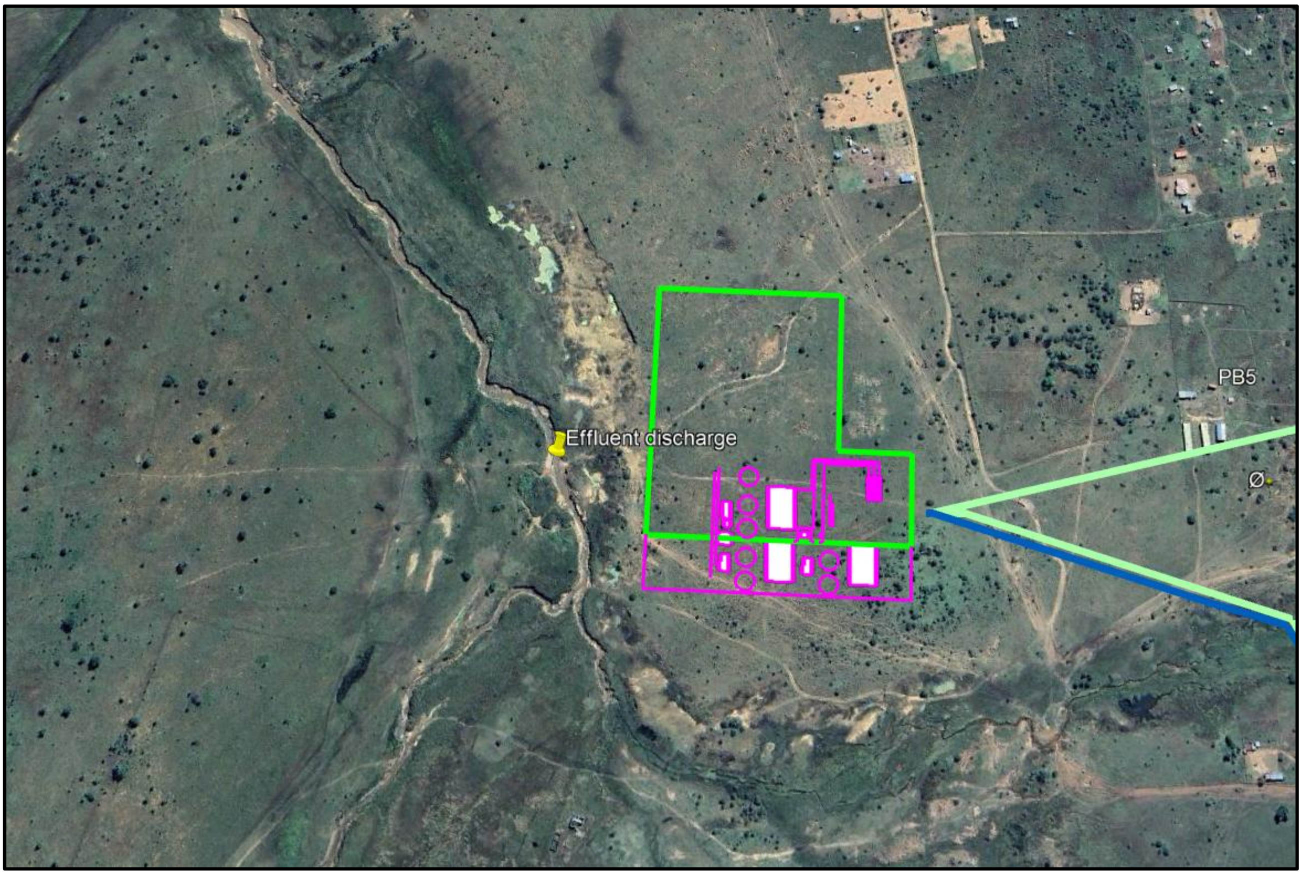

Figure 4.1: Location of treated effluent discharge point

The WWTW will be constructed in phases as follows:

- Phase 1: 6 Mℓ/day
- Phase 2: 9 Mℓ/day
- Phase 3: 12 Mℓ/day
- Phase 4: 15 Mℓ/day

This report only addresses Phase 1.

The impact of this effluent discharge has been determined for each phase by comparing the MAR and flow duration curves of present day flow with the duration curve of flow after completion of each phase of the WTW.

4.2 Results

The MAR of the Natural, Present Day and flow after each development phase is shown in Table 4.1.

Table 4.1: MAR of each development phase

Development Phase	Effluent Discharge (Mℓ/day)	MAR (million m^3/annum)
Natural Flow	0	1.56
Present Day Flow	0	1.61
Phase 1	6	3.80

The impact of the effluent discharge expressed as duration curves is shown in Figure 4.2.

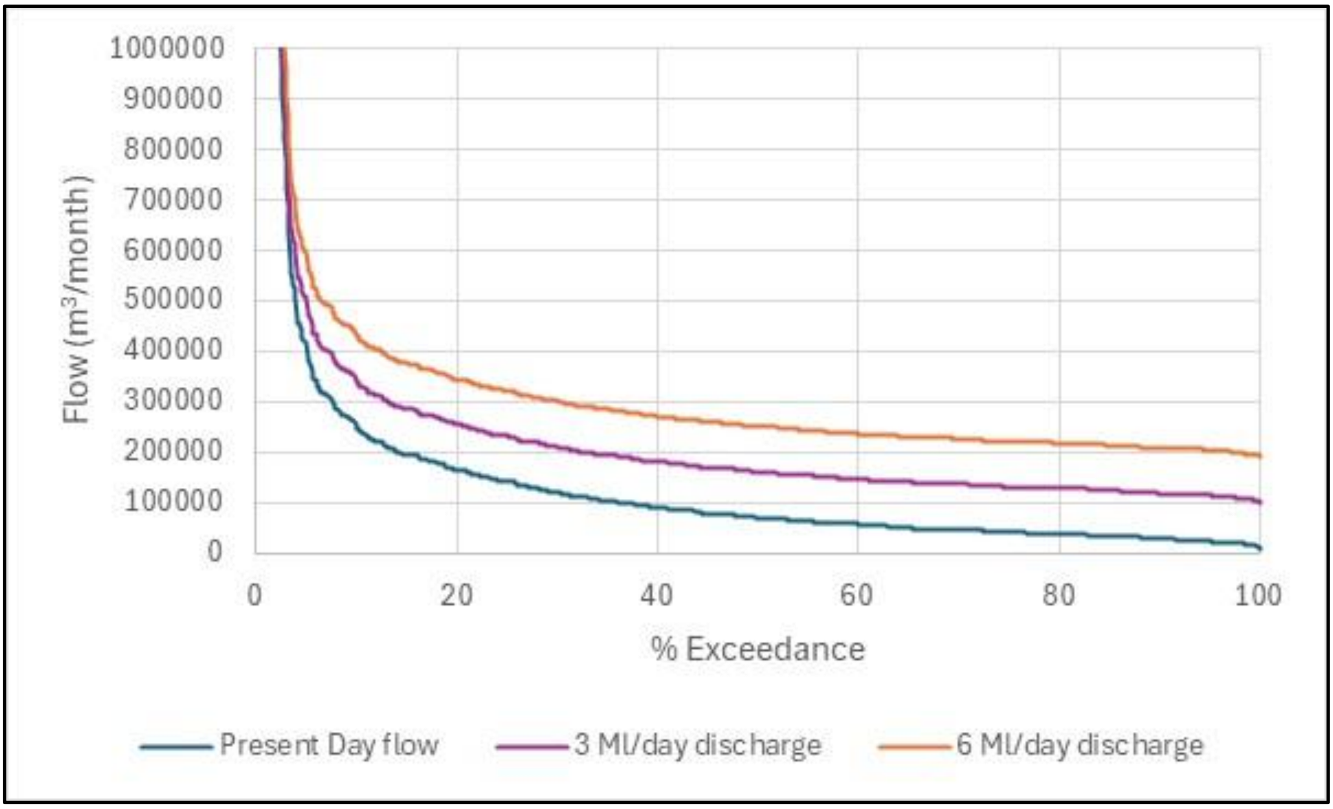

Figure 4.2: Duration curves showing increase flow in the water course due to effluent discharge

It can be concluded that the discharge of effluent from the proposed WWTW will have a significant impact on the water course, initially increasing the flow by about 50% and then than doubling the flow. To summarise, the average flow is currently approximately 51 ℓ/s, and this will increase to 86 ℓ/s with 3 Mℓ/day effluent discharge and to 121 ℓ/s with 6 Mℓ/day discharge.

However, the impact will be much higher on low flows with the low flows increasing by 4 with the first 3 Mℓ/day by a factor of 7 with a discharge of 6 Mℓ/day.

4.3 Impacts

The impact of the effluent discharge on the watercourse will be significant, essentially changing the nature of the watercourse from one with highly variable flow to one with a higher near to constant flow. The increased flow will probably lead to a change in riparian vegetation and channel erosion. Moving downstream, the impact will reduce and become insignificant with tributaries contributing to the natural river. This should be monitored during the initial phase of the project so that mitigation measures can be developed.

There does not seem to be any water use on the watercourse downstream of the WWTW so the impact will not be on human activity but rather ecological.
There are several ways to mitigate the impact which could be considered:

- The effluent could be piped to the Elands River as a better discharge point due to the much larger flows in the Elands River.
- The Effluent could be used for irrigation.
- The watercourse could be changed into a wetland with the additional of many small in-stream dams to reduce the flow velocity and hence prevent erosion.. This could occur naturally with no intervention. Monitoring is therefore recommended to document how the watercourse and riparian zone responds to the change in flow regime.

5 CONCLUSIONS AND RECOMMENDATIONS

A hydrological analysis was carried out in order to quantify the impact of a sewer outfall at four watercourse crossings as well as the discharge of treated effluent into the water course. Only three of the watercourse crossings have significant catchment areas. The flow at these watercourse crossings is variable with very low baseflows and small floods during rainfall events. The flow is slightly higher than natural in two of the catchments due to the paved surfaces in the urban areas upstream of the watercourse crossings. There is schedule 1 water use from the largest catchment which reduces the flow.

No sewage will be discharged at the watercourse crossings so there will be no impact on the watercourse flows. Also, the sewer outfall will be buried at the watercourse crossings and hence will not impede the flow in any way. There will however be a short-term local impact during the construction phase due to coffer dams that will need to be constructed at the watercourse crossing.

The catchment of the point of effluent discharge is significantly larger than the catchment area of the watercourse crossings and the runoff from this catchment, both natural and present day is about double that from the largest watercourse crossing. The discharge of effluent from the proposed WWTW will ultimately be about double the present day MAR. The impact will be much higher on low flows with the first phase increasing low flows by a factor of 4 with a 3 Mℓ/day discharge and a factor of 7 with a discharge of 6 Mℓ/day.

There does not seem to be any water use on the watercourse downstream of the WWTW so the impact will not be on human activity and rather ecological, which will probably entail a change in riparian vegetation and channel erosion.

It will be difficult and costly to mitigate such large changes in the flow regime of the receiving watercourse but the following options could be considered:

- The effluent could be piped to the Elands River as a better discharge point due to the much larger flows in the Elands River.
- The Effluent could be used for irrigation.
- The watercourse could be changed into a wetland with the additional of many small in-stream dams to reduce the flow velocity and hence prevent erosion. This could occur naturally with no intervention. Monitoring is therefore recommended to document how the watercourse and riparian zone responds to the change in flow regime.

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Bailey, A,K and Pitman, W.V (2015). Water Resources of South Africa, 2005 Study (WR2012), Water Research Commission, Pretoria, South Africa

Mallory, S.J.L, Desai, A.Y., Odendaal, P. (2013) Water Resources Modelling Platform (Version 3.4) – User's Guide, www.waterresources.co.za