UPPER JUKSKEI RIVER CATCHMENT REHABILITATION

FRESHWATER SPECIALIST STUDY

for

Advisian

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by

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EXECUTIVE SUMMARY

Enviro-Insight and Confluent Environmental were appointed to conduct an aquatic ecosystem health assessment and compile a rehabilitation plan for part of the upper Jukskei River catchment within the City of Ekurhuleni. The study area incorporates parts of Edenvale and Bedfordview in the eastern suburbs of Johannesburg.

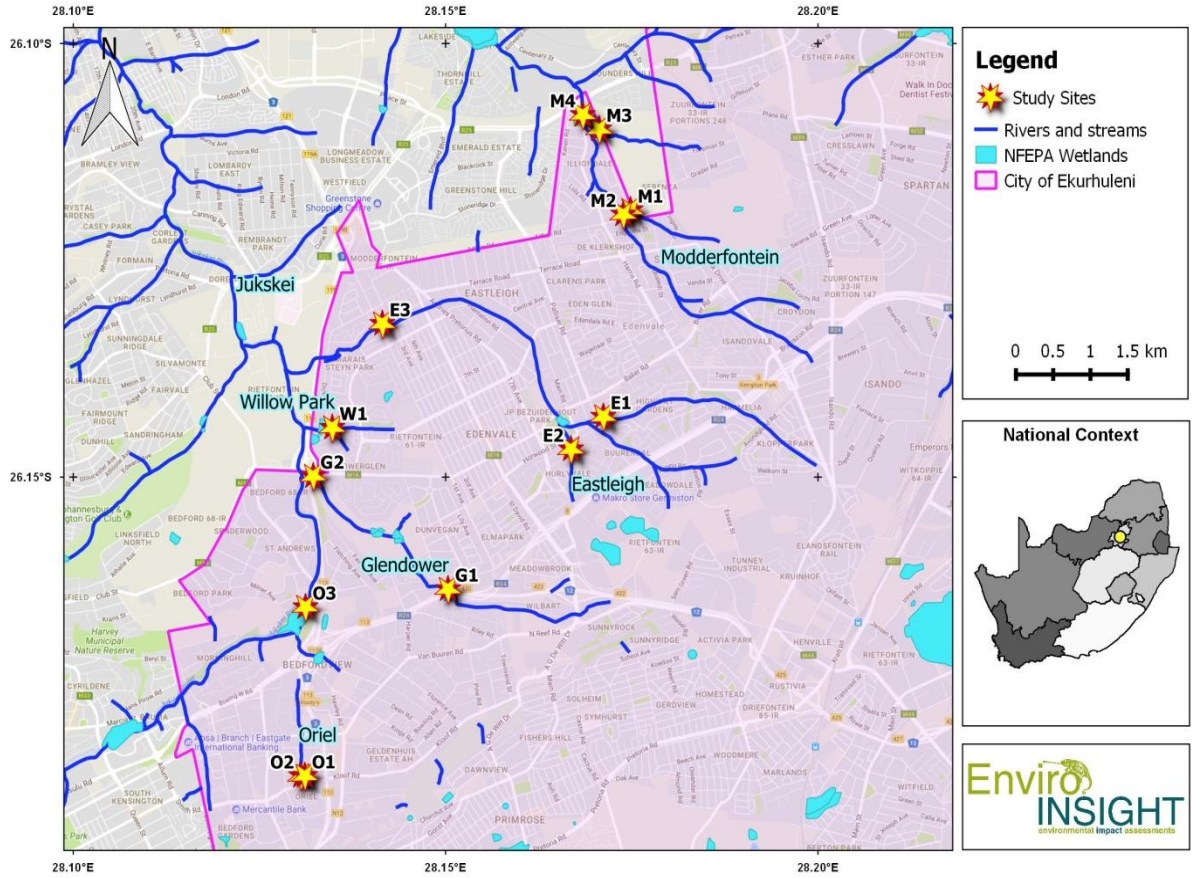
BACKGROUND AND SITE SELECTION

Five watercourses were included in the study. These were the Modderfontein Stream, Eastleigh Stream, Willow Park Stream, Glendower Stream and Oriel Stream. All streams flow into the Jukskei River and are located in the upper catchment area. Historically they were small, mostly non-perennial streams channelled in valley bottoms. Current impacts affecting their ecological integrity influence almost every aspect of aquatic ecosystem health including flow, water quality, habitat and biota. Each watercourse is designated as an Ecological Support Areas, with the exception of Illiondale Wetland in Modderfontein Stream, which is a Critical Biodiversity Area according to the Gauteng Conservation Plan (Version 3.3).

A literature review was completed in order to determine the extent to which each watercourse has been previously studied, and whether any existing rehabilitation projects have been initiated. A number of studies were identified and are summarised in the table below:

Watercourse	Studies available
Illiondale wetland (Modderfontein)	Rehabilitation Project (GAUT: 002/15-16/E0043)
Modderfontein Stream	Modderfontein Outfall Sewer (GAUT: 002/08-09/N0584)
Modderfontein Stream	Isandovale Erosion Control (GAUT: 002/07-08/NO946)
Eastleigh Stream	Three bridge upgrades (GAUT: 002/13-14/E0307)
Eastleigh Stream	Eastleigh Stream Rehabilitation (GAUT: 006/11-12/E0082)
Harmelia Stream (Eastleigh)	Cunningham Road Stormwater infrastructure (GAUT: 002/17-18/E0036)
Glendower Stream	Solheim stormwater channel (GAUT 002/13-14/E0294)
Oriel Stream	Rehabilitation Project (GAUT: 002/11-12/E0052)

Based on the results of the literature review, known pollution sources and CoE water quality monitoring points, a total of thirteen study sites were selected as shown below:



METHODS

At each site the Present Ecological State (PES) was determined using the SASS5 macroinvertebrate assessment, diatom community assessment and Index of Habitat Integrity (IHI). Water samples were collected for chemical and microbial analyses. Constituents analysed were selected to determine the presence and severity of sewage and industrial pollution. Parameters included the measurement of the presence / absence of *Vibrio cholerae* (Cholera) and a non-quantitative scan for 68 elements to provide insight into the array of pollutants present in the ecosystem. The combined results of the assessment were used to inform the rehabilitation plan which provided prioritised interventions at a generalised and site-specific scale. Recommendations to improve catchment management were integrated with the rehabilitation plan. Fieldwork was carried out from 26 – 30 June and the final report was submitted on 27 July 2018.

RESULTS: WATER QUALITY

Faecal coliform counts exceeded the maximum measureable level (according to the test used) at every site except O1 and G1. Along with elevated nutrient levels (Inorganic N and P), this confirms the presence of current or recent impacts by sewage wastewater at almost every site. The presence of boron at each watercourse further supports sewage pollution in the stream, as it is used in laundry detergents. Although *Vibrio cholerae* were

detected at 4 sites (Sites M1, M2, M4 and E2), they were non-toxigenic and therefore not able to produce Cholerat Toxin (CT). Industrial impacts were reflected in elevated metals at Sites M1 and M4. Enriched metals included copper, gallium, lithium, molybdenum, nickel, rubidium, vanadium and tungsten. Based on common uses of these metals, it seems likely that industries related to electrical, batteries, solar panels and power generation may be responsible according to common uses of these elements.

RESULTS: MACROINVERTEBRATE AND DIATOM ASSESSMENTS

According to the SASS5 macroinvertebrate assessment, all of the sites were rated as E/F, critically impacted. These results indicated that both habitat and water quality were highly impacted in each watercourse. Instream habitat was scored for its suitability to support a diverse range of macroinvertebrates, and scores were mainly below 50%. In most cases the gravel, sand and mud biotope was very poor or not present. This is likely due to the effects of scouring during high flows.

Diatom communities at each site reflected slightly less impacts than the macroinvertebrates. However diatoms are not habitat specific as they will comfortably grow on any substrate from a rock to an old plastic bottle. Therefore their results were more reflective of impacts affecting water quality for the last 6-8 weeks. Dominant diatom species at all four sites on Modderfontein Stream reflected osmotic fluctuations and eutrophication. The ecological category for Modderfontein Stream was between E and F, indicating bad water quality. On Eastleigh Stream diatoms indicated the worst water quality at Site E1 (Harmelia Stream) with organic pollution and osmotic fluctuations, while diatoms at the remaining sites indicated moderate organic pollution, eutrophication and high salinity. The ecological category of Harmelia Stream was F (bad quality) and the remainder of the stream was categorised as D, poor quality. Diatoms indicated that water quality at Willow Park was in the category D/E, poor quality. Dominant species were moderately to highly pollution tolerant. Site G1 reflected higher water quality impacts than Site G2 on Glendower Stream, with dominant species indicating moderate organic pollution and eutrophication. The ecological category ranged from moderate to bad quality. Sites on Oriel Stream ranged from moderate to bad quality (C – F) with dominant diatom species reflecting organic pollution, eutrophication and a high tolerance for pollution.

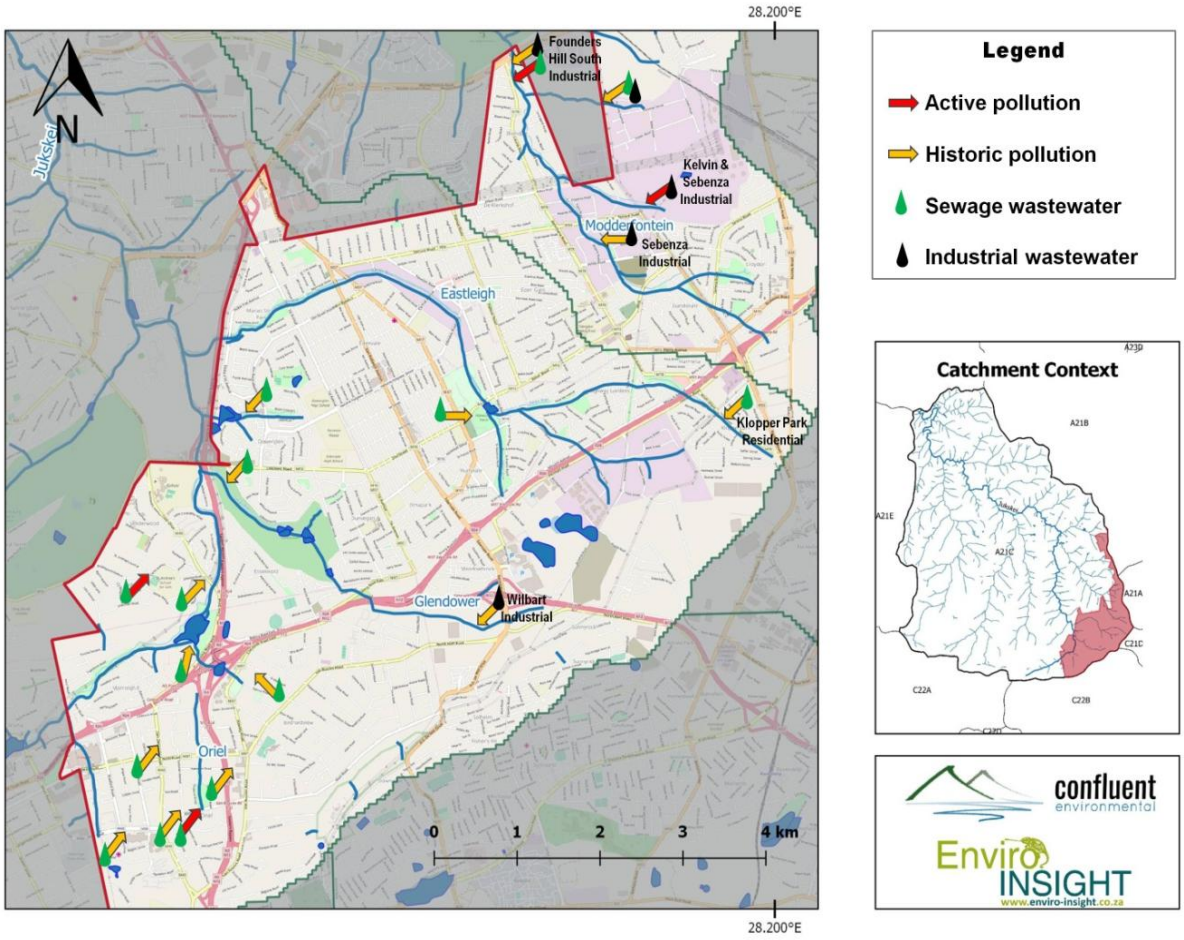
HABITAT ASSESSMENT & PES

Based on the results of the Index of Habitat Integrity as well as the water quality and biomonitoring assessments, the present ecological state of each stream was determined and is summarised in the table below.

Stream	Instream Impacts	Riparian Impacts	Present Ecological State
Modderfontein	• Water quality (sewage and industrial) • Erosion (scouring) • High flows (channel incision)	• Channel modified by severe erosion in places • Extensive alien vegetation • Rubbish dumping	E/F Seriously to Critically Modified
Eastleigh	• Water quality (sewage) • Erosion (scouring) • High flows (channel incision)	• Severe channel erosion & destabilisation of banks • Extensive alien vegetation • Long sections canalised • Rubbish dumping	E/F Seriously to Critically Modified
Willow Park	• Impoundment alters flow, bed and channel, and reduces connectivity • Concreted stream channel • Alien fish in dam (carp & bass) • Historic fish kills (sewage inflows)	• Alien vegetation • Mowing up to stream edge • Channel and bank modified by the dam • Dam caused inundation of the riparian zone	E, Seriously Modified
Glendower	• Water quality (sewage) • Multiple impoundments alter flow, bed and channel and reduce connectivity • Siltation of dams • High flows cause flooding and instream erosion	• Mowing up to stream edge (vegetation removal) • Channel and banks modified by dams • Dams cause inundation of riparian zones • Alien vegetation	E/F Seriously to Critically Modified
Oriel	• Water quality (sewage) • Sections of severe erosion • Gillooly's Dam alters flow, bed and channel, and reduces connectivity • Eutrophication of dam causes fish kills • High flows cause extreme erosion • Channelled in sections	• Mowing up to stream edge (vegetation removal) • Channel modification (due to dam and channel) • Inundation of riparian zones • Alien vegetation substantial in places	E/F Seriously to Critically Modified

POLLUTION SOURCES

A number of pollution sources were identified during this study (see below). This map presents the best available information at the time of writing, but may look substantially different in a few months time. As infrastructure is repaired or maintained a problem spot may disappear, however a new one will inevitably present itself.



REHABILITATION PLANS

1. Modderfontein Stream

A summary of the site-specific rehabilitation measures are listed and prioritised (1,2 or 3 from most to least urgent respectively) below, along with an annotated aerial image to provide details on the location of proposed interventions.

Priority 1

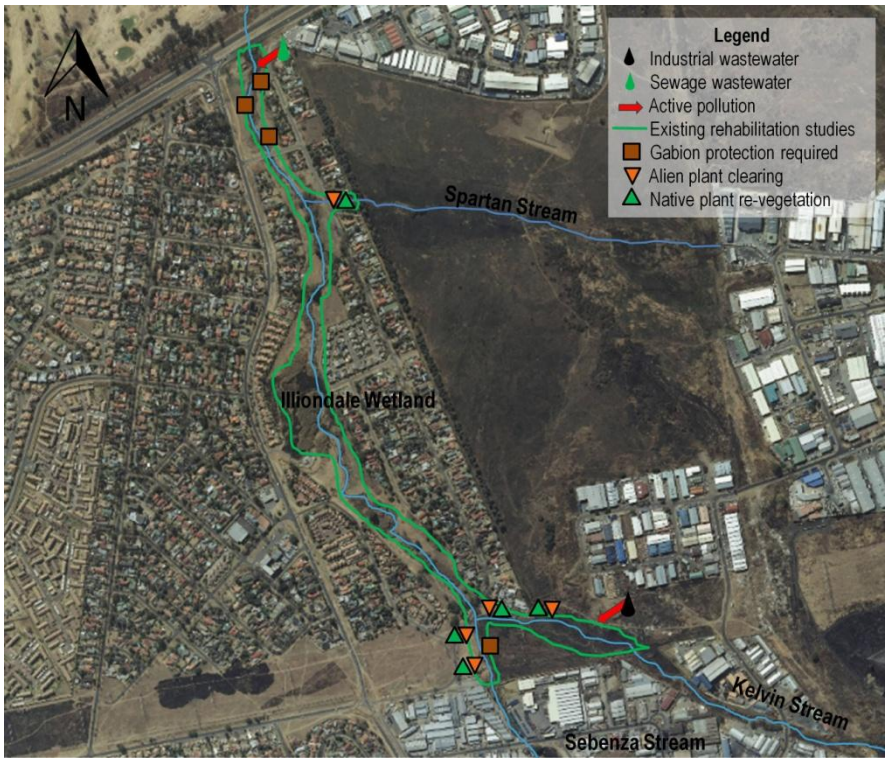
- Urgently put a stop to the overflowing sewage opposite the pump-station south of Modderfontein Road;
- Move the CoE water quality monitoring point to downstream of the above impact so as to monitor it;
- Continue with existing rehabilitation plans developed for the Illiondale Wetland;
- Stabilise stream banks on Sebenza Stream upstream of the Kelvin Stream confluence.

Priority 2

- Embark on a fact-finding mission to identify sources of industrial pollution on Kelvin Stream, Sebenza Stream and Spartan Stream;

Priority 3

- Alien plant removal and indigenous plant revegetation for the park on Spartan Stream, as well as in the vicinity of the confluence of Kelvin and Sebenza Streams.



2. Eastleigh Stream

Priority 1

- Identify the sewage source from Klopper Park which is frequently flowing into Harmelia Stream and eliminate it;
- Continue with existing rehabilitation plans, particularly with regard to stream stabilisation given the potential threats to human safety and infrastructure;
- Clear flood-related debris from bridges and culverts prior to the next rainfall season to ensure maximum capacities for these structures;
- Manholes in Protea Park have had their covers stolen resulting in a safety hazard in the park. These should be replaced as soon as possible.

Priority 2

- Stabilisation of stream banks required downstream of St Andrews Road bridge on Hurlyvale Stream;
- Remove alien vegetation from the banks of Hurlyvale Stream, and plant indigenous vegetation;

- Remove alien vegetation from the banks of Eastleigh Stream in Protea Park (may be covered in the existing rehabilitation plan);

Priority 3

- Alien plant removal from Harmelia Stream (may be covered in the existing rehabilitation plan);

3. Willow Park

Priority 1

- Prevent sewage from flowing into the dam at all costs, given that it is an impoundment susceptible to eutrophication;
- Remove alien vegetation along the west bank and isolated locations around the dam;
- Stop the practice of mowing grass right up to the water's edge. Allow a natural buffer zone of vegetation to develop.

Priority 2

- Improve instream habitat diversity by increasing heterogeneity of the stream bed (currently concrete) by altering the stream substrate and gradients;
- Plant indigenous wetland plants along the edge of the stream to enhance the buffer zone and value as a wildlife corridor.

4. Glendower Stream

Priority 1

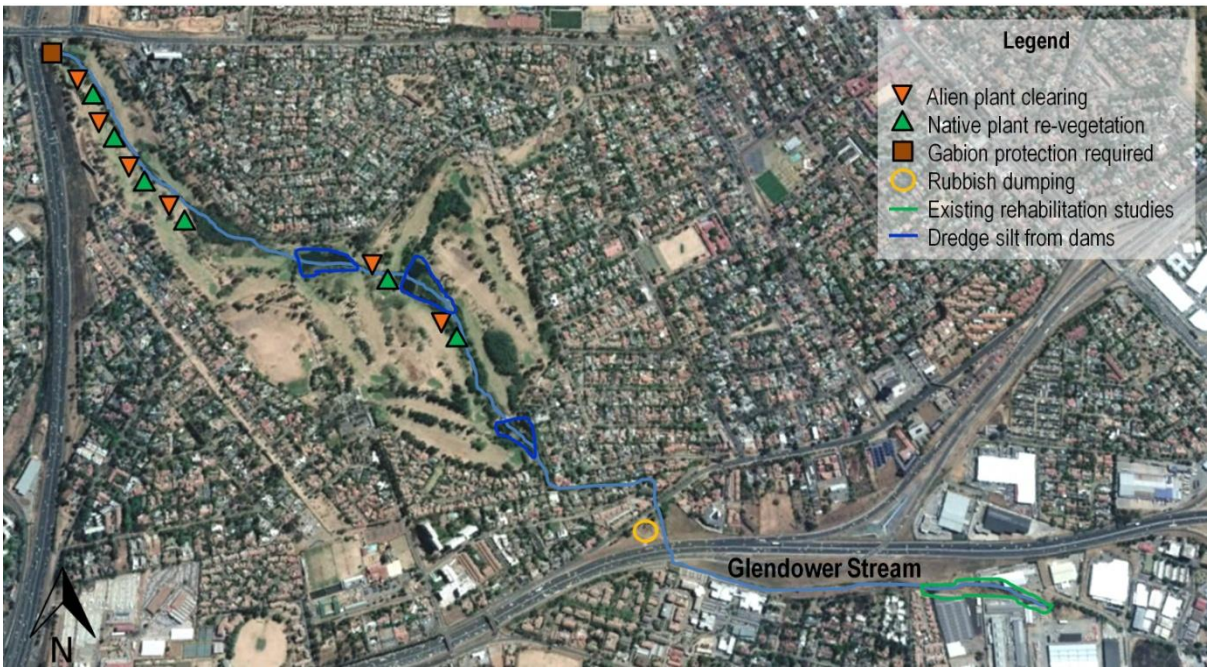
- Identify sources of industrial pollution in Wilbart industrial area and eliminate them;
- Refer to the map of sewage pollution points. Attend to these sites and ensure all efforts are made to prevent their re-occurrence;
- Stabilise slumping gabions at the lower end of Glendower Stream in the golf course;
- Stabilise stream banks in the Wilbart / Solheim areas (if this hasn't been done so already according to an existing rehabilitation study);

Priority 2

- The rubbish dumping site identified near Site G1 should be cleaned up and locked away from public access;
- Enhance the riparian zone of the stream in the golf course by reducing mowing along the stream edges and planting indigenous wetland plants along the stream-edge to enhance the buffer zone and improve cover for wildlife.

Priority 3

- Remove alien trees and plants from the riparian zone in the golf course and enhance the habitat by replanting indigenous wetland plants (as per Priority 2).



5. Oriel Stream

Priority 1

- Identify the source of sewage entering Oriel Stream from the west in Oriel Park, and eliminate the source;
- Continue with existing rehabilitation plans which may not have been completed in their entirety;
- Stabilise stream banks where extreme erosion is taking place downstream of Gillooly's Dam;

Priority 2

- Revise park management plans to stop mowing the grass to the water's edge at Oriel Park. Allow a buffer zone of vegetation to develop naturally which can be encouraged with indigenous revegetation;
- Consider options for the attenuation of floods immediately downstream of Gillooly's Dam. As an initial solution, a flood attenuation dam is recommended.

Priority 3

- Remove alien vegetation at the inflow of Oriel Stream to Gillooly's Dam;
- Remove alien vegetation downstream of the outflow from Gillooly's Dam IF floods can be attenuated. Currently, alien trees are all that is holding the banks together;
- Remove flood debris from the stream downstream of Gillooly's Dam.

6. General rehabilitation interventions

- **Stormwater management** needs to be a high priority consideration of future developments in the study area. Consider the cumulative impacts.
- Following significant high flows, maintenance teams must **clear flood debris** from culverts and pipes as this may reduce their capacity in future high flow events, resulting in blockages and flooding of roads and infrastructure. This also relates to removal of flood debris from the instream and riparian zone.
- Efforts to **control alien plant invasions** must be properly implemented. Species-specific methods of control must be followed using recommendations (e.g. herbicide application, and not just surface material removal), and most importantly have to be followed up annually as a minimum requirement. To be sustainable, alien plant control must be integrated into routine environmental and park maintenance plans, and staff must be given appropriate training for implementation.
- Where possible (considering aspects such as safety), revise public park management plans to **reduce mowing and vegetation clearing** within the riparian zone, and allow the establishment and re-generation of indigenous plants.

SPECIALIST CREDENTIALS & DECLARATION

This report was compiled by Jacqueline (Jackie) Dabrowski, the Director of Confluent Environmental (Pty) Ltd. Jackie holds a Ph.D. in Veterinary Science and her post-graduate studies were in the field of freshwater ecology. She has conducted research and published scientific articles on a range of topics including aquatic food webs, fish health, trends in water quality, branchiopod diversity, and land-use impacts on water quality. Her consulting work has focussed on a range of environmental assessments of dams, rivers, ephemeral watercourses and wetlands at various locations in South Africa. She has worked in a number of sectors including agricultural, mining (coal and platinum), urban developments, animal health, transport and pipelines.

At the time of conducting the assessment and compiling this report Jackie did not have any interest, hidden or otherwise, in the outcomes related to this study. Work performed for this study was done in an objective manner with the aim to present facts, findings and recommendations based on relevant professional experience and scientific data.

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SACNASP Registration Number 115166

29 July 2018

GLOSSARY OF TERMS, ABBREVIATIONS & DEFINITIONS

ASPT	Average Score Per Taxon
CoE	City of Ekurhuleni
COD	Chemical Oxygen Demand
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
DO	Dissolved Oxygen
EC	Electrical Conductivity
EI	Ecological Importance
ES	Ecological Sensitivity
FEPA	Freshwater Ecosystem Protected Area
GSM	Gravel, Sand and Mud
IHAS	Invertebrate Habitat Assessment System
NFEPA	National Freshwater Ecosystem Protection Areas
NWA	National Water Act
PES	Present Ecological State
SASS5	South African Scoring System Version 5
SPI	Specific Pollution sensitivity Index
SQR	Sub-Quaternary Reach
TWQR	Target Water Quality Range
WMA	Water Management Area

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1 INTRODUCTION

The City of Ekurhuleni has initiated a project to rehabilitate watercourses located within their municipal boundary that form part of the upper catchment of the Jukskei River. The project forms part of an effort to rehabilitate, develop and beautify city parks in this area. Enviro-Insight CC and Confluent Environmental (Pty) Ltd. were appointed by Advisian to conduct a freshwater specialist assessment of the current condition of affected watercourses, along with recommendations for their rehabilitation.

A comprehensive desktop study was completed in addition to the aquatic ecosystem health assessment and rehabilitation plan. The proposed approach to this project covered the following aspects:

DESKTOP STUDY

- Identify and map all watercourses within the defined catchment area;
- Assess the site (all watercourses) from the perspective of provincial and regional systematic biodiversity plans;
- Examine historical images of the study area;
- Review of available documentation pertaining to the study area;
- Review available water quality monitoring data from relevant authorities to identify constituents of concern;
- Make contact with stakeholder groups such as the Illiondale Wetland Buddies who could provide insights into historical and current impacts;
- Identify and map land uses that may negatively impact on aquatic ecosystem health;
- Based on known and anticipated impacts, determine a suitable combination of ecosystem health indicators / biomarkers to be assessed during the site visit;
- Identify suitable sites for assessment in consultation with the client.

ECOSYSTEM HEALTH ASSESSMENT AND REHABILITATION PLAN

- Conduct a site visit to assess each of the watercourses in the study area;
- Determine the Present Ecological State (PES) of each site;
- Identify and map pollution sources associated with various land uses;
- Provide recommendations to improve the health of aquatic ecosystems and reduce negative impacts;
- Prioritise recommendations for short-term and long-term improvements to aquatic ecosystem health;

2 STUDY AREA

2.1 REGIONAL CONTEXT

The study area is located in quaternary catchment A21C (Upper Crocodile River). Watercourses covered by this study lie within the municipal boundary of the City of Ekurhuleni within Sub-Quaternary Reaches (SQR; also known as NFEPA areas) 1268 and 1269 (Figure 1). Five watercourses are included in this study, all of which flow

into the Jukskei River forming part (but not all) of the upper catchment of the Jukskei River. The Modderfontein Stream is located in SQR 1268 and the Jukskei River and associated watercourses to the west are in SQR 1269.

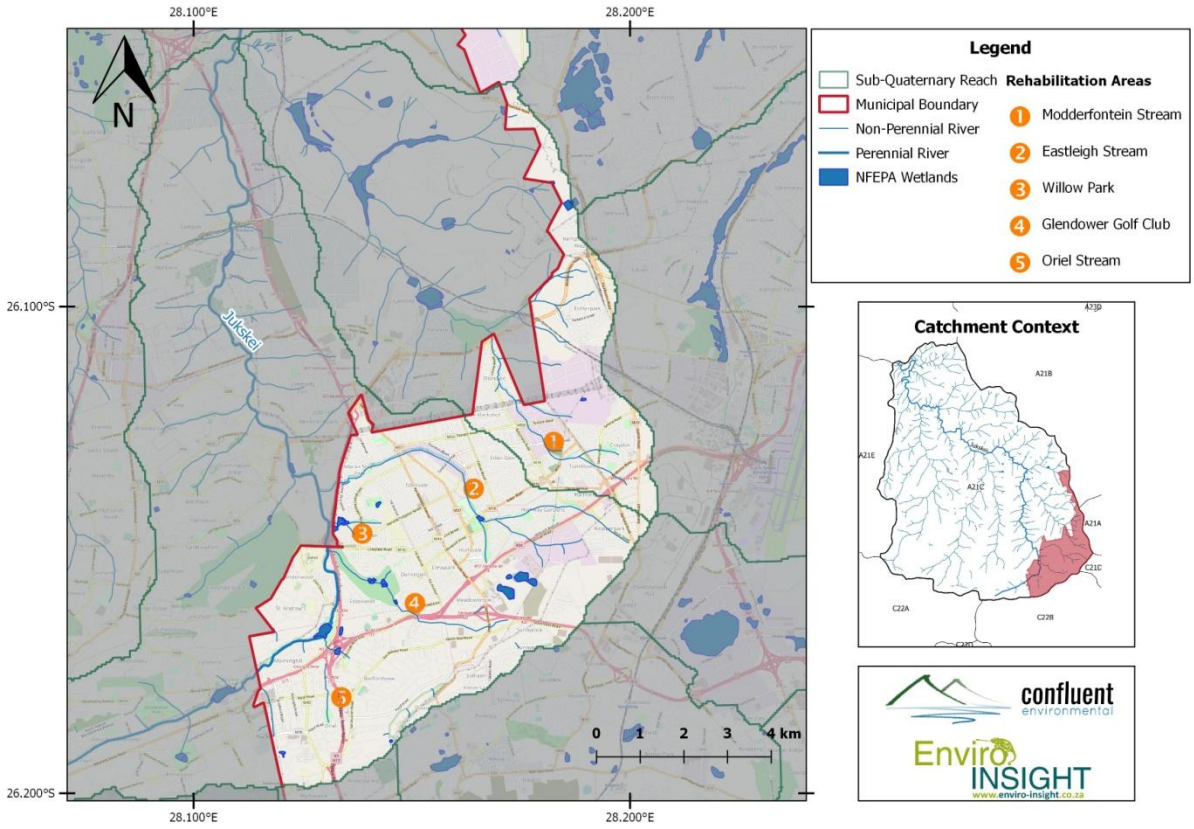

Figure 1: Map of the study area showing the City of Ekurhuleni municipal boundary and five watercourses included in this study.

2.1 NATIONAL FRESHWATER ECOSYSTEM PRIORITY AREAS (NFEPA)

According to NFEPA, the study area is within an Upstream Management Area. By definition, these are areas in which human activities need to be managed to prevent degradation of downstream areas that may be formally protected or ecological sensitive (Nel *et al*., 2011).

2.2 GAUTENG CONSERVATION PLAN

According to the Gauteng C-plan (Version 3.3), there are sections of each watercourse classified as Ecological Support Areas (ESA) and Critical Biodiversity Areas (CBA; Figure 2). The Modderfontein Stream (Site 1) is classified as an ESA in the upper reaches, while the area known as the Illiondale Wetland between Aitken Road and the R25 is classed as a CBA. The full length of the Eastleigh Stream (Site 2) is classed as an ESA apart from a small CBA identified adjacent to the N3 Highway. Willow Park (Site 3) has a mixed classification of both

ESA and CBA. The watercourse flowing through the Glendower Golf Club is classified as an ESA. The Jukskei River at Gillooly's Farm is a CBA while the dam and its source to the south (Oriel Stream) are classed as ESAs.

2.2.1 Ecological Support Areas

Ecological Support Areas are meant to be maintained in an ecologically functional state to support and prevent the degradation of CBAs and Protected Areas (PAs). Thus the function of CBAs and PAs is dependent on the maintaining ecological processes in ESAs. Some ESAs may be critically modified but could still play an important role in supporting ecological processes.

2.2.2 Critical Biodiversity Areas

Critical Biodiversity Areas may be selected based on irreplaceable biodiversity features, or they may represent an efficient configuration of sites to meet biodiversity targets in an ecologically sustainable way. CBAs should be maintained in the appropriate condition for their category.

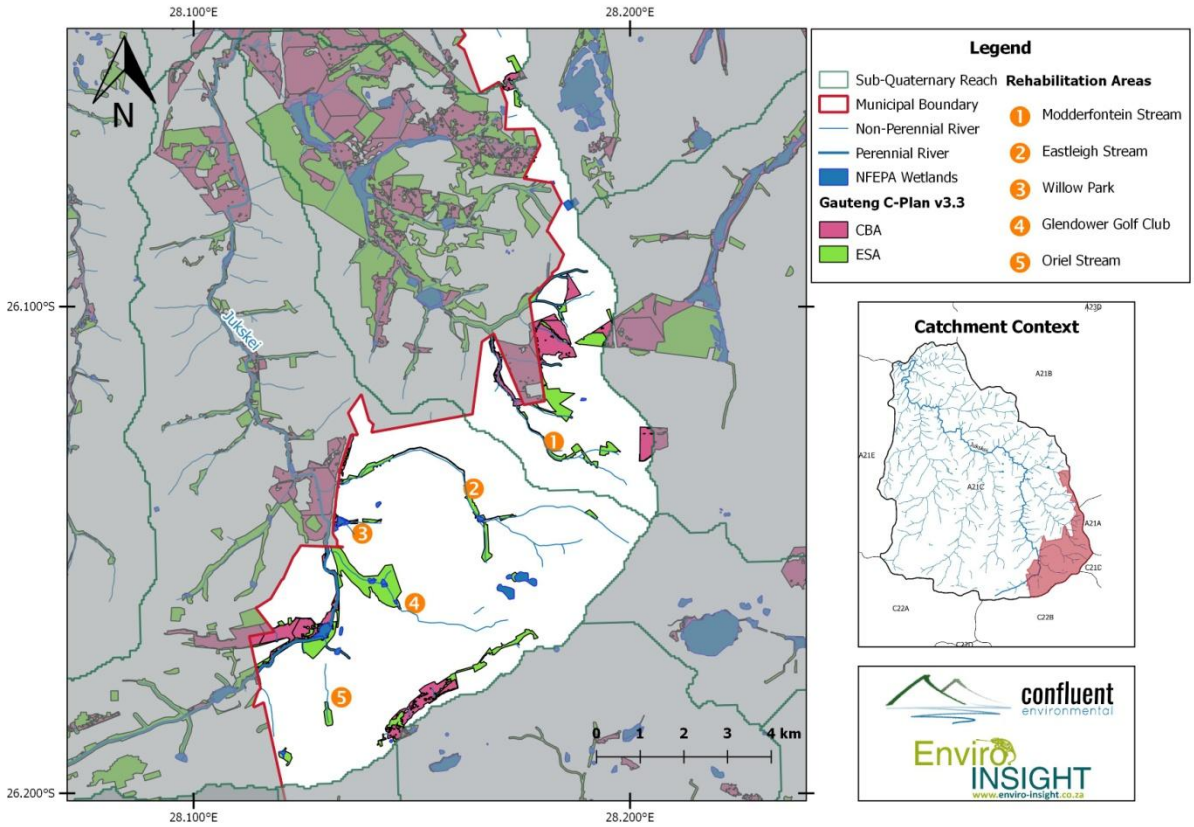

Figure 2. Map of the study area showing areas identified in the Gauteng C-plan V.3.3.

2.1 REGIONAL DESCRIPTION

The study area is located within the Highveld Ecoregion (Kleynhans *et al*., 2005). This area is distinguished by plains with low to moderate relief. The region is characterised by early to mid-summer rainfall with a mean annual precipitation of 500 – 700 mm and a moderate mean annual temperature ranging from 14°C to 18°C. The elevation of watercourses in the study area ranges from 1 570 to 1 690 m.a.m.s.l.

The geomorphological zone for the watercourses in the study area is classified as D, Upper Foothills (Rowntree *et al.,* 2000). Channel features that are characteristic of river channels in this zone are moderately steep, cobble bed or mixed bedrock-cobble bed, with plane bed, pool-rapid or pool-riffle reach types. A narrow flood plain of sand, gravel or cobble is often present.

2.2 DESKTOP PRESENT ECOLOGICAL STATE, ECOLOGICAL IMPORTANCE & SENSITIVITY

According to the desktop Present Ecological State (PES) assessment, both sub-quaternary reaches 1268 (Modderfontein) and 1269 (Jukskei) are categorised as **E, Seriously Modified**. In both SQRs, the listed impacts relate to almost every aspect of aquatic ecosystem health and habitat.

Critical impacts include algal growth, bed and channel disturbance, increased flows, runoff / effluent, and urbanisation. **Serious impacts** include canalization, alien vegetation, roads and vegetation removal. **Large impacts** include farm dams and associated inundation. **Moderate impacts** include industrial runoff / effluent and sedimentation.

Ecological Importance (EI) of a system is defined as the expression of its importance to the maintenance of ecological diversity and functioning on local as well as broader scales. Ecological Sensitivity (ES) relates to the system's resilience to disturbance, or its ability to recover from disturbance that has occurred. For both SQRs in the study area the Ecological Importance (EI) is classified as **Low**, while the Ecological Sensitivity is classified as **Moderate**. The Low category indicates catchments that are not unique at any scale in terms of their biota or habitat, are not sensitive to flow modifications and have substantial capacity for use. The Moderate category indicates catchments considered unique on a provincial or local scale due to their diversity of habitat, aquatic species and unique (rare or endangered) species.

3 HISTORIC CONTEXT

Historic photographs provide valuable insight into the reference condition of a watercourse prior to current impacts. Although many anthropogenic impacts may already have been present at the time of historic aerial surveys and maps, these images provide useful information about historic land uses and watercourse characteristics. Aerial photographs of the study area taken in 1952 are presented in Figure 3. The three photographs that cover the study area are also included as an attachment to this report, enabling the reader to enlarge areas of interest. In addition, a 1:50 000 topographic map dated 1945 is also included as an attachment as it provides useful insight into the land-use present at the time.

Glendower Stream flows in a north-westerly direction into the Jukskei River. In 1952, sections of the Glendower Golf Course were already developed. A distinct channel with a well developed riparian zone was evident in some sections, and the stream was dammed at various points in the golf course. Apart from golf course, most of the adjacent land use was small scale agriculture Figure 3a).

Oriel Stream flows in a northerly direction and historically flowed directly into the Jukskei River at Gillooly's Farm. More recently, Oriel Stream was impounded to form Gillooly's Dam before the confluence with the Jukskei River. The surrounding land use was small scale agriculture and smallholdings (Figure 3a). There was no distinct stream channel and sections of the watercourse were either dammed or had small pans according to the 1:50 000 topographic map from 1945.

Eastleigh Stream flows mainly in a western direction into the Jukskei River. In 1952 the lower reaches were largely undisturbed (presen-day Protea Park), while the middle reaches were developed suburban housing and smallholdings. Stream crossings at 4th Avenue and 6th Avenue were already present in 1952. According to both the 1:50 000 map and historical images there was a non-perennial drainage line flowing into the stream near the present-day intersection of Fountain Road and Jordaan Street. The stream mostly had a distinct channel with sections of well developed riparian zone (Figure 3b).

Willow Park was indicated as a non-perennial drainage line on the 1: 50 000 topographic map of 1945. In the aerial photograph of 1952, there is an indistinct channel and darker areas adjacent to the watercourse suggestive of a channelled valley-bottom wetland. Apart from an agricultural field upslope of the watercourse, the area was relatively undisturbed (Figure 3b).

The upper reaches of the Modderfontein Stream originate in two streams from present-day Kelvin power station and Sebenza industrial area (Kelvin and Sebenza Streams respectively; Figure 3c). Land use in the upper reaches of Sebenza Stream was generally small-scale agriculture and undisturbed land. Further downstream, the Edenvale Location human settlement occupied the area near present day Mopedi and Venda Streets in Sebenza. Kelvin Stream and the confluence area with Sebenza Stream were largely undisturbed with a number of small dams in the upper reaches of the Kelvin Stream. In the area known as Illiondale wetland, the Modderfontein Stream was impounded by a small dam. A small stream flows in a westerly direction into the Modderfontein Stream after the Illiondale Wetland. This stream was largely undisturbed with small-scale agriculture in the upper reaches.

The watercourses in this system were characterised by a distinct channel, which was braided at times without a well developed riparian zone. Given their position in the landscape they were likely to have had attributes of channelled valley bottom wetlands with small streams.


a)
Glendower Stream
Jukskei River
Oriel Stream
314


b)
314
Modderfontein Stream
Jukskei River
Eastleigh Stream
Willow Park
Glendower Stream

Figure 3. Aerial photographs taken in 1952 of the southern (a) central (b) and north-eastern (c) areas of the study site.

4 LITERATURE REVIEW

Literature was largely obtained from Irwin Juckes, the co-ordinator and founder of Edenvale RiverWatch. Edenvale RiverWatch monitors water quality and pollution of all the watercourses covered in this study. Water quality monitoring records were obtained for City of Ekurhuleni monitoring points on any watercourses in the study area.

4.1 MODDERFONTEIN STREAM

The Illiondale Wetland was comprehensively assessed, and a report published by Wetland Consulting Services for the Illiondale Wetland Rehabilitation Project (GAUT: 002/15-16/E0043) in September 2014 (WCS, 2014). The aspects covered in this study included the following: Desktop wetland delineation; determined the PES using WET-Health; determined the EIS; determined the ecosystem services using a level 2 (detailed) WET-Ecoservices; prioritised proposed rehabilitation measures. The PES was determined as **D, Largely Modified**. The EIS was determined to be Moderate. The report provides a comprehensive rehabilitation plan. The primary, short-term goals for rehabilitation were recommended as stabilisation of the channel and erosion control, and the

removal of alien invasive vegetation. The report went as far as to provide a relatively detailed budget (R1 915 901.23 excl. VAT) that included all the recommended interventions which were then prioritised. The authors determined that if the interventions were implemented, the PES of the wetland could be improved to a C, but that without intervention, the PES would likely decline to an E.

The wetland specialist report was then incorporated into very comprehensive rehabilitation plan for the Illiondale Wetland (LRI, 2014). This report provided photos of each site for intervention along with a detailed description of the intervention required and a full bill of quantities. Detailed aerial maps were provided with areas where interventions were recommended indicated on the maps. Rehabilitation measures were grouped and prioritised into Phase 1 and Phase 2. To date only part of the Phase 1 recommendations have been carried out, which included the removal of invasive vegetation such as poplars and *Arundo donax* (giant reed). These were simply cut back, but have since regrown, and the work wasn't finished (pers. comm. Irwin Juckes, June 2018).

The Modderfontein Stream including Illiondale Wetland and Kelvin Stream had a wetland delineation study conducted for the purpose of the proposed construction of the Modderfontein Outfall Sewer (Enviroguard, 2008). Included in this study was a vegetation and basic soil assessment to determine wetland indicators. This report was provided as one of the specialist studies for the Basic Assessment for authorisation to construct the outfall sewer, compiled by Seaton Thompson & Associates (GAUT: 002/08-09/N0584).

In 2007/2008 the City of Ekurhuleni commissioned a study with the aim to limit erosion and flooding of properties along the Modderfontein Stream. This was known as the Isandovale Erosion Control project (GAUT: 002/07-08/NO946). The capacity of each of the crossings of the Modderfontein Stream upstream of Modderfontein Road, including Illiondale Wetland, was assessed by MDC Consultants (MDCC, 2007). This amounted to eight stream crossings. Recommendations were made for each crossing including whether their capacity was adequate for 20-, 50-, and 100-year floods. Where capacity was inadequate, the report provides a recommendation to improve erosion control as well as a detailed budget. Environmental authorisation for these improvements was obtained from DEA in 2008 and DWS in 2012. Specialist studies were limited to birds and Mammals for this report.

In summary, the Modderfontein Stream has been quite extensively studied from the perspective of ecological attributes of the Illiondale wetland, and erosion-related impacts at stream crossings. The rehabilitation plan provided for the Illiondale Wetland appears to be comprehensive and well composed. The limited implementation of recommendations that has occurred suggests that before further studies are conducted on this section of the Modderfontein Stream, the existing body of work should be reviewed and recommendations considered for implementation.

4.2 EASTLEIGH STREAM

Storm-related flooding along Eastleigh Stream has caused severe erosion in places. As a result of damaged property to businesses along the watercourse, a number of court-cases have been brought against the municipality which has resulted in significant attention given to rehabilitation of the physical environment.

A basic assessment to upgrade 3 bridges on 1st, 4th and 6th Avenues was commissioned by The City of Ekurhuleni in 2014 (GAUT: 002/13-14/E0307). Specialist studies for this assessment were conducted by Scientific Aquatic Services (2013) and covered terrestrial aspects only (flora, fauna and habitat). This report indicated extensive alien plant invasion and habitat degradation in the vicinity of the bridge upgrades. One of the report's recommendations was to undertake an aquatic study for the purposes of the WULA. A hydrological study of the stream sections covered by the three bridges was undertaken by Sinotech CC for Ndodana Consulting Engineers to determine hydrological characteristics such as flood-lines and intervals.

An aquatic study was then undertaken by Scientific Aquatic Services (2010, updated 2017). This study comprehensively assessed aquatic ecosystem health at 3 sites in the middle reach of the Eastleigh Stream. Methods to determine the PES were SASS5 and the IHI (Index of Habitat Integrity). At all three sites in the reach studied, the PES was rated as **F (Critically Modified)** for SASS, and the IHIA was classed as **D (Largely modified)**. Fish were sampled at each point, but no fish were recorded. The Riparian Vegetation Index was measured and was categorised as class C (Moderately modified) at the upper site, but was classed as E (Seriously modified) in the middle and lower sites. The report included a DWS risk assessment which indicated that the rehabilitation activities would pose a 'low' risk.

Flooding was particularly severe in November 2016. The City of Ekurhuleni commissioned a Basic Assessment to upgrade 10 bridges and rehabilitate stream sections. This proposal also included development of an attenuation pond on the site of sports fields on Homestead Road, and upgrading of various stream sections to include culverts, concrete channels and gabion channels. This plan extends along the full length of the stream from Hurleyvale Park to the N3 just before the confluence with the Jukskei River. The City of Ekurhuleni appointed Information Decision Systems (Pty) Ltd. (IDS) as the environmental consultants for this project. It appears that an ammended authorisation from GDARD was obtained on 25 May 2018 (GAUT: 006/11-12/E0082) for the following work which covers the length of Eastleigh Stream (Table 1).

Table 1. Table extracted from the Basic Assessment report to GDARD showing the location for proposed rehabilitation work on Eastleigh Stream.

PROPOSED LOCATION	CO-ORDINATES
Rietfontein, 63, 8 (Pretoria) – 23.1 ha	26° 8'27.18"S , 28° 9'45.13"E
Concrete rectangular culvert	26°08'34.6"S 28°09'53.1"E
	26°08'01.86"S 28°09'42.93"E
	26° 7'53.63"S 28° 9'30.48"E
	26°07'44.30"S 28°09'05.84"E
	26°07'47.29"S 28°08'53.85"E
	26°07'49.06"S 28°08'48.86"E
	26°07'52.58"S 28°08'04.24"E
	26°07'54.71"S 28°08'36.12"E
	26°07'56.92"S 28°08'27.56"E
	26° 8'9.15"S 28° 8'2.99"E
Shaping of Natural Channel	(26° 9'10.88"S, 28°10'4.60"E) to (26° 8'19.22"S, 28° 9'45.65"E)
	(26°07'56.92"S 28°08'27.56"E)to (26° 8'10.55"S, 28° 7'59.80"E)
Concrete lined rectangular channel	(26° 8'19.22"S, 28° 9'45.65"E) to (26°07'49.06"S 28°08'48.86"E)
Gabion lined walls with Natural Channel	(26°07'56.92"S 28°08'27.56"E) to (26°07'49.06"S 28°08'48.86"E)

In a separate project to construct stormwater infrastructure on the northern tributary of Eastleigh Stream flowing adjacent to Beverley Avenue (GAUT: 002/17-18/E0036), an aquatic specialist assessment was carried out as part of a Basic Assessment (The Biodiversity Company, 2017). The assessment was restricted to determining the risks associated with the proposed development at a road crossing, and used basic river health monitoring methods to determine the PES **(E, Seriously modified).** The report identified existing impacts including stormwater-related erosion, invasive alien vegetation in the riparian zone, sewage and solid waste instream. The SASS score was 12 and the ASPT was 3, which is very low. Sewage was observed flowing into the tributary of Eastleigh stream at this site in July 2018 by Irwin Juckes, with the source identified upstream, somewhere in Klopper Park (Figure 4).

Figure 4. Sewage pollution in the tributary of Eastleigh Stream at Beverley Avenue, Highway Gardens (Irwin Juckes, July 2018).

In addition to sewage, industrial pollution also originates from somewhere near Klopper Park, but it remains a challenge to identify precise source locations on a more specific level without going 'door to door' and 'pipe to pipe' (Figure 5).

Figure 5. Pollution (sewage and industrial) in a channelized section of the northern tributary of the Eastleigh Stream originating in Klopper Park (Irwin Juckes, 15 June 2018).

4.3 WILLOW PARK

There is little information available for Willow Park, and no environmental studies had been sourced at the time of writing. Essentially the focus is on the dam which collects water from a small stream and is used by the local community for angling and recreation. The stream is non-perennial, and most of the water would therefore

originate from stormwater runoff. A number of articles in the Bedfordview and Edenvale Times (May, 2017; Figure 6) reported water quality issues in the dam which resulted in a fish die-off, probably due to low oxygen. Reportedly, sewage was flowing via the stream into the dam due to a blocked sewer.

Of concern is that efforts were made to rescue and move dying fish from the dam when the species involved appear to be carp and bass. As alien invasive species, it may be necessary to obtain a permit from the Department of Environmental Affairs to move fish in this category to another location, so as to restrict their distribution and impact on native fish and aquatic ecosystems where they do not yet occur. In future, the transfer of these fish species between waterbodies must be considered with caution.

Bedfordview and Edenvale News May 24, 2017

Dead fish removed from Willow Park's dam are disposed of in black bags. The fish died when sewage flowed into the dam.

Fish relocated

Before going to print, the NEWS was informed that the fish in the dam at Willow Park were to be relocated.

This information came on Friday after the dam was visited by the NEWS on May 17 when the dead and dying fish at the Dowerglen park caused concern.

The dam is home to an estimated 700 fish.

Councillor Heather Hart (ward 18) said community members and various departments from local and national government assisted on Friday.

Hart estimated that over 90 dead fish were removed from the dam.

Some of the dead fish were believed to have been between 30 and 40 years old.

On May 18, Ekurhuleni's Water and Sanitation Department took 21 000 litres of tap water to try and aerate the dam.

ECO-tabs, oxygenating tablets, were also added to the dam to try help with the oxygenation.

On Friday morning, the rescue operation continued.

Hart said local anglers on a rubber-duck boat assisted the Gauteng Fisheries Department in collecting fish from the dam.

The fish were transferred to holding tanks at the park. The tanks had been filled with clean water from the Hurlyvale Spruit.

The additional water was brought in by Ekurhuleni's parks department.

Once the fish were removed from the dam they were relocated to a dam in Primrose and a Department of Fisheries dam near Hartbeespoort.

The fish will not return to Willow Park.

"There are not enough resources to treat the dam any further," said Hart.

She said removing fish from the dam would also remove the "competition" for oxygen.

"A business owner in the Sebenza area has donated a large pump to ensure the dam remains aerated, so that the remaining fish will survive," said Hart.

She thanked all involved in the rescue operation.

"Everyone involved has been wonderful," said Hart.

Hart urged residents to report anything they feel is amiss at their local parks to their local ward councillors immediately.

A speedy response could lessen the impact on the environment.

"Residents must speak up and stand up," said Hart.

She said the fish were fortunate in this incident as some could still be saved.

Rescuers preparing for the rescue operation at Willow Park. On May 19, community members and government departments came together at the Dowerglen Dam to remove the dead fish and relocate some other fish. The fish removed from this dam are to be permanently transferred to two other dams.

www.bedfordviewedenvalenews.co.za news 3

Dead fish litter park

STEPHAN LEHMAN

Events at Willow Park, a space with the potential to be picturesque, had residents up in arms last week.

The NEWS visited the park on Wednesday and as one walked closer to the water's edge, the reason for the residents' aggravation was immediately identified - dead fish floating on the surface of the water or washed up on the banks of the dam as swarms of flies buzzed over their flesh.

The stench of sewage hung over the streams leading into the dam.

A concerned Bedfordview resident and local fisherman, Kyle Hoedemaker, contacted the NEWS and highlighted his concerns about the dam.

Hoedemaker has been fishing at the dam once a week for the past six years.

When the NEWS spoke to Hoedemaker, he said he realised something was wrong when he went to the dam on the morning of May 17.

Noticing something was amiss, Hoedemaker tried to get hold of as many people as possible for assistance.

Ward councillor Heather Hart (ward 18) was there to help.

Hoedemaker added that when, two hours later, he arrived home, he was physically ill from the sight of the dead fish. Hart said Hoedemaker was among several of the residents who had contacted her.

She said the community members claimed sewage was leaking into the dam.

Inspector Jade-Nel of the the Edenvale SPCA urged the municipality to test the water to determine what had contaminated it.

Hoedemaker explained that he had noticed the water quality at the park deteriorating for some time but never realised it was so bad.

"When water quality in a dam deteriorates the population of barbel tends to increase while carp and bass populations start to decrease or die," said Hoedemaker.

This is the second incident of fish dying at local dams.

In the April 26 edition of the NEWS, in the article *Huge rock cause of sewer spill at Gilloolys dam*, the NEWS also reported on fish dying.

Themba Gadebe, spokesperson of the Ekurhuleni Metropolitan Municipality (EMM), said at the time that it was found that a rock had blocked a sewage pipe south of Gilloolys Farm.

The sewage then flowed into the dam and killed the fish.

A request for comment was sent to the communications department of the EMM on May 18.

Comment was requested for May 19 at 10.30am.

At the time of going to print no comment had been received.

Read the update to this story, on this page.

To view the video from this news event, visit our website

A dead fish lies on the bank of the Willow Park dam.

A dead fish lying on one of the banks of the dam a Willow Park. The fish appears to be a bass.

ws.co.za Bedfordview and Edenvale News May 31, 2017

A small dead fish lies on the bank of the Willow Park dam on Wednesday, May 17. Efforts to rescue the fish began on May 18 and 19.

EMM gives comment on Willow Park catastrophe

Ekurhuleni Metropolitan Municipality has commented on the death of about 90 fish at Willow Park in Dowerglen Edenvale.

The NEWS published two articles in its May 24 edition.

The first article focused on the death of the fish and the condition of the park after the NEWS visited the park on Wednesday 17.

The second article highlighted the efforts of community members and the municipality to rescue and relocate some of the surviving fish.

Some of the fish were relocated to dams in the Primrose and Hartbeespoort areas.

Some of the fish will remain in the Dowerglen dam now that the competition for oxygen has been reduced.

In the EMM's response to the NEWS, Themba Gadebe, spokesperson and senior media manager, said a blocked sewer was to blame for the death of the fish.

Gadebe said a team of technicians attended to a sewer blockage on the corner of Hendrik Potgieter Avenue and Elm Street.

In order to prevent further wildlife catastrophes Gadebe said plans have been put in place by the EMM.

"The sweeping of all sewer pipelines in the area is currently under way. CCTV inspections of the pipelines will also be conducted to identify any problematic pipelines in an effort to prevent future blockages," said Gadebe.

He said the water at the dam was treated and aerated on the weekend of May 27 in an effort to oxygenate the water to prevent further fish deaths.

"The aquatic wildlife living in the City of Ekurhuleni is very high on the city's priority list and all measures will be put in place to prevent the re-occurrence of such incidents," said Gadebe.

To read the initial article on the fish at Willow Park, visit our website

Figure 6. Articles from the Bedfordview & Edenvale Times during May 2017 reporting the fish kill at Willow Park.

4.4 GLENDOWER STREAM

Glendower Stream has had serious issues with flooding as well as pollution from sewage. A section of the stream south of the N12 highway known as the Solheim storm water channel was earmarked for stabilisation following extensive erosion. A draft Basic Assessment (GAUT 002/13-14/E0294) and WULA were compiled in May 2015 which included a desktop aquatic ecology assessment completed by Ecotone Freshwater Consultants (2014). This highlighted aquatic ecological considerations for the proposed emergency stabilisation of the stream due to extensive erosion. Overall, this study classified the PES as **D, Largely Modified**. The results of the IHI

resulted in a riparian PES of E and an instream PES of F. The latter reflects the very poor water quality in this stream. Recommendations were made to re-introduce indigenous vegetation and improve the biodiversity of the stream.

4.5 ORIEL STREAM

Stormwater attenuation was a significant problem in the upper reaches of Oriel Stream, which high rates of erosion and flooding of properties. A rehabilitation plan was proposed for the stream in Oriel Park and a basic assessment was completed for this project in 2012 (GAUT: 002/11-12/E0052) by Chameleon Environmental. An aquatic specialist study was completed as part of this project which included an assessment of Oriel Stream in Oriel Park, and a number of sites downstream (S.A.S., 2011). Based on SASS5 results the Ecological Category of the stream was determined to be E/F, Seriously to Critically Modified. This project appears to have been mostly implemented, although the planting plan doesn't seem to have been carried out completely.

Discussions with Councillor Jill Humphries and Irwin Juckes suggest that sewage overflows into the stream have occurred frequently at various times. This has resulted in significant nutrient enrichment of the dam at Gillooly's Farm which has intermittent fish kills as a result (reported in Bedfordview & Edenvale Times, April 2017). There is a fairly natural pan that was recently rehabilitated at Oriel Park in Bedfordview, which may serve as a reasonable reference site for the stream. The pan is naturally fed by groundwater and is therefore largely independent of the water flowing through the stream. Problems with stormwater flooding lead to the recent rehabilitation of Oriel Park at Kloof Road and included the construction of flood attenuation ponds along the watercourse.

5 WATER QUALITY REVIEW

The City of Ekurhuleni monitors water quality on a bi-monthly (every 2nd month) basis at six monitoring points in the study area (**Error! Reference source not found.**). Comprehensive water quality records were not made available at the time of writing this report, but a summary of the faecal coliform data collected between 2013 and 2018 were obtained from Irwin Juckes and this information is presented in **Error! Reference source not found.**.

Faecal coliforms are considered an indicator of sewage. Although on their own they are not detrimental to the ecological health of rivers, they provide evidence of recently discharged sewage effluent which is rich in the nutrients responsible for eutrophication (enrichment) of water resources. Their numbers are also closely correlated to pathogen causing viruses and bacteria. From a human health perspective, the presence of elevated faecal coliforms is a useful indicator that the water may pose a human health risk depending on the level of exposure.

It is not anticipated or recommended that humans drink raw water from any of the watercourses in the study area so comparison to drinking water guidelines is not practical. Given that many watercourses occur in recreational parks, it is conceivable that there may be a degree of light exposure to the water through splashing or playing.

Therefore the guideline most appropriate for comparison would be the South African Water Quality Guidelines for Recreational Water Use (DWAF, 1996). The target water quality guideline for intermediate contact recreation is 0 – 1000 counts per 100ml. Water quality monitoring results show extremely high levels of faecal coliforms throughout the period of measurement, and most sites are almost permanently contaminated (**Error! Reference source not found.**). The only sites where water quality very occasionally meets the target are at the outflow of Gillooly's Dam (JG6) and Kelvin Stream (J2).

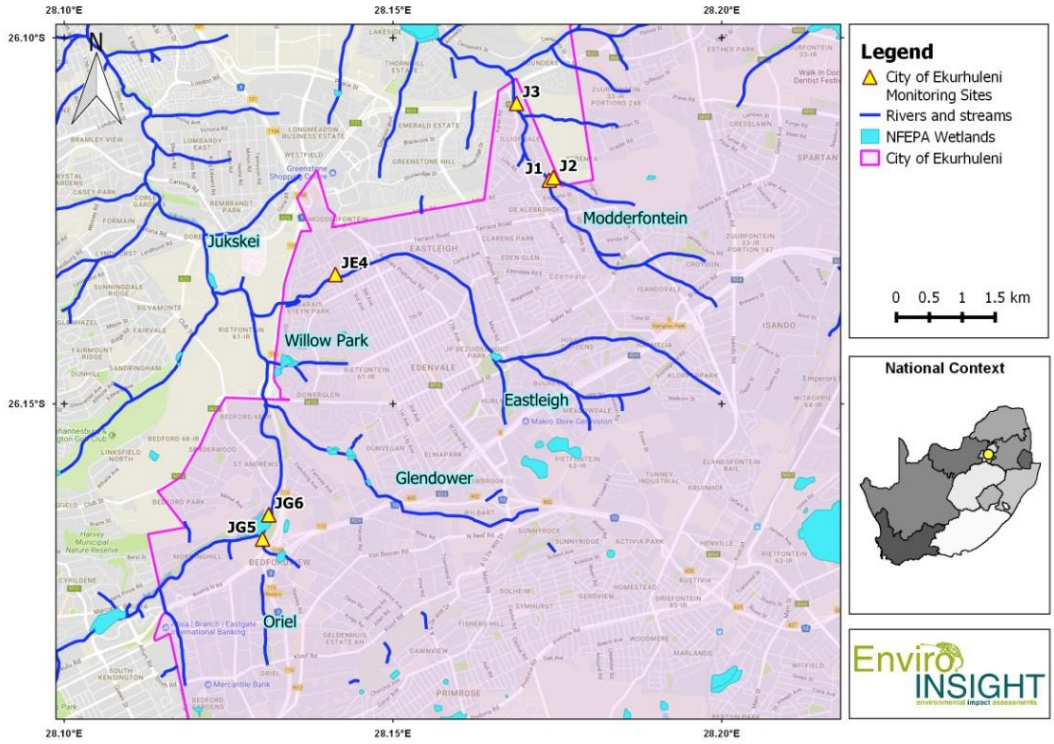

Figure 7. Map of the study area showing the location of six locations (yellow triangles) where water quality is monitored by the City of Ekurhuleni.

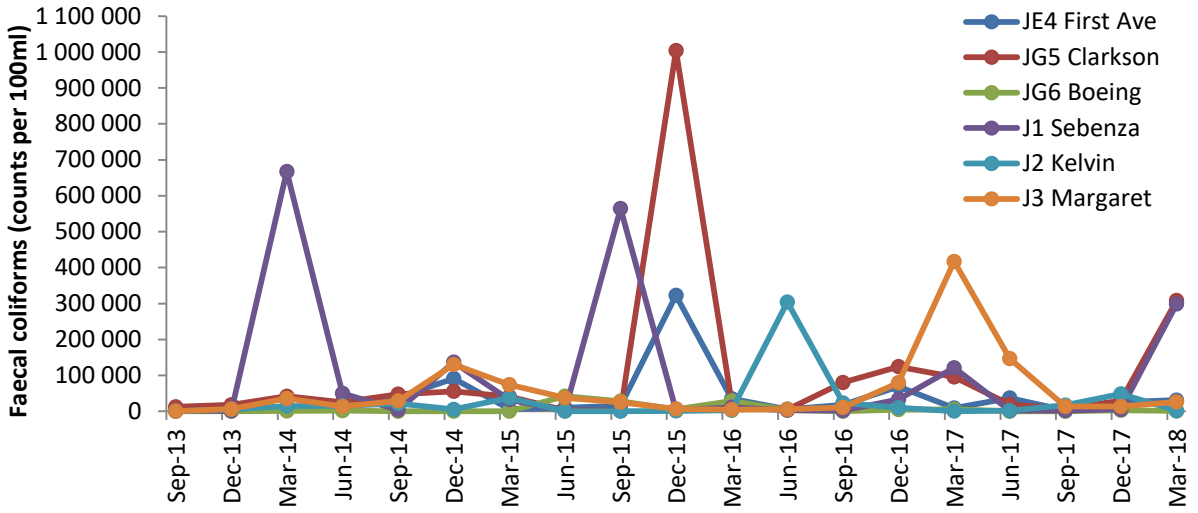

Figure 8. Faecal coliform counts (per 100 ml) measured at six CoE water quality monitoring points in the study area.

5.1 WATER QUALITY MONITORING

The constituents routinely monitored are Chemical Oxygen Demand (COD), Electrical Conductivity (EC), faecal coliforms, manganese, nitrogen, phosphorus, pH and suspended sediments. These constituents are a reasonable selection of parameters, but there are deficiencies in the reporting which make interpretation and use of the information difficult. It is not clear what forms of nitrogen and phosphorus are being measured as these are reported simply as 'N' and 'P'. An additional form of nitrogen is reported as 'NOX' which usually relates to nitrogen oxide measured in atmospheric emissions. None of the units of measurement (e.g. µg/L or mg/L) are reported for any of the measured constituents, making it difficult to compare results to water quality guidelines. A colour-coded key is provided which categorises results as ideal, acceptable, tolerable or unacceptable. The reference for this key is not provided and it is therefore unclear what water guidelines are being used for comparison. When this point was queried, the respondent indicated that the guidelines for instream water quality for the Klip River catchment are used for comparison. This does not make sense because the Klip River is another catchment altogether. Results are averaged per quarter which reduces the statistical power of long-term trend analyses, and obscures extreme values (high or low). Finally, the results are not freely available on request. One needs to provide an official request in writing and supply an appointment letter for a project in order to access the data.These records should be freely available to the public as they are in the public interest and public funds are used to obtain them. Although a written request was made for the data during the initial stages of this project, no data had been made available by the time the report had been completed.

The only water quality data available for analysis was obtained from records maintained by Irwin Juckes.

5.2 FAECAL COLIFORMS

Faecal coliforms are considered an indicator of sewage. Although on their own they are not detrimental to the ecological health of rivers, they provide evidence of recently discharge sewage effluent which is rich in the nutrients responsible for eutrophication (enrichment) of water resources. Their numbers are also closely correlated to pathogen causing viruses and bacteria. From a human health perspective, the presence of elevated faecal coliforms is a useful indicator that the water may pose a human health risk depending on the level of exposure.

It is not anticipated or recommended that humans drink raw water from any of the watercourses in the study area so comparison to drinking water guidelines is not practical. Given that many watercourses occur in recreational parks, it is conceivable that there may be a degree of light exposure to the water through splashing or playing. Therefore the guideline most appropriate for comparison would be the South African Water Quality Guidelines for Recreational Water Use (DWAF, 1996). The target water quality guideline for intermediate contact recreation is 0 – 1000 counts per 100ml. Water quality monitoring results show extremely high levels of faecal coliforms throughout the period of measurement, and most sites are almost permanently contaminated (Figure 9). The only sites where water quality very occasionally meets the target are at the outflow of Gillooly's Dam (JG6) and Kelvin Stream (J2).

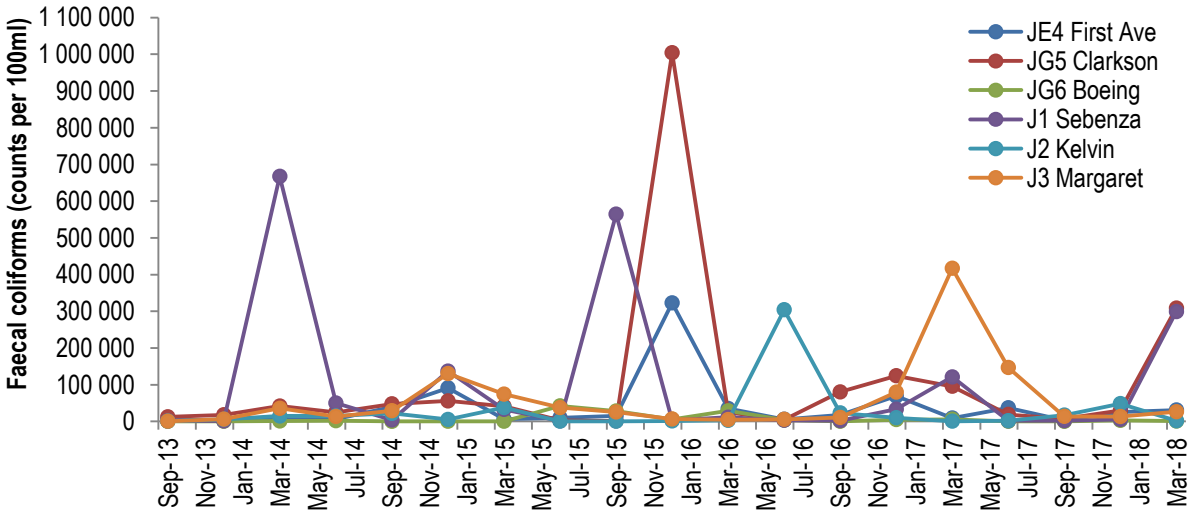

Figure 9. Faecal coliforms measured at six monitoring sites bi-monthly from 2013 to 2018 by the City of Ekurhuleni.

5.3 STUDY SITES

Based on a review of literature, water quality monitoring data and known pollution sources, a number of sites were selected along each of the five watercourses. There are thirteen sites in total. Their location is shown in Figure 10 along with a photograph and brief description inTable 2. Sites selected were considered representative

of the general impacts affecting aquatic ecosystem health for each watercourse. An area ranging from 150m to 300 m was investigated along the watercourse at each site, depending on available access.

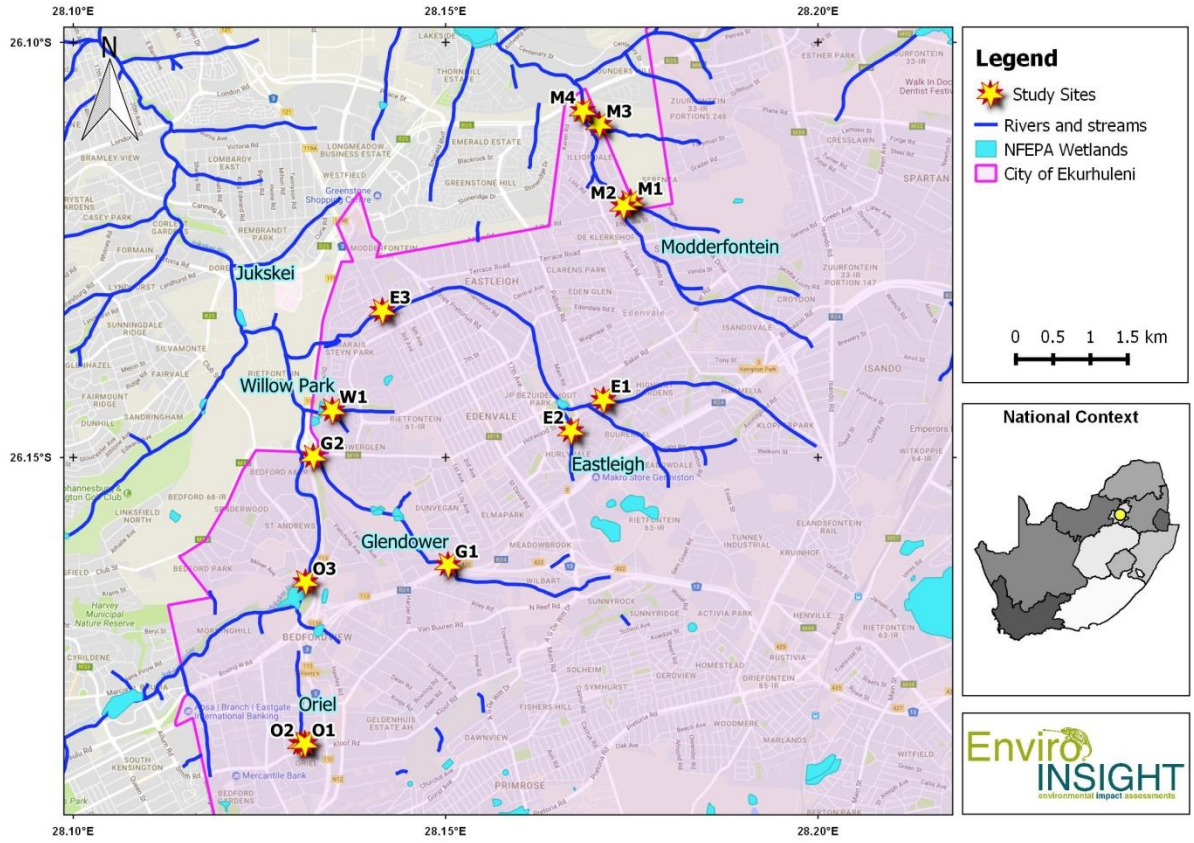

Figure 10: Map depicting the location of thirteen study sites selected for this project.

Table 2. Photographic and descriptive overview of the thirteen study sites assessed in this project.

Site	Photograph	Description
M1 Modderfontein Stream		Downstream of Kelvin power station, comparable to the CoE monitoring site J2. Upstream of the confluence with M2 (Sebenza Stream). Start: Lat. -26.119427°, Lon. 28.175828° End: Lat. -26.119173°, Lon. 28.173706° Distance: 220 m
M2 Modderfontein Stream		Downstream of Sebenza industrial area (known as Sebenza Stream) and upstream of the confluence with M1. Site may be compared to CoE Site JE1. Start: Lat. -26.119173°, Lon. 28.173706° End: Lat. -26.120393°, Lon. 28.174129° Distance: 150 m
M3 Sebenza Stream		West of the boundary between CoE and CoJ, downstream of piped stream-flow under a dirt road crossing. Water quality and diatoms sampled upstream from a seep, and SASS5 attempted at the pictured site, which proved inadequate. Start: Lat. -26.110250°, Lon. 28.170415° End: Lat. -26.110167°, Lon. 28.173378° Distance: 300 m

M4 Modderfontein Stream		South of Modderfontein Road, downstream of the wastewater pump station, Founders Hill South outfow, and CoE Site J3. The area extended from Modderfontein Road to Margaret Road. Start: Lat. -26.109023°, Lon. 28.168860° End: Lat. -26.106826°, Lon. 28.168371° Distance: 260 m
E1 Eastleigh Stream		In the park adjacent to Beverley Avenue, downstream of the piped outflow which originates at Klopper Park industrial area. Start: Lat. -26.143216°, Lon. 28.170209° End: Lat. -26.142857°Lon. 28.172709° Distance: 250 m
E2 Eastleigh Stream		In the park, upstream of the confluence with E1 stream at Horwood's Farm. Also known as Hurleyvale Stream. Access from St. Andrew Road. Start: Lat. -26.147717°, Lon. 28.166910° End: Lat. -26.145606°, Lon. 28.166823° Distance: 240 m

E3 Eastleigh Stream		In Protea Park upstream of 1st Avenue Bridge (pictured). May be compared to CoE monitoring Site JE4. Start: Lat. -26.132823°, Lon. 28.139897° End: Lat. -26.132066°, Lon. 28.142386° Distance: 260 m
W1 Willow Park		Upstream of the dam at Willow Park, water quality and diatoms sampled from the stream. SASS5 not possible due to unsuitable habitat and inadequate flow. Start: Lat. -26.144158°, Lon. 28.136664° End: Lat. -26.144287°, Lon. 28.134713° Distance: 900 m (incl. around dam)
G1 Glendower Stream		Stream assessed between the N12 highway and Boeing Road East. Start: Lat. -26.163332°, Lon. 28.150474° End: Lat. -26.162702°, Lon. 28.150177° Distance: 80 m

G2 Glendower Stream		Sampling conducted at the north-western point of the Glendower Golf Club a short distance before the stream is channelled under the N3 highway. Start: Lat. -26.150544°, Lon. 28.133033° End: Lat. -26.149836°, Lon. 28.131816° Distance: 280 m
O1 Oriel Stream		Pan in Oriel Park which is sustained by groundwater, separate from Oriel Stream which flows approximately 40m away. Location: Lat. -26.184378°, Lon. 28.131043°
O2 Oriel Stream		Stream in the upper part of Oriel Park, before the first flood attenuation dam. May be used as a reference site for the CoE monitoring Site JG5, which is at the inflow of Oriel Stream into Gillooly's Dam. Start: Lat. -26.185976°, Lon. 28.130997° End: Lat. -26.182898°, Lon. 28.130635° Distance: 330 m

O3 Oriel Stream		Downstream of Gillooly's Dam before the confluence between the Jukskei River and Oriel Stream. May be compared to the CoE monitoring Site JG6. Start: Lat. -26.165350°, Lon. 28.131068° End: Lat. -26.163814°, Lon. 28.130760° Distance: 220 m (plus around the dam)

6 METHODS

Each of the sites was assessed in a similar way, except where the type of watercourse or flow conditions required alternative protocols. Upon arrival at each site, approximately 150 m of the watercourse was explored upstream and downstream in order to select appropriate sample collection points (e.g. for water and diatoms) and identify instream and riparian impacts affecting aquatic ecosystem health.

6.1 *IN SITU* WATER QUALITY

At each site where water was present, a hand-held multiparameter water meter was used to measure dissolved oxygen (DO; mg/L), electrical conductivity (EC; µS/cm), temperature (°C) and pH.

6.2 INSTREAM WATER CHEMISTRY AND MICROBIOLOGY

At each site where water was present, two individual one litre water samples were collected for water chemistry and microbiology analysis respectively. Water chemistry samples were refrigerated until delivery to Aquatico Laboratories in Centurion, where they were analysed for the following parameters: chloride (Cl), sulphate (SO_4), orthophosphate (PO_4), ammonium (NH_4), nitrate + nitrite (NO_3 + NO_2), total kjeldahl nitrogen (TKN), total phosphorus (TP), total suspended solids (TSS), total nitrogen (TN), and a scan for metal elements using ICP-MS.

Microbiology samples were maintained at room temperature until delivery to the Water Resources Microbiology Laboratory at the Council for Scientific and Industrial Research (CSIR) in Pretoria. Samples were analysed for *Escherichia coli*, total faecal coliforms and *Vibrio cholerae*. Quantification of *E. coli* and total coliforms was carried out using the Colilert™ Most Probable Number (MPN) method (IDEXX, USA) according to the

manufacturer's protocol. For the detection of *Vibrio cholerae*, 100 mL of water sample was added to 100 mL of double-strength Alkaline Peptone Water (APW) [1% peptone, 0.5% NaCl (w/v), pH 8.4] and incubated overnight at 35°C. One mL was collected from the overnight incubation of APW and was centrifuged at 13000 rpm. The supernatant was discarded and the DNA was extracted from the cells using InstaGene™ Matrix (Biorad Technologies) according to the manufacturer's protocol. For the detection of *V. Cholerae* (all strains) the gene coding for the Outer Membrane Protein (*ompW*) was targeted using real-time PCR (Nandi *et al*., 2000; le Roux *et al*., 2011). For the detection of enterotoxigenic strains, the *ctxAB* genes were targeted in a real-time PCR amplifying a section of the cholera toxin A and B sub-unit (Goel *et al*., 2005; le Roux *et al*., 2011).

Results of the water quality analyses were compared to the South African Water Quality Guidelines (DWAF, 1996) for recreational use or aquatic ecosystem health, where most appropriate.

6.3 AQUATIC ECOSYSTEM HEALTH

6.3.1 SASS5

At each site where flowing water was present the assessment included bio-monitoring of aquatic macroinvertebrates using the South African Scoring System version 5 (SASS5) based on the method developed by Dickens and Graham (2002). In brief, the method involves the collection of macroinvertebrates from different riverine habitats (stones, vegetation, gravel, sand and mud). Each of the taxa have been allocated a sensitivity score based on their ability to tolerate degradation of water quality or habitat. Samples from each of the habitats are identified and their abundance is scored for 15 minutes. The combined sensitivity scores of all the taxa are summed to provide the SASS score which gives an indication of the ecological state of the river. The SASS score divided by the number of taxa recorded, gives the Average Score Per Taxon (ASPT) which gives a good indication of the state of the stream.

6.3.2 Region-specific assessment of macroinvertebrates

Macroinvertebrate communities may vary depending on the ecoregion within which they occur, and differences in abundance and diversity are not always reflective of modified water quality or habitat. In order to interpret the SASS scores in relation to established scores in the same ecoregion, the SASS5 and ASPT scores were compared to reference values obtained from Dallas (2007; Figure 11). Plotted scores result in a category for each site within a biological band which can be used to indicate the present state of the site according to various classes (**Error! Reference source not found.** and Table 3).

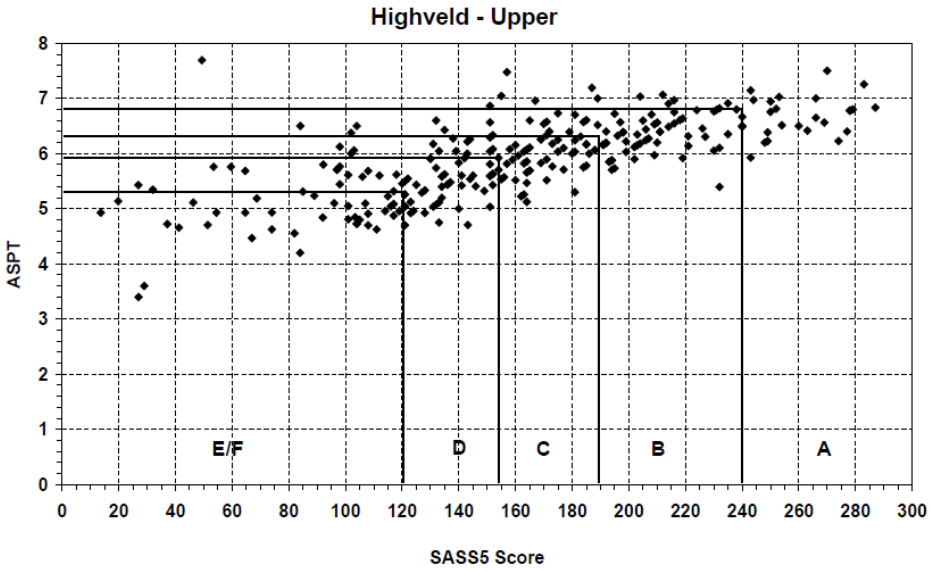

Figure 11: Biological bands for the Highveld upper zone, calculated using percentiles (Dallas, 2007).

Table 3. Biological bands / ecological categories for interpreting SASS data.

Class	Ecological Category	Description
A	**Natural**	Unmodified natural. High abundance and diversity, including sensitive taxa.
B	**Good**	Largely natural with few modifications. High diversity, but lowered sensitivity.
C	**Fair**	Moderately modified. Fair diversity of taxa present.
D	**Poor**	Largely modified. Mainly tolerant taxa present.
E/F	**Seriously modified**	Severely impacted. Only the most tolerant taxa present.

6.3.3 Diatom communities

Diatoms are a unicellular group of algae. They are widely used as indicators of river and wetland health as they provide a rapid response to specific physico-chemical conditions in the water and are often the first indication of change. The presence or absence of indicator taxa can be used to detect specific changes in environmental conditions such as eutrophication, organic enrichment, salinisation and changes in pH. Diatoms are therefore useful for providing an overall picture of trends within an aquatic system.

Methods of sample collection and analyses were according to Taylor *et al.* (2005). At each site where flowing water was present, the upper surface of five individual stones was scrubbed with a toothbrush to remove

diatoms. The water from this exercise was preserved in a container to a final volume of 20% alcohol. Samples were sent to Dr. Jonathan Taylor at the University of the North-West for analysis and species identification following Taylor *et al*. (2007). The aim of the data analysis was to identify and count diatom valves (400 counts) to produce semi-quantitative data from which ecological conclusions can be drawn. An ecological category of the watercourse was derived using the Specific Pollution Sensitivity Index (SPI; CEMAGREF, 1982; Table 4) which was calculated in OMNIDIA Ver. 4.2 (Lecointe *et al*., 1993). Additional metrics were determined using the % deformed valves and % pollution tolerant valves.

Table 4. Ecological categories derived from the SPI score which is based on diatom communities.

Interpretation of index scores		
Ecological Category (EC)	**Class**	**Index Score (SPI Score)**
A	High quality	18 - 20
A/B		17 - 18
B	Good quality	15 - 17
B/C		14 - 15
C	Moderate quality	12 - 14
C/D		10 - 12
D	Poor quality	8 - 10
D/E		6 - 8
E	Bad quality	5 - 6
E/F		4 - 5
F		<4

6.4 WATERCOURSE HABITAT ASSESSMENT

At each of the study sites, and particularly where flowing water wasn't present, the instream and riparian habitat was assessed. Critical factors that influence the structure and function of aquatic communities is the condition of the surrounding physico-chemical habitat. Habitat loss, alteration, or degradation generally results in a decline in species diversity. The Index of Habitat Integrity (IHI) was developed by Kleynhans (1996) as a rapid assessment of the severity of impacts affecting habitat integrity within a river reach. It can be applied to both perennial and non-perennial watercourses. The following instream impacts were assessed in this study: water abstraction; flow modification; bed modification; channel modification; physico-chemical modification; inundation; alien macrophytes; and rubbish dumping. The riparian impacts assessed were: vegetation removal; exotic vegetation; bank erosion; channel modification; water abstraction; inundation; flow modification; physico-chemistry. Each of the impacts are given a score based on their degree of modification (1-25; Table 5), along with a confidence rating based on the level of confidence in the score. The scores were determined after walking upstream and downstream along the watercourse for approximately 150m.

Table 5: Descriptive classes for the assessment of habitat modifications (Kleynhans, 1996)

Impact Class	Description	Score
None	No discernible impact, or the modification is located in a way that has no impact on habitat quality, diversity, size and variability.	0
Small	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.	1-5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability is limited.	6-10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11-15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not affected.	16-20
Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	21-25

An IHI class is then determined based on the resulting score (Table 6). These results provide an indication of the present ecological state (PES) as observed at the site compared to that determined in the desktop PESEIS (DWS, 2014).

Table 6: Index of habitat integrity (IHI) classes and descriptions.

Integrity Class	Description	IHI Score (%)
A	Natural	> 90
B	Largely Natural	80 – 90
C	Moderately Modified	60 – 79
D	Largely Modified	40 – 59
E	Seriously Modified	20 – 39
F	Critically Modified	0 – 19

6.5 ASSUMPTIONS AND LIMITATIONS

- Aquatic ecosystem health assessments were limited to approximately 150 m of stream habitat investigated at each site during the site visit. An investigation of the entire length of each stream system was beyond the scope of this study. Study sites were considered representative of impacts affecting each stream.

- The study was conducted during low flow conditions thus constraining conclusions regarding the PES and water quality of watercourses to this season only. However, this is beneficial in terms of understanding the 'worst case scenario' for water quality as low flow conditions have the lowest dilution factor.

7 RESULTS

The study area was visited over a period of 5 days from 26 – 30 June 2018. Water was present at low to moderate flow levels at most sites.

7.1 WATER QUALITY

Dissolved oxygen levels were mostly within acceptable limits for ecosystem health. Low concentrations at Site M3 were probably related to the sampling location being downstream of water emanating from underground as the stream 'ducks and dives'. Whereas low concentrations at Site E3 were related to the sewage observed flowing into the site, which has the effect of increasing the biological oxygen demand. Site O1 is a pan with zero flow and high amounts of organic matter, therefore the low oxygen levels are to be expected.

Eutrophication is one of the biggest threats to water quality in South Africa. The trophic state (degree of nutrient enrichment) of a waterbody can be inferred from the concentration of nutrients such as nitrogen and phosphorus. While these concentrations are transient in a flowing system such as a stream or river, temporary increases in nutrient levels are cause for concern because they can lead to the eutrophication of receiving waterbodies such as reservoirs (dams) where outflow may be limited and nutrients readily accumulate. Concentration ranges used to classify the trophic state are presented in Table 7, and range from oligotrophic (least enriched) to hypertrophic (most enriched).

At the time of water sample collection, Sites E2 and O1 showed the least level of eutrophication in the study area and could be classified as oligotrophic / eutrophic (Table 8). Sites G1, O2 and O3 could be considered mestrophic / eutrophic. On the basis of phosphorus concentrations, a large number of sites could be considered eutrophic / hypertrophic including M1, M2, M3, M4, E1, E3, W1, and G2.

Table 7. Trophic status classification based on total inorganic nitrogen (TIN) and phosphorus (TIP) values (DWAF, 1996), and total phosphorus (TP) values (DWAF, 2002)

Parameter	Oligotrophic	Mesotrophic	Eutrophic	Hypertrophic
Inorganic nitrogen (mg/L)	< 0.5	0.5 - 2.5	2.5 - 10	> 10
Inorganic phosphorus (µg/L)	< 5	5 - 25	25 – 250	> 250
Total phosphorus (µg/L)	< 15	15-47	47 – 130	> 130

Total suspended solids (TSS) results were within acceptable levels for aquatic ecosystem health at all sites. The highest value was 54 mg/L at Site M1 (Kelvin Stream) which reflected a plume of turbid water that temporarily flowed downstream whilst the site was being visited. This was also reflected in the EC value which was highest at this site (1 467 µS/cm). These values are likely to increase during summer when elevated flows cause erosion.

Chloride is generally a conservative ion, found in low concentrations in natural surface waters. Where elevated concentrations occur this usually indicates sources such as wastewater from industry or sewage treatment, or water softening. Sites M1 and M4 had slightly elevated concentrations which may be related to activities at Kelvin Power Station and the malfunctioning pump station at these sites respectively. The extremely high chloride concentrations at Site M3 (783 mg/L) were probably related to sewage, given the correspondingly high concentrations of phosphorus and elevated microbial counts.

Sewage pollution was strongly indicated at almost every site due to elevated faecal coliform and *E. coli* counts. The only two sites that had no evidence of recent sewage inflow were Site G1 on Glendower Stream, and Site O1 which is an isolated pan fed by groundwater in Oriel Park. This suggests that every other site is impacted by sewage inflows, even if they aren't visible as grey / black water with a strong smell. These levels of microbial contamination are above the limits acceptable for even light exposure for recreational use. Given that most of the watercourses assessed were in public parks used for recreation where humans and pets may be exposed to the water, this represents an unacceptable health risk.

The presence of enterotoxigenic *Vibrio cholerae* was not detected at any sites. These *V. cholerae* have Cholera Toxin (CT) and Toxin Co-Regulated Pilli (TCP) and are therefore fully capable of causing cholera epidemics. However, environmental *Vibrio cholerae* (non-toxigenic) were detected at Sites M1, M2, M4 and E2. Non-toxigenic *V. cholerae* are a strain that lack the genes that code for CT, and typically also lack crucial virulence factor like the TCP which play an important part in virulence (severity of disease). Cholera epidemics are caused exclusively by *V. cholerae* strains that have the ability to produce CT. However, lacking those genes does not mean that environmental *V. cholerae* strains cannot cause disease - as most of them have a number of other virulence genes and accessory toxins to their disposal. They can cause cholera-like symptoms and are also known for wound infections. They are seen as opportunistic pathogens.

It is important to note that although Sites M1 and M2 are separated from Site M4 by the extensive area of Illiondale Wetland, there is virtually no improvement in water quality because of the leaking sewage at Site M4. Therefore any effect of remediation that the wetland may have on water quality is lost due to the inflow of further pollution.

The results of the semi-quantitative scan for elements are presented in Table 9. A total of 68 elements were included in the scan, but only results where values were detectable were presented. Many of the elements have no established guidelines for aquatic ecosystem health, and the results are (as the name indicates) semi-quantitative and it is therefore not entirely accurate to compare values to water quality guidelines. However, the

results confirm what elements are present, and where they occur. This information can help to identify pollutants at different sites.

Another indicator of sewage is the presence of Boron, which is used in laundry detergents. Elevated Boron levels were detected at all sites except O1 and O2. The latter indicates that the sewage stream entering Oriel Park does not contain high quantities of domestic grey water. The highest Boron concentrations were on the Modderfontein Stream at Sites M1 and M4. Barium concentrations were similar at all watercourses which is indicative of normal background levels. Elevated copper levels were detected at Sites M1 and M4 which is probably reflective of a degree of enrichment. Gallium is an element increasingly being used in the manufacture of high-speed semiconductors, particularly in solar panels. Elevated levels were detected at Sites M1, M3 and M4. Lithium was also detected at M1 and M4. In both cases the concentrations measured at M4 for these elements are lower than upstream, indicating that M1 and M2 are the source. Lithium is used in pharmaceuticals and in the manufacture of batteries among other uses. Molybdenum was detected at Site M1 only. It is used to make electrodes and electrical filaments. Nickel and rubidium were only detected at Sites M1 and M4. The origins of nickel can be from power plants, waste incinerators, and metal industries. Rubidium has a number of uses, the most likely of which to originate in the catchment is the development of photocells. Although strontium was detected at all sites, it was highest at Site M1.Strontium is used to make red flares (in fireworks, tracer bullets and flares), refine zinc, old television tubes and in the formulation of various alloys. Both vanadium and tungsten were also elevated at Sites M1 and M4. Tungsten is used to make tools as well as in electrical and lighting industries.

The results confirm that Modderfontein Stream is most negatively impacted by industrial waste, which probably originates from multiple sources. The industries likely to be involved including electrical, lighting, batteries and Kelvin power station. These results suggest that industrial impacts are not related to Kelvin power station alone, although it is the largest land user on the Kelvin Stream.

Table 8. Water chemistry and microbiology results for thirteen study sites.

Site	pH	DO mg/L	EC µS/cm	Temperature °C	Cl mg/L	SO_4 mg/L	TIN mg/L	TN mg/L	TIP µg/L	TP µg/L	TSS mg/L	*E. coli* Count/100ml	Total Coliforms Count/100ml	*V. cholerae* (enterotoxigenic)	*V. cholerae* (non-toxigenic)
M1	8.5	7.5	1467	15.2	146	262	18.91	38.6	691	877	54	770.1	> 2419.6	ND	✓
M2	7.6	7.9	289	12.8	15.1	261	0.99	2.03	166	233	BD	410.6	> 2419.6	ND	✓
M3	7.58	4.09	2540	9.5	789.0	114	0.52	1.38	405	480	10	6.3	> 2419.6	ND	ND
M4	8.6	8.1	817	15.3	69.4	113	8.31	12.4	440	687	29	> 2419.6	> 2419.6	ND	✓
E1	7.5	2.6	489	10.0	44.8	22.7	0.63	2.97	405	670	6	57.1	> 2419.6	ND	ND
E2	8.0	7.5	844	12.4	91.8	105	1.86	4.02	17	23	26	209.8	> 2419.6	ND	✓
E3	8.0	6.8	515	9.7	41.2	66.7	2.16	4.54	154	257	BD	123.4	> 2419.6	ND	ND
W1	9.5	10.5	629	10.2	34.1	28.8	1.84	3.64	64	173	51	1	> 2419.6	ND	ND
G1	8.6	8.2	---	19.2	30.3	57.6	2.45	5.65	19	67	5	<1	5.2	ND	ND
G2	8.1	8.1	515	13.0	39.0	58.7	4.69	6.87	226	400	11	> 2419.6	> 2419.6	ND	ND
O1*	7.25	3.63	284	10.5	26.9	12.0	0.48	6.30	20	70	BD	13.4	114.5	ND	ND
O2	7.79	6.6	286	16.5	22.3	26.9	4.22	8.94	28	63	BD	> 2419.6	> 2419.6	ND	ND
O3	8.7	8.4	420	12.0	33.8	44.1	1.98	4.46	17	63	13	4.1	1986.3	ND	ND

* Site O1 is a lentic waterbody, a pan; BD = below instrument detection limits; ND = Not Detected; Trophic state represented by green shading, refer to Table 7; *Vibrio cholerae* values are either detected or not detected in 100ml of water.

Table 9. Semi-quantitative results for the elemental scan for 13 study sites.

Element	Study Sites												
	M1	M2	M3	M4	E1	E2	E3	W1	G1	G2	O1	O2	O3
Ag (Silver, mg/L)	< 0.010	**0.029**	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Al (Aluminium, mg/L)	0.401	< 0.100	< 0.100	0.130	< 0.100	< 0.100	< 0.100	0.234	< 0.100	< 0.100	< 0.100	< 0.100	0.192
B (Boron, mg/L)	**0.983**	**0.025**	**0.098**	**0.386**	**0.066**	**0.051**	**0.030**	**0.028**	**0.065**	**0.087**	< 0.010	< 0.010	**0.007**
Ba (Barium, mg/L)	0.068	0.044	0.088	0.050	0.038	0.052	0.050	0.057	0.059	0.034	0.073	0.048	0.050
Ca (Calcium, mg/L)	95	24	96	51	33	77	44	35	38	44	24	21	37
Cu (Copper, mg/L)	**0.017**	< 0.010	< 0.010	**0.016**	< 0.010	< 0.010	< 0.010	< 0.010	0.100	< 0.010	< 0.010	< 0.010	< 0.010
Fe (Iron, mg/L)	0.626	0.062	< 0.025	0.037	0.443	0.040	0.127	0.691	0.185	0.115	0.288	0.084	0.368
Ga (Gallium, mg/L)	**0.019**	< 0.010	**0.011**	**0.010**	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.010	< 0.010	< 0.010
K (Potassium, mg/L)	35	3.1	1.7	16.6	3.6	2.0	2.6	2.8	2.8	3.7	1.2	1.1	1.8
Li (Lithium, mg/L)	**0.777**	< 0.010	< 0.010	**0.287**	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Mg (Magnesium, mg/L)	22	16	153	20	15	48	29	17	25	27	14	15	23
Mn (Manganese, mg/L)	0.074	< 0.025	< 0.025	< 0.025	0.213	< 0.025	0.035	0.141	0.112	0.038	< 0.025	< 0.025	0.064
Mo (Molybdenum, mg/L)	**0.169**	< 0.010	< 0.010	0.062	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Na (Sodium, mg/L)	150	12	251	81	42	18	24	27	19	29	12	11	16
Ni (Nickel, mg/L)	**0.019**	< 0.010	**0.026**	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Rb (Rubidium, mg/L)	**0.051**	< 0.010	< 0.010	**0.021**	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Si (Silica, mg/L)	13.7	4.2	8.6	7.9	9.2	8.1	7.1	5.3	8.5	5.2	6.7	9.5	6.2
Sr (Strontium, mg/L)	2.04	0.110	0.392	0.768	0.146	0.310	0.194	0.134	0.165	0.169	0.111	0.084	0.139
Ti (Titanium, mg/L)	0.068	0.019	0.076	0.037	0.027	0.061	0.040	0.034	0.030	0.036	0.021	0.018	0.042
V (Vanadium, mg/L)	**0.077**	< 0.010	< 0.010	**0.028**	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
W (Tungsten, mg/L)	**0.058**	< 0.010	< 0.010	**0.021**	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Zn (Zinc, mg/L)	0.059	0.084	0.040	0.079	0.045	0.044	0.035	0.039	0.075	0.037	0.049	0.074	0.032

7.2 AQUATIC ECOSYSTEM HEALTH

The following biomonitoring results for SASS5 and diatoms can be used as a baseline reference for winter from which to monitor and compare changes following rehabilitation measures.

7.2.1 SASS5

The results of the SASS5 survey were fairly similar across sites, with each site sampled categorized as E/F, Seriously Modified in the context of the upper Highveld ecoregion (Table 10; Figure 12). This result indicates that the taxa present were highly tolerant of elevated pollution levels. While some sites may be less impacted than others, generally speaking aquatic ecosystem health is very poor in all the watercourses studied, as reflected by the macroinvertebrate assemblage. There was a general lack of the gravel, sand and mud (GSM) biotope, as well as instream vegetation, which is likely related to annual flooding and scouring of the stream bed. This was reflected in the generally poor habitat scores. Habitat was further affected at Site E1 where the stream bed was mostly concrete, and at Site M3 where water levels were too low to permit sampling of a wide range of biotopes. The actual SASS sheet for each site is available in the Appendices.

Table 10. Macroinvertebrate biomonitoring results

Site	SASS score	No. of taxa	ASPT	Habitat (%)	Ecological category
M1	16	5	3.2	33	E/F
M2	23	8	2.9	29	E/F
M3	14	3	4.7	13	E/F
M4	20	7	2.9	36	E/F
E1	11	4	2.8	13	E/F
E2	35	9	3.9	49	E/F
E3	10	4	2.5	49	E/F
W1*	-	-	-	-	-
G1	35	10	3.5	40	E/F
G2	34	11	3.1	36	E/F
O1*	-	-	-	-	-
O2	38	11	3.5	38	E/F
O3	34	11	3.1	40	E/F

*** SASS not done due to unsuitable conditions**

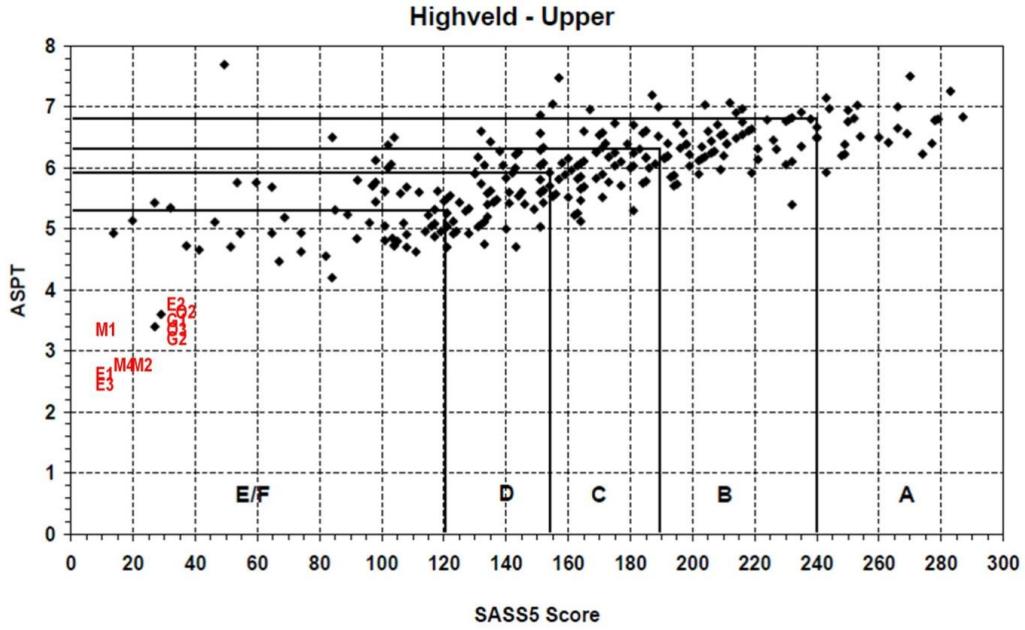

Figure 12: Biological bands for the upper Highveld depicting the plotted study sites.

7.2.2 Diatom Analysis

Diatoms are largely reflective of site-specific water quality as they are less influenced by habitat quality and availability than macroinvertebrates. The latter may also move between sites more readily via drift than diatoms which generally adhere to a substrate. The ecological categories for each of the sampling sites based on diatom species compositions are presented in

Where dominant species are indicative of osmotic fluctuations this indicates their tolerance to fluctuations in electrical conductivity which may indicate the presence of industrial wastes. This was the case at Sites M1, M2, M3 and E1. All of the Modderfontein Stream sites occur downstream of industrial areas (Kelvin power station and Sebenza).

At some sites diatom communities reflected a higher ecological category downstream than at upstream sites. This was the case for Eastleigh Stream, Glendower Stream and Oriel Stream. This indicates that despite impacts upstream, there are factors mitigating the impacts on water quality downstream which in all likelihood include dilution of pollutants, and the presence of impoundments (pollution traps). This pattern was not observed in Modderfontein Stream where despite the stream flowing through Illiondale wetland before reaching the downstream site, diatom communities reflected high levels of pollution. This is due to the fact that both sewage and industrial wastewater emanate from the site, thus reducing any positive effects the wetland may have had.

Table 11. Based on the diatom species compositions, the most impacted sites were M2, M4, E1 and G1, largely as a result of high nutrient inputs. Given that no other major sources of nutrients occur within these catchments (e.g. agriculture), the source of nutrients is likely to be sewage. These sites were categorized as F (Bad water

quality). The two least impacted sites were E2 and G2, categorized as Moderate quality, where periodic increases in nutrients were reflected by the dominant diatom species. The remaining sites were categorized as poor quality. The complete record of diatom species collected from each site is available in the appendices.

The % of pollution tolerant valves was considered high and indicative of organic pollution at every site except E2, O1 and O3. Organic material is largely composed of carbon-based dead matter. Sites where the % PTV is high are likely impacted by wastewater containing sewage, as this is high in organic matter. The % deformed valves (individual diatoms) is considered indicative of toxins if the value exceeds 2%. Therefore potentially toxic water quality constituents are likely to be present periodically at Sites M3, M4, E1, G1 and G2. The origins of toxins could be wastewater from sewage or industrial sources.

Where dominant species are indicative of osmotic fluctuations this indicates their tolerance to fluctuations in electrical conductivity which may indicate the presence of industrial wastes. This was the case at Sites M1, M2, M3 and E1. All of the Modderfontein Stream sites occur downstream of industrial areas (Kelvin power station and Sebenza).

At some sites diatom communities reflected a higher ecological category downstream than at upstream sites. This was the case for Eastleigh Stream, Glendower Stream and Oriel Stream. This indicates that despite impacts upstream, there are factors mitigating the impacts on water quality downstream which in all likelihood include dilution of pollutants, and the presence of impoundments (pollution traps). This pattern was not observed in Modderfontein Stream where despite the stream flowing through Illiondale wetland before reaching the downstream site, diatom communities reflected high levels of pollution. This is due to the fact that both sewage and industrial wastewater emanate from the site, thus reducing any positive effects the wetland may have had.

Table 11. Diatom index scores and ecological category of sites based on diatom species composition.

Site	# Species	SPI	%PTV	% Deformed	Ecological Category	Dominant species pollution indicator
M1	11	5.3	96	1	E	Osmotic fluctuations, eutrohpication
M2	8	3.2	99	0.3	F	Osmotic fluctuations, eutrohpication
M3	9	6.5	79	2.5	D E	Osmotic fluctuations, eutrohpication
M4	14	3.7	87	6.3	F	Osmotic fluctuations, eutrohpication
E1	12	2.9	69	2.8	F	Organic pollution, osmotic fluctuations
E2	17	10.4	14	1.5	C D	Moderate organic pollution, eutrophication
E3	15	6.1	23	0.3	D E	High salinity, eutrophication
W1	16	7.4	75	0.8	D E	Moderate to high pollution tolerance
G1	5	4.3	40	2.5	E F	Moderate organic pollution, eutrophication
G2	15	10.2	23	2.3	C D	Moderate organic pollution, eutrophication
O1	19	7.2	7	0	D E	Pollution tolerant
O2	21	4.6	81	0	E F	Organic pollution
O3	34	10.6	7	1.8	C D	Eutrophication, well oxygenated waters

SPI = Specific Pollution sensitivity Index; PTV = Pollution Tolerant Valves (> 20% indicates significant organic pollution); > 2% Deformed indicates toxin impacts.

7.2.3 Aquatic Ecosystem Health Summary

The combined results of the macroinvertebrate and diatom indices provide an integrated assessment of water quality and habitat degradation at each site. The SASS5 results uniformly indicated all sites to be in a Seriously Modified condition. While this result was maintained by the diatom analysis for Sites M2, M4, E1, and G1, the ecological conditions of the remaining sites was slightly better. This is because the indices are measuring different aspects of ecosystem health. In both indices, the dominant taxa present at sites were largely pollution tolerant with low sensitivity scores. One of the benefits of using the diatom indices is that the dominant species at each site provide insights into the causes of degraded water quality. The dominant species clearly indicated wastewater related impacts largely associated with sewage, as well as industrial sources. For these indices to improve, impacts affecting water quality must be significantly reduced. The improvement of instream habitat would require improved flood attenuation to reduce instream scouring and loss of vegetation, but this would result in more diverse habitat for macroinvertebrates. However, even with the most diverse habitat, the community will not respond positively until the water quality is improved.

7.3 WATERCOURSE HABITAT ASSESSMENT

7.3.1 Modderfontein Stream

The results of the IHI for Modderfontein Stream show the instream and riparian habitat to be in a Seriously to Critically Modified state (E/F; Table 12). Photographs depicting some of the major impacts to instream and riparian habitat are shown in Figure 13. The largest instream impact is degraded water quality which is largely attributable to sewage and industrial wastewater. The pump station located at Site M4 had been continuously discharging significant volumes of wastewater for an extended period of time (weeks to months) at the time of the site visit. While assessing Site M1, a plume of polluted water was observed in the stream and was sampled. The most likely source of this would be Kelvin Power Station. Along the length of the sites assessed, the riparian zone was thoroughly invaded by alien plants, and where this was not the case vegetation had been removed by burning at Sites M1 and M2. Some work has been completed at the confluence of Sebenza and Kelvin Streams in order to stabilize the stream banks. However, there is extensive erosion upstream of this intervention on Sebenza Stream which has resulted in an exposed pipeline and collapsing banks. Erosion has also taken place in the stream section between Margaret Road and Modderfontein Road, where floodwaters have eroded stream banks causing gabion structures to fail in some places.

Rubbish dumping was commonly observed in open areas adjacent to the stream. This is one impact that could be mitigated by fencing and securing open spaces.

Table 12. Index of Habitat Integrity (IHI) assessment for **Modderfontein Stream**

Habitat Modification	Impact score 1-25 (Confidence)	Explanation
		INSTREAM
Water abstraction	6 (3)	No point source water abstraction but extensive growth of alien invasive trees would reduce water available for stream flow.
Flow	18 (4)	Increased flows associated with urban development / effluent; moderate flows during winter maintained and evidence of flood flows during summer rainfall season.
Bed	18 (4)	Scouring due to floods; historic ash spills cleaned up by power station, absence of gravel, sand and mud biotopes in streams; infrastructure such as gabion aprons.
Channel	20 (4)	Enlarged and incised by flood flows of large volumes of water; modified through infrastructure such as road bridges, culverts, weirs and supporting gabions.
Physico-chemistry	22 (5)	Frequent sewage inflows (poor microbiology, high nutrients), industrial pollution from numerous sources, ash spills.
Inundation	6 (3)	Minor inundation upstream of weirs but there are no known major impoundments in this stream section.
Alien macrophytes	0 (3)	Nothing causing a major obstruction to flow or influencing water quality.
Introduced aquatic fauna	0 (3)	None known to cause a significant impact to instream habitat.
Rubbish dumping	12 (3)	Mainly occurs in the riparian zone where it is quite prevalent.
		INSTREAM INTEGRITY CLASS = E, SERIOUSLY MODIFIED
		RIPARIAN
Vegetation removal	12 (3)	Burning along stream banks; mowing and clearing of vegetation in parks and along servitudes.
Exotic vegetation	18 (4)	Extensive stands of *Populus* spp., *Acacia mearnsii, Arundo donax*, *Solanum mauritianum*, *Eucalyptus* spp., *Salix babylonica* and complete invasion of *Pennisetum clandestinum* along stream edges.
Bank erosion	22 (4)	Extensive areas where banks are undercut and eroded; infrastructure (e.g. pipelines) exposed and damaged by flooding; failure of bank stabilising structures (e.g. gabions).
Channel modification	18 (4)	Channel enlarged and incised by floods, and infrastructure such as bridges, culverts etc.;
Water abstraction	0 (3)	None that is affecting the riparian zone.
Inundation	3 (3)	Very few locations where inundation upstream of infrastructure (e.g. weir) causes inundation and loss of the riparian zone.
Flow modification	10 (4)	Increased and seasonally sustained flows related to urban development have resulted in a more developed riparian zone compared to historical images.
Physico-chemistry	0 (4)	In most cases the channel is so deep and incised that riparian vegetation is barely influenced by instream water chemistry.
		RIPARIAN INTEGRITY CLASS = F, CRITICALLY MODIFIED

Figure 13: Photographs showing some of the impacts considered in the Index of Habitat Integrity for the Modderfontein Stream.

7.3.2 Eastleigh Stream

The results of the IHI for Eastleigh Stream show the instream and riparian habitat to be in a Seriously to Critically Modified state (E/F; **Error! Reference source not found.**). Photographs depicting some of the major impacts to instream and riparian habitat are shown in **Error! Reference source not found.**

Stream water at Site E1 (also known as Harmelia Stream) emerges from two pipes on the eastern side of the park where it has travelled underground for approximately 1.2 km from Klopper Park. The water was grey and foamy with a distinct sewage smell. Most of the stream bed is concrete, however, there are parts where this has deteriorated and broken up. The banks have been severely eroded by stormwater related flooding. Moderate to severe erosion was evident all along the river reach assessed, and previous attempts to stabilize the banks have failed. Dumping of rubble and building material was observed adjacent to the river. The riparian zone was dominated by alien plants with a number of very large *Eucalyptus* sp. trees at the site. The park at Site E1 has the potential to be a good recreational site because it is in a secured suburb with access control on Beverley Avenue. However, public health and safety would be at risk given the current water quality and deteriorating infrastructure in the stream.

The habitat assessment at Site E2 (also known as Hurleyvale Stream) was better than E1. No obvious sewage was flowing in the stream, although the water quality results did indicate high counts of faecal coliforms (Table 8). This indicates a leakage of sewage must be entering the watercourse at an unknown point upstream. Although some flood-related erosion was observed downstream of the St Andrew Road bridge, the banks were fairly stable along most of the reach assessed. An abundance of invasive alien plants are present along the riparian zone upstream of St Andrew Road, and downstream large alien trees are dominant. Given the stable banks and relatively secure access to the park, this site would be a good area for focused rehabilitation to remove alien plants and regenerate the indigenous riparian zone.

Site M3 is located in Protea Park, which appeared to be somewhat unsafe, with several vagrants apparently overnighting in small shelters in the park. Banks along the Eastleigh Stream at this site have been severely eroded, and significant damage has occurred to infrastructure at the 1st Avenue road crossing. The instream habitat at Site M3 was among the best of all sites, with islands of marginal vegetation, riffles, runs and glides. As with most sites however, there was limited gravel, sand and mud due to instream scouring. Significant amounts of solid waste (e.g. entire t.v. sets) were found in the stream, and large quantities of flood-related debris were washed up against the road bridge. Extensive growth of invasive alien plants in the riparian zone was observed downstream of 1st Ave. bridge. Alien plant growth was less abundant upstream of 1st Ave. bridge.

Table 13. Index of Habitat Integrity (IHI) assessment for **Eastleigh Stream**

Habitat Modification	Impact score 1-25 (Confidence)	Explanation
		INSTREAM
Water abstraction	6 (3)	No point source water abstraction but extensive growth of alien invasive trees would reduce water available for stream flow.
Flow	23 (4)	Moderate flows during winter maintained, and severe damage from flood flows in summer due to urban densification.
Bed	21 (4)	Stream piped underground and canalised through urban areas for extensive distances; natural stream bed scoured due to floods; absence of gravel, sand and mud biotopes in streams.
Channel	22 (4)	Natural areas enlarged and incised by flood flows of large volumes of water; In places no channel exists where stream is piped or canalised.
Physico-chemistry	22 (4)	Frequent sewage inflows (poor microbiology, high nutrients), industrial pollution from sources such as Klopper Park; prolific growth of filamentous algae due to eutrophication
Inundation	10 (3)	Inundation at Horwood's Farm at the dam, but not a major impact elsewhere.
Alien macrophytes	0 (3)	Nothing causing a major obstruction to flow or influencing water quality.
Introduced aquatic fauna	0 (3)	None known to cause a significant impact to instream habitat.
Rubbish dumping	12 (3)	Mainly occurs in the riparian zone where it is quite prevalent but there is also a significant amount of solid waste instream as a result of floods.
		INSTREAM INTEGRITY CLASS = E / F, SERIOUSLY TO CRITICALLY MODIFIED
		RIPARIAN
Vegetation removal	18 (3)	Mowing and clearing of vegetation in parks. Complete loss where stream is piped or canalised.
Exotic vegetation	18 (4)	Extensive stands of *Populus* spp., *Acacia mearnsii, Arundo donax*, *Solanum mauritianum*, *Eucalyptus* spp., *Salix babylonica, Amaranthus hybridus* and complete invasion of *Pennisetum clandestinum* along numerous stream sections.
Bank erosion	23 (4)	Significant areas where flood flows have cause severe damage to bridges (e.g. 1st Avenue) and the associated banks. One of the most prevalent impacts.
Channel modification	18 (4)	Channel enlarged and incised by floods, and infrastructure such as bridges and culverts
Water abstraction	0 (3)	None that is affecting the riparian zone.
Inundation	10 (3)	Inundation at Horwood's Farm at the dam, but not a major impact elsewhere.
Flow modification	10 (4)	Increased and seasonally sustained flows related to urban development have resulted in a more developed riparian zone (dominated by aliens) compared to historical images.
Physico-chemistry	3 (3)	In most places the channel is deeply incised, piped or canalised, effectively separating the riparian zone from the water.
		RIPARIAN INTEGRITY CLASS = F, CRITICALLY MODIFIED

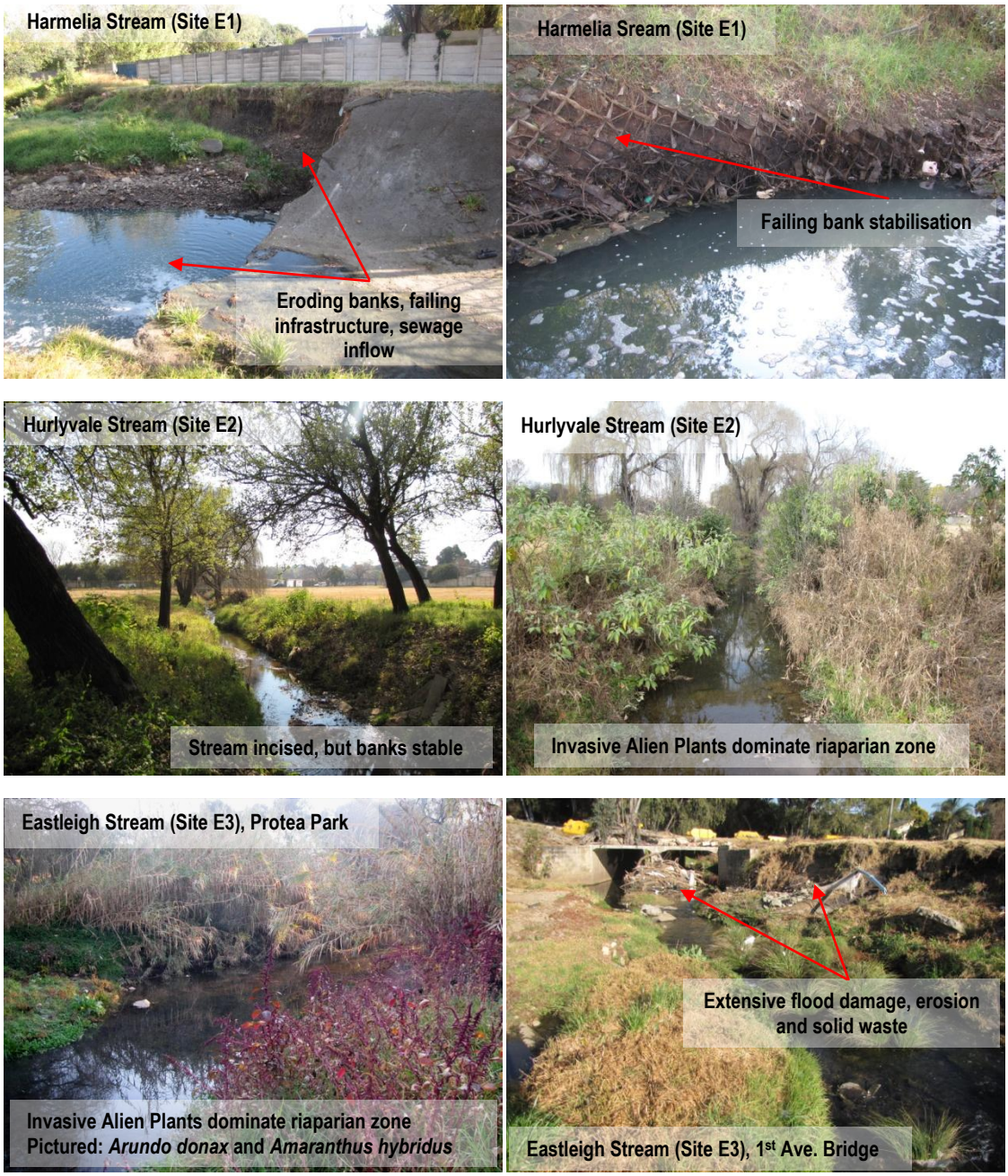

Figure 14: Photographs showing some of the impacts considered in the Index of Habitat Integrity for the Eastleigh Stream.

7.3.3 Willow Park

The dam was circumnavigated and the entire length of the stream was investigated in Willow Park. The park is surrounded by palisade fencing in an access-controlled suburb and is therefore relatively secure. The stream originates upstream in a small park in Dowerglen adjacent to Tamboekie Street, and is impounded at Willow Park. This represents a significant interruption in connectivity of the aquatic system from the Jukskei River which is largely responsible for the result of the IHI class of E/F, Seriously to Critically Modified (Table 14).

Water quality has historically been affected by sewage inflows which have resulted in fish kills (See appendices). Impoundments with limited outflows are highly susceptible to eutrophication if they receive high nutrient loads, and therefore every effort should be made to prevent the inflow of wastewater. If and when fish kills do occur, it should be noted that the species present are largely alien invaders and may not be rescued and moved without permits (as has occurred previously).

Alien plants in the park could relatively easily be controlled as they are largely in isolated stands, and there are a fair number of established indigenous plants. There is a small non-perennial drainage line that flows into the dam on the southern side, which provides a good impression of the reference condition of the original stream (Figure 15). The original stream has been entirely concreted which severely limits the structure and function of the aquatic ecosystem. However, given the relatively limited stream length and secure access to the park (± 210 m) it may be feasible to rehabilitate the stream and attempt to re-construct a more natural watercourse typical of what would have been present at the site. At the bare minimum, park management plans should be altered to prevent mowing of the stream edges to allow the regeneration of an appropriate buffer zone of vegetation. This would provide cover for a range of small mammals and habitat for instream macroinvertebrates such as Odonata (dragonflies and damselflies).

Table 14. Index of Habitat Integrity (IHI) assessment for **Willow Park**

Habitat Modification	Impact score 1-25 (Confidence)	Explanation
		INSTREAM
Water abstraction	0 (4)	No water abstracting activities, dam is for recreation and flood attenuation.
Flow mod.	22 (4)	Dam altered environment from a non-perennial lotic to a perennial lentic system.
Bed mod.	22 (4)	Inundation of stream bed, concrete in stream channel upstream of the dam.
Channel mod.	22 (4)	Inundation of stream channel, concrete where stream channel would have been.
Physico-chemistry	18 (4)	Water chem. Indicates sewage; historic fish kills due to sewage pollution; could support algal blooms.
Inundation	20 (5)	Large area of the original stream is now inundated due to the dam.
Alien macrophytes	0 (2)	None observed.
Introduced aquatic fauna	10 (4)	Carp (*Cyprinus carpio*) and Bass (*Micropterus* sp.) known to be present.
Rubbish dumping	5 (4)	Mild impact, mainly rubbish left by people picnicking.
		INSTREAM INTEGRITY CLASS = E / F, SERIOUSLY TO CRITICALLY MODIFIED
		RIPARIAN
Vegetation removal	15 (4)	Grass in the park is mowed right to the edge of the stream, but not the dam.
Exotic vegetation	8 (3)	Mainly around the dam, large stand of *Acacia mearnsii* on western edge, isolated stands of *Populus* sp., *Salix babylonica, Solanum mauritianum*, and *Amaranthus hybridus* Many other indigenous trees, sedges and reeds around the dam.
Bank erosion	5 (4)	Not significant in the park, but downstream there is erosion from overflows from the dam.
Channel mod.	22 (4)	Combination of concreted stream bed and inundation have irreversibly altered the channel.
Water abstraction	0 (4)	No known water abstraction activities.
Inundation	22 (4)	Inundation has permanently flooded and altered the original riparian zone.
Flow mod.	15 (3)	Flow modified from a lotic to a lentic system, flooding the riparian zone and reducing connectivity.
Physico-chemistry	5 (2)	Nutrient enrichment would increase the density of marginal vegetation.
		RIPARIAN INTEGRITY CLASS = E / F, SERIOUSLY TO CRITICALLY MODIFIED

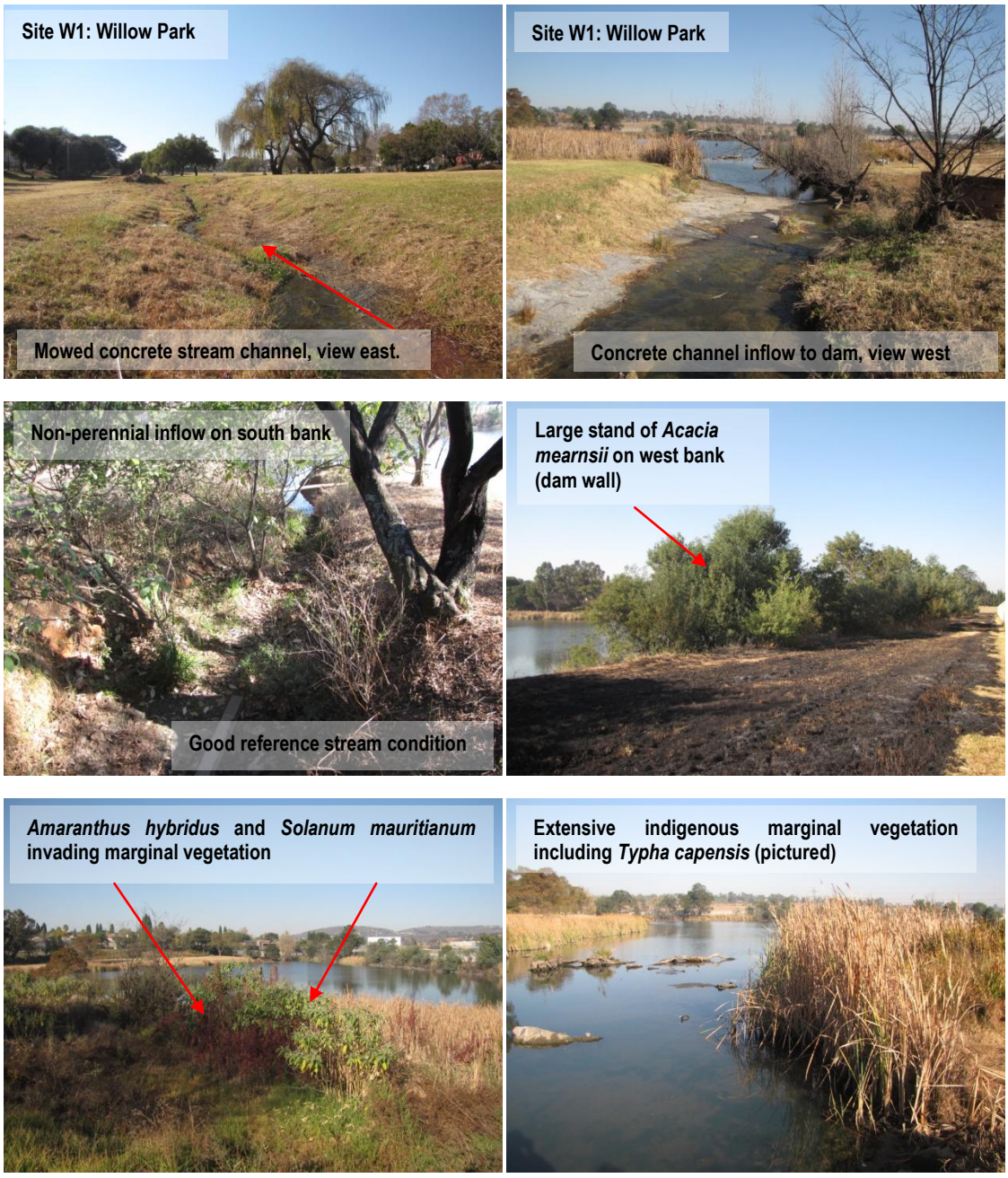

Figure 15. Photographs showing some of the impacts considered in the Index of Habitat Integrity for Willow Park.

7.3.4 Glendower Stream

Multiple impacts are affecting the instream and riparian habitat integrity of Glendower Stream, which have led to the IHI classification of E/F, Seriously to Critically Modified (Table 15). The stream begins in the Wilbart industrial area and is channeled for a section of approximately 500m before flowing under the N12 highway and into the Glendower Golf Club where it flows through a series of dams for approximately 2km before being channeled under the N3 highway and into the Jukskei River.

Major impacts affecting the instream integrity of Glendower Stream begin with water quality which has been repeatedly impacted by sewage and industrial waste. The latter originating from the Wilbart Industrial area. Sewage was observed flowing into the stream from a point source on Linksfield Road at the time of the site visit (Figure 16). Bed and channel modification has occurred as a result of channeling and dam construction. Severe flooding of the stream transports large quantities of sediment downstream to the golf course, where the dams are almost completely silted up. These impoundments would benefit from dredging as it would increase their capacity to attenuate floods and remove accumulated nutrients from the sediment.

Major impacts affecting the integrity of the riparian zone relate to the removal of indigenous vegetation and the large numbers of alien species. This has occurred to a large extent at the golf course where grass is kept mown right along the stream edge, and invasive trees dominate the landscape. The riparian zone has also been completely modified where impoundments have been created.

Flooding has caused serious bank erosion and scouring of the stream bed in several places. Gabions supporting the banks at the outflow from the golf course are sagging and require support following flood damage.

Table 15. Index of Habitat Integrity (IHI) assessment for **Glendower Stream**

Habitat Modification	Impact score 1-25 (Confidence)	Explanation
		INSTREAM
Water abstraction	4 (3)	Water may be abstracted by the golf course for irrigation purposes.
Flow mod.	18 (4)	Significantly higher flows than would be expected due to urban runoff, historic flood events in Solheim, impoundments in the golf course.
Bed mod.	18 (3)	Stream channelled in upper catchment, bed scoured by floods.
Channel mod.	18 (3)	Stream channelled in upper catchment, incised and eroded in places due to flooding, banks replaced with gabions in sections.
Physico-chemistry	20 (5)	Intermittent but frequent inflows of sewage and industrial wastewater. Latter recorded from Wilbart Industrial area.
Inundation	10 (3)	Several impoundments causing inundation at the golf course; mostly instream, but some are offstream, thus limiting their impact to the stream course.
Alien macrophytes	0 (3)	None observed
Introduced aquatic fauna	0 (1)	None observed, but possibly alien fish introduced to golf course dams.
Rubbish dumping	5 (3)	Large amounts of rubble dumped at Site G1.
		INSTREAM INTEGRITY CLASS = E, SERIOUSLY MODIFIED
		RIPARIAN
Vegetation removal	23 (4)	Complete vegetation removal in channelized section upstream and at the golf course.
Exotic vegetation	20 (4)	Mostly alien trees at the golf course including *Eucalyptus* sp., and *Salix babylonica*
Bank erosion	15 (4)	Upstream erosion due to flooding, but less in the golf course which receives a lot of the silt transported downstream.
Channel mod.	18 (4)	Stream channelled in upper catchment, banks replaced with gabions all lead to entire loss of the riparian zone; severely modified by impoundments in the golf course.
Water abstraction	0 (4)	Although water is abstracted from the stream, the modified high flows are greater than would be expected under natural conditions.
Inundation	15 (4)	Significant alteration of natural riparian habitat through inundation of dams at the golf course.
Flow mod.	15 (3)	Flow reduced to lotic conditions at impoundments which favours different riparian species, increased flood flows and overtopping banks causes damage to the riparian zone.
Physico-chemistry	10 (2)	Nutrient enrichment would increase the density of marginal vegetation which is mainly exotic.
		RIPARIAN INTEGRITY CLASS = F, CRITICALLY MODIFIED

Figure 16. Photographs showing some of the impacts considered in the Index of Habitat Integrity for Glendower Stream.

7.3.5 Oriel Stream

The IHI assessment classified the instream habitat of Oriel Stream as E, Seriously Modified, and the riparian habitat as E/F, Seriously to Critically Modified (Table 16). Instream water quality is significantly impacted by sewage which was flowing into the stream at Oriel Park on the day of this assessment. Historic fish kills have occurred at Gilllooly's Dam which were linked to large volumes of sewage inflow. As there is a limited outflow of water from the dam, it is sensitive to eutrophication. Eutrophication of the dam will result in bloom of aquatic flora such as macrophytes or algae which detract from the visitor's experience, cause bad smells, and further exacerbate water quality issues. This situation is to be avoided at all costs and is best prevented by reducing or eliminating the inflow of sewage.

Characteristics of the stream bed and channel have been significantly altered during rehabilitation of the stream in Oriel Park, including the gabion and brick channel downstream of the park. In addition, the impoundment of Oriel Stream at Gillooly's Dam has resulted in the permanent loss of bed and channel characteristics.

Recent rehabilitation efforts at Oriel Park have made a significant improvement in the attenuation of floods during high rainfall events. Two attenuation dams have been constructed which effectively reduce downstream impacts of flooding. Rehabilitation efforts could be greatly enhanced by adjusting the park management plan to exclude mowing of the stream edges, and implementing the re-vegetation of stream banks with indigenous wetland plants. There are natural seeps in the park, especially near Site O1 (the pan) which could become an extended mosaic of wetland if mowing ceased and wetland plants were introduced..

Severe erosion is taking place downstream of Gillooly's Dam before the confluence with Jukskei River. This area is largely out of sight and difficult to access, in part because flood waters have so badly eroded the bed and banks of the river. The gradient is fairly steep at this point which leads to more rapid flows. There are huge *Eucalyptus* sp. trees that have fallen across the stream, trees are covered in flood debris, large boulders have been exposed, and an adjacent property is in danger of losing their fence in the next significant flood.

Table 16. Index of Habitat Integrity (IHI) assessment for **Oriel Stream**

Habitat Modification	Impact score 1-25 (Confidence)	Explanation
		INSTREAM
Water abstraction	0 (3)	None known.
Flow mod.	15 (3)	Increased flows above natural conditions, more frequent floods, alteration of flow from lotic to lentic at Gillooly's Dam.
Bed mod.	20 (4)	Scouring due to floods, alteration for rehabilitation in Oriel Park, inundation at Gillooly's Dam.
Channel mod.	20 (4)	Re-shaped during rehabilitation in Oriel Park, completely modified in sections of channelized gabions
Physico-chemistry	20 (3)	Sewage flowing into the stream at Oriel Park from Bedford Centre direction, periodic spills from the N3 highway washed into the stream, fish kills have occurred at Gillooly's Dam due to sewage inflows.
Inundation	15 (4)	Impoundment at Gillooly's Dam covers a significant area of the original stream and has resulted in the loss of instream habitat.
Alien macrophytes	0 (3)	None observed, but growth may be stimulated by warmer temperatures in summer.
Introduced aquatic fauna	10 (4)	The Gillooly's Dam has carp (*Cyprinus carpio*) which can exacerbate water quality issues.
Rubbish dumping	5 (2)	None observed, but anecdotes that Oriel Park was used significantly for dumping, and vagrants living alongside the stream at Hope Hughes Avenue likely leave litter.
		INSTREAM INTEGRITY CLASS = E, SERIOUSLY MODIFIED
		RIPARIAN
Vegetation removal	20 (4)	Grass mowed to stream edges in Oriel Park, complete removal in channelized sections and where inundation has occurred at Gillooly's Dam.
Exotic vegetation	20 (3)	Established alien trees in Oriel Park (*Populus* sp., *Eucalyptus* sp., *Salix babylonica*) and similar species around Gillooly's Dam.
Bank erosion	5 (3)	Flood prone areas have been rehabilitated in Oriel Park, resulting in far less erosion in the catchment of Oriel Stream.
Channel mod.	20 (3)	Rehabilitation efforts including channelization and re-shaping in Oriel Park, along with inundation at Gillooly's Dam has resulted in wide-spread modification of the channel.
Water abstraction	0 (3)	No known water abstraction.
Inundation	15 (4)	Gillooly's Dam has resulted in the inundation of an extensive area of the riparian zone of the original stream.
Flow mod.	10 (2)	More frequent flood events may damage the riparian zone.
Physico-chemistry	5 (2)	Increased nutrients due to eutrophication may result in increased marginal vegetation.
		RIPARIAN INTEGRITY CLASS = E / F, SERIOUSLY TO CRITICALLY MODIFIED

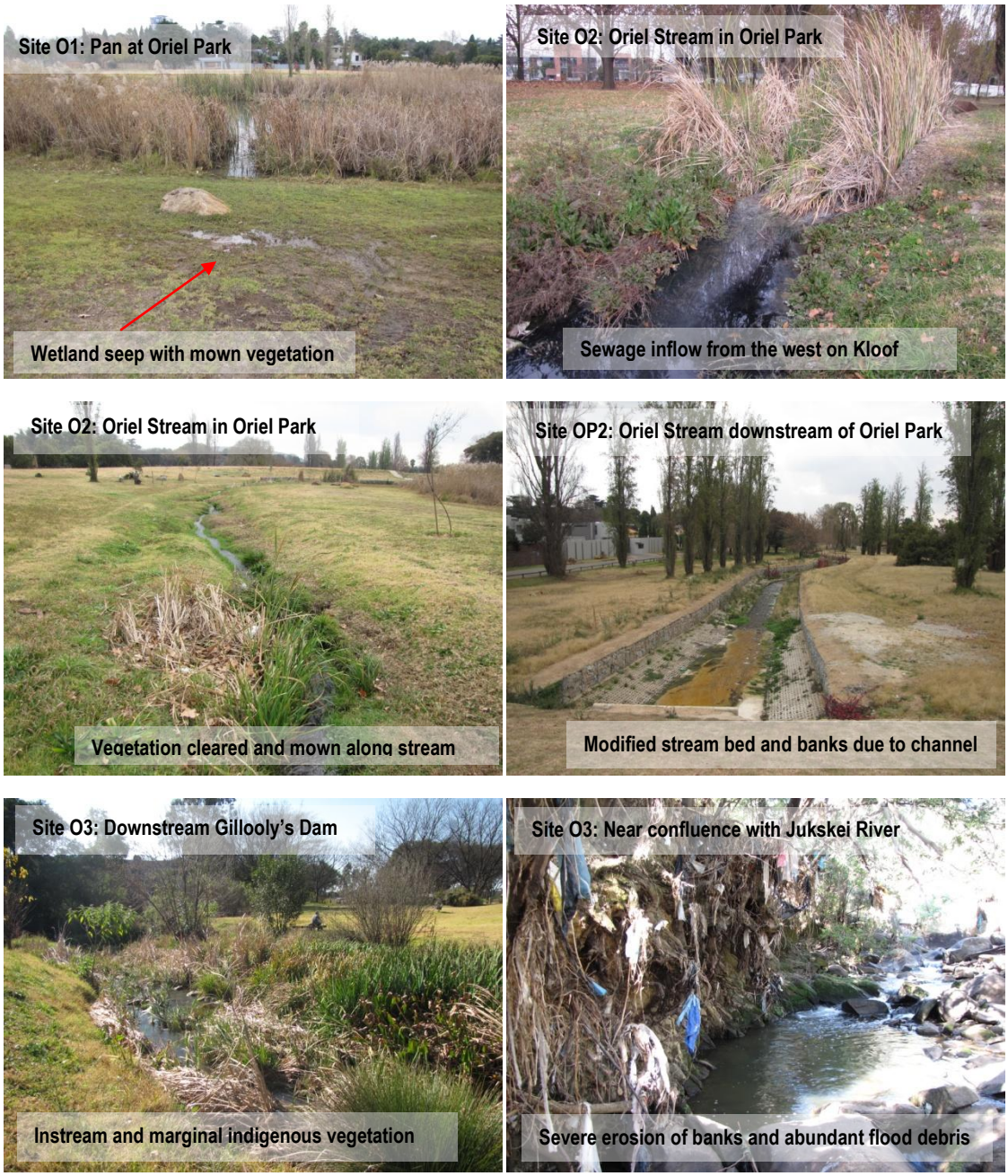

Figure 17. Photographs showing some of the impacts considered in the Index of Habitat Integrity for Oriel Stream.

8 POLLUTION SOURCES

Part of the aim of this study was to identify point and diffuse sources of pollution affecting aquatic ecosystem health. The water chemistry and microbial results (current and CoE monitoring) along with observations during site visits and discussions with actively concerned community members all confirm that sewage and industrial waste are the two most common pollutants. Unfortunately, pinpointing the precise location of these sources is not straightforward. Chemicals entering a stream via a stormwater pipe could come from any number of drains leading into that pipe. Sewage overflowing form a manhole could result from a blockage located some distance away, invisible on the surface, and only detectable with detailed maps of the pipe system and camera investigations. Pollution varies in time and space. A point source may be problematic for a while, but once it has been attended to the problem abates and new problems arise elsewhere.

Both historic and current pollution sources have been identified and mapped (Figure 18). However, this list of locations could look entirely different in three months time. For this reason, a few underlying issues regarding the prevention, reporting of and response to pollution events are discussed below (Table 17). The identification of these issues and suggestions for their improvement are provided with the aim of reducing pollution and improving the response time to pollution events, thus limiting their damage to aquatic ecosystems. The aim is also to shift the focus to preventative and proactive management versus crisis management. This list is based on feedback from concerned stakeholders and councilors who have firsthand experience with the current system. It is recommended that these suggestions be considered and incorporated into the rehabilitation plan where feasible.

Table 17. Challenges and suggested solutions for preventing, reporting and responding to pollution events in the City of Ekurhuleni.

Problems	Suggested solutions
Preventing pollution	
Pollution outflows are out of sight and haven't been noticed by anyone.	Ensure infrastructure such as manholes, pump stations and stormwater outflows are kept free of debris and vegetation so they are more visible. Sites should be inspected before and after the rainfall season. Repeat problem areas should be monitored on a regular basis.
Blockage of sewerage infrastructure due to inappropriate disposal of refuse.	Provide basic education and increase awareness of what can and cannot be flushed into a toilet or down a drain beginning at schools, but including social and print media.
Pipelines damaged during floods leaking into streams.	Identify all sewage pipeline crossings over streams and inspect them visually at the start and the end of the rainfall season to ensure that supporting structures are stable, joins are not leaking or damaged, and their height is sufficient to prevent flood damage.
Lack of preventative maintenance such as sweeping of pipes.	Sewers should be swept and cleaned at the beginning and the end of the rainfall season. If this is not possible using existing teams, then utilize 'as and when' contracts to implement.
Reporting a pollution event	
People don't know who to report incidents to and how to contact them.	Advertise the correct phone number in places where pollution could be observed (e.g. parks) and in the newspaper.
People don't think anything will be done about it, or they personally don't care about it (apathetic).	Encourage residents to take an active role through advertising and explaining the process. Increase awareness.
There may be confusion about municipal boundaries and who the responsible authority is.	Ensure CoE respondents are aware of municipal boundaries and provide useful advice even if the event is in an adjacent area.
Responding to a pollution event	
The CoE call centre is geared to respond to domestic issues. If there is no street address they cannot respond. They do not take GPS co-ordinates, receive WhatsApp pins, Google images or photos.	Create a dedicated line or service for reporting water quality (and other environmental) problems. The service should be geared to receive multimedia information regarding any location.
The CoE call centre generally send staff to deal with the problem who are equipped to deal with domestic issues such as unblocking small drains.	Staff must be trained to discriminate between small scale and large scale blockages to ensure an appropriate response.
If you happen to know the contact details of the person(s)	As above, advertise the contact details of the correct,

responsible for addressing pollution spills, then they can be dealt with efficiently (24 – 48 hrs). But you have to know their contact details which are not widely publicized.	competent person to contact in the event of an incident.
The individual you know may be on leave or unavailable.	Ensure there are always staff on duty who are able to respond to incidents. Staff on leave must include auto-replies with contact details of colleagues that can assist.
Sometimes an Environmental Health Inspector is sent to the site as a first step. They take a sample, send it to a lab, wait for the results, and then write up a report. This process takes weeks, and in the interim the pollution event continues.	Ensure staff are trained to assess whether sample collection is even necessary. More often it isn't and simply looking at a photograph and having a conversation are enough to determine the type of pollution and best course of action. Samples should only be collected when human health is at risk or there is a need to learn more about the source of the pollution.

Mapped pollution sources in Figure 18 show that historic pollution events have occurred at several points, while current pollution is occurring at four sites (that we are aware of). The sites mapped as historic problem areas indicate locations with intermittent and recurring problems, as opposed to a single incident. Industrial waste has been observed downstream of almost every industrial area in the study area. This occurs on an intermittent basis and it is difficult to pinpoint the source because of the large areas being drained. Sewage pollution along the Modderfontein Stream system will hopefully improve in the future due to the construction of the Modderfontein Outfall Sewer which is currently underway.

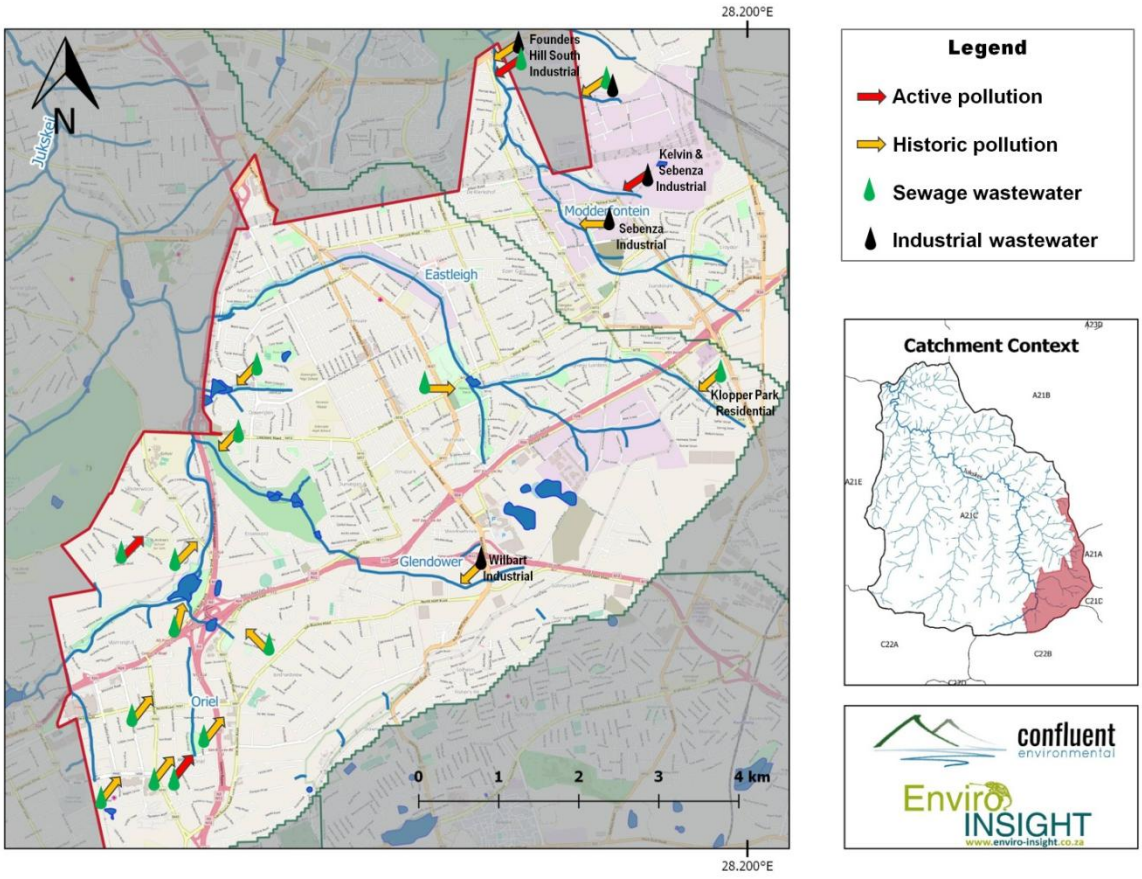

Figure 18. Map depicting active and historic sources of sewage and industrial pollution in the upper Jukskei River catchment.

9 REHABILITATION RECOMMENDATIONS

Rehabilitation interventions have been recommended on a site-specific basis for each watercourse, as well as on a general basis for better management of the catchment at large. For generalized rehabilitation recommendations, the interventions suggested in Table 17 for the prevention of pollution are recommended in addition to those provided in the following section.

9.1 GENERALISED REHABILITATION RECOMMENDATIONS

Generalised recommendations are applicable to numerous locations throughout the study area and are aimed at the rehabilitation and better management of all the watercourses.

- Stormwater management needs to be a high priority consideration of future developments in the study area. Industrial developments in particular can significantly increase impervious surface areas and

generate large amounts of runoff, which these streams are mostly incapable of managing. Cumulative impacts must be considered and planned for in all developments.

- Following significant high flows, maintenance teams must clear flood debris from culverts and pipes as this may reduce their capacity in future high flow events, resulting in blockages and flooding of roads and infrastructure.
- Related to the above recommendation is that maintenance teams should also remove flood debris from the instream and riparian environment where large quantities have accumulated.
- Efforts to control alien plant invasions must be properly implemented. Species-specific methods of control must be followed using recommendations (e.g. herbicide application, and not just surface material removal), and most importantly have to be followed up annually as a minimum requirement. To be sustainable, alien plant control must be integrated into routine environmental and park maintenance plans, and staff must be given appropriate training for implementation.
- Where possible (considering aspects such as safety), revise public park management plans to reduce mowing and vegetation clearing within the riparian zone, and allow the establishment and re-generation of indigenous plants.

9.2 MODDERFONTEIN STREAM

9.2.1 Summary of problems affecting Modderfontein Stream

The impacts affecting aquatic ecosystem health in the Modderfontein Stream affect critical aspects of flow, habitat, biota, and water quality. A summary of impacts affecting the integrity of the system include:

- Partially treated sewage (wastewater) in the water at every site assessed during this study. As indicated by elevated nutrients, *E. coli* and faecal coliforms;
- Specific point sources of industrial and sewage pollution are not easily identified without detailed investigation;
- A lack of / failure of stormwater conveyance systems is leading to severe erosion and damage to infrastructure in places;
- Widely established alien invasive vegetation, and the loss of indigenous species
- Rubbish dumping

These combined factors have resulted in the ecological category of **E/F, Seriously to Critically Modified**. This category is not entirely irreversible and there are opportunities to significantly improve aquatic ecosystem health in the Modderfontein Stream.

9.2.2 Rehabilitation recommendations for Modderfontein Stream

Recommendations for rehabilitation for the Modderfontein Stream largely exclude the Illiondale wetland area because a comprehensive ecological assessment and rehabilitation plan was developed for this area in 2014 (L.R.I.). Work has reportedly stalled on this project due to complications with contract appointments as opposed to any significant issues with the quality of the plan. Locations identified for rehabilitation have been identified on an annotated aerial photo in Figure 19 and explained in Table 18.

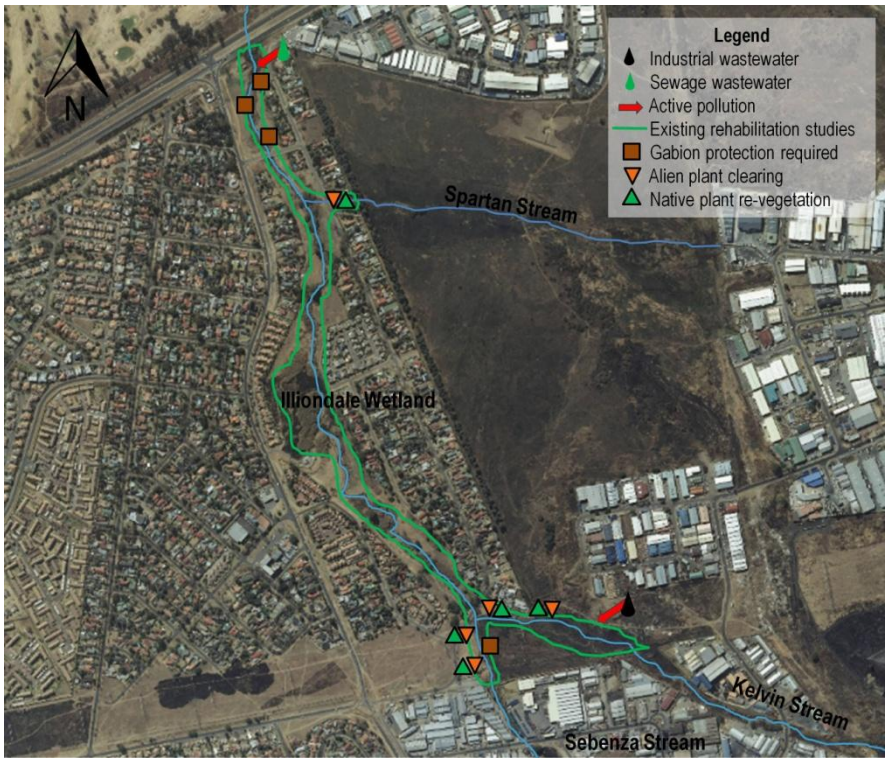

Figure 19. Locations of the proposed interventions for Modderfontein Stream.

Table 18. Site-specific rehabilitation interventions recommended for Modderfontein Stream.

Problem	Interventions	Stream	Priority
Water quality	There is an ongoing sewage overflow opposite the pump-station below Margaret Roadd (Site M4; Lat. -26.107073°, Lon. 28.168526°). 1. Devise short-term and long-term strategies to remove the pollution source. Short-term treatment could include the on-site treatment of wastewater with portable, containerized sewage treatment systems. These can then be used elsewhere as the need arises. While the long-term solution will include the maintenance and replacement of infrastructure (e.g. Construction of the Modderfontein outfall sewer which is in progress). 2. Move the CoE water quality monitoring point at Margaret Road (Site J3) downstream to below the leaking pump-station and outflow of industrial pollution from Founders Hill South (Site M4; Lat. -26.106926°; Lon. 28.168480°).	Modderfontein	1
	Industrial pollution flows into the streams intermittently from Sebenza, Spartan & Kelvin industrial areas, and water quality results indicate that a large number of elements are entering the Modderfontein Stream. Sources are difficult to trace because they flow intermittently and could come from multiple locations. However, likely industries identified in this study should be identified, and compliance inspections should be carried out. All pollution reports should be investigated and followed up.	Spartan, Kelvin & Sebenza	2
Existing rehabilitation plans	Continue with the comprehensive rehabilitation plan developed for the Illiondale Wetland (Modderfontein Stream) by L.R.I. (2014). The report contains a detailed plan containing 26 interventions that cover the short term (Phase 1) and long term (Phase 2) and have been prioritized in categories as follows: • Protect the area – fencing and control access • Reinforce breached structures • Stabilise the banks • Eradicate alien invasive vegetation.	Modderfontein	1
	Determine the extent of work carried out for the Isandovale Soil Erosion Management Project (S.E.F., 2007; M.D.C.C., 2007) which was for the Sebenza Stream (upstream of Site M2). Establish whether interventions have been successfully implemented. For this project, interventions to build and repair infrastructure to accommodate 20-year floods were recommended for six road crossings in Isandovale.	Sebenza	1
Gabion streambank protection required or	1. Stream banks have been badly eroded exposing a pipeline running adjacent to and across the river on Sebenza Stream (M2). Gabions previously installed at this site have completely collapsed. Banks need to be stabilized and the pipeline needs to be re-aligned and possibly elevated	Sebenza	1

needs repairs.	to prevent further flood damage (Lat. -26.119741°, Lon. 28.173997°). ** Not identified in the Illiondale Wetland Rehabilitation plan. 2. The Modderfontein Stream section between Margaret Road and Modderfontein Road (± 200m) has multiple areas where bank stabilization is necessary, especially to protect properties adjacent to the stream near Modderfontein Road. Gabions have failed in some sections and require infilling and repair. *This intervention was identified in the existing rehabilitation plan.*		
Alien vegetation removal & re-vegetation	1. Numerous sites are indicated for clearing in the existing rehabilitation plan. This activity was listed a Priority 4 intervention in the plan, but was the first activity tackled when the plan was implemented, and was executed poorly. Above-ground material was cut and removed, but no herbicides were used and no follow up was done. Alien vegetation has since re-estabished. 2. The removal of vegetation should be followed up with the re-establishment of native riparian plants and trees.	Illiondale Wetland	2
	1. Kelvin Stream (adjacent to Dunbar Street) and Sebenza Stream (adjacent to Aitken Road) provide good opportunities to clear alien plants. Provided stream banks are stabilized on Sebenza Stream first. Improving the quality of riparian cover along these streams could contribute to improved habitat and landscape connectivity for animals associated with aquatic ecosystems, such as water mongoose and otters. This area falls within a Critical Biodiversity Area according to the Gauteng C-Plan and is *connected* to a much larger area located within the City of Joburg. These sites were not identified in the existing rehabilitation plan.	Kelvin and Sebenza	3
	1. A small park is located at Site M3 (Lat. -26.110234°, Lon. 28.170780°) on Spartan Stream. The riparian zone of the stream is invaded and would benefit from alien plant removal and revegetation with suitable indigenous plants. This park is in a Critical Biodiversity Area according to the Gauteng C-Plan and rehabilitation would enhance landscape connectivity with the larger open area located to the east in City of Joburg.	Spartan Stream	3

9.3 EASTLEIGH STREAM

9.3.1 Summary of problems affecting Eastleigh Stream

The impacts affecting aquatic ecosystem health in the Eastleigh Stream affect critical aspects of flow, habitat, biota, and water quality. This is reflected in the ecological category of **E/F, Seriously to Critically Modified**. A summary of major impacts affecting the integrity of the system include:

- Poor water quality, particularly in Harmelia Stream due to frequent and large volumes of sewage from a source originating in Klopper Park.
- Widespread and severe erosion due to flooding that has been partially addressed through existing rehabilitation plans, which have not yet been implemented.
- Extensive modification of the instream and riparian environment in order to mitigate the impacts of flooding.
- Riparian vegetation is dominated by alien invasive plants.
- Macroinvertebrate and diatom communities reflect the above impacts as they are dominated by pollution-tolerant species.

9.3.2 Rehabilitation recommendations for Eastleigh Stream

The locations for suggested interventions for Eastleigh Stream are presented in Figure 20 and

Table **19**. An aquatic specialist study has already been completed for a large section of the Eastleigh Stream as part of an exisiting project to rehabilitate physical aspects of the stream (S.A.S., 2017;). Therefore, recommendations have focused on the assessment sites upstream and downstream of this section, as well as Harmelia Stream.

Figure 20. Locations of the proposed interventions for Eastleigh Stream.

Table 19. Site-specific rehabilitation interventions recommended for Eastleigh Stream.

Problem	Description and Interventions	Stream	Priority
Water quality	Industrial waste and particularly sewage is regularly observed in the stream at the park on Beverley Avenue, and is severe at times. The point source is unknown but it can be traced back to Klopper Park before the stream is piped underground. The source needs to be identified and eliminated. In the event of large spills then measures should be taken to collect or treat the wastewater in a mobile plant to prevent it from entering the river system.	Harmelia	1
	A manhole regularly overflows with sewage located in Horwood park near the original homestead (Lat. -26.143575°, Lon. 28.164032°).	Eastleigh	2
Existing rehabilitation plans	For the Harmelia Stream (Site E1) at Beverley Avenue, the proposed construction of stormwater infrastructure and removal of alien invasive plants along the channel received approval in 2017 (Project GAUT 002/17-18/E0036). This plan should be reviewed to determine whether it includes re-vegetation following alien clearing.	Harmelia	1
	A project to upgrade Eastleigh Stream received environmental authorization in May, 2018 (Project GAUT 006/17-18/E0146) and should be implemented. Interventions are aimed at upgrading bridges and culverts, shaping natural channels, 76channeling and lining streams with gabions. The project appears to include the entire stream section (± 5.3 km) from Hurlyvale to the N1 highway (± 5.3 km).	Eastleigh	1

Gabion streambank protection required or needs repairs.	1. The entire stream section assessed at Site E1 requires urgent stabilization of streambanks, but this may already have been addressed by the Eastleigh River rehabilitation study, see above. The revegetation of banks with indigenous vegetation may not be included in the existing project, and would be beneficial. 2. The bridge at 1st Avenue on Eastleigh Stream (Site E3: Lat. -26.132445°, Lon. 28.141052°) needs to be assessed in terms of its capacity to accommodate large floods. In all likelihood it needs to be enlarged and the stream banks upstream of this site need to be stabilized, particularly on the northern stream bank. However, this site is included in an extensive rehabilitation project for Eastleigh Stream and appears to be earmarked for a concrete channel (See above). This is unfortunate as the instream habitat at this site was among the best in the study area, making it a prime location for rehabilitation.	Eastleigh	1
	Stabilisation of banks is required downstream of the St Andrew's Road Bridge on the Hurlyvale Stream (Site E2; Lat. -26.147632°, Lon. 28.166874°).	Hurlyvale	2
Alien vegetation removal & re-vegetation	Harmelia Stream (Site E1) at Beverley Avenue is a good location for rehabilitation as there is an existing, access controlled park in a suburban area. Banks would need to be stabilized and there are a large number of alien trees along the stream banks that need to be removed (refer to the existing rehabilitation plan – see above). There may be opportunity to add value to rehabilitation of this site by re-vegetating banks once aliens are cleared.	Harmelia	3
	Although the stream channel is incised, the stream banks along Hurlyvale Stream at Site E2 are mostly stable. Extensive and established alien trees and shrubs line the stream throughout the park at Hurlyvale and this site has been selected to 'remain natural' in the Eastleigh Stream rehabilitation study. It therefore represents a good opportunity to effectively manage alien vegetation.	Hurlyvale	2
	Further downstream on Eastleigh Stream, Site E3 at Protea Park would be suitable for the removal of alien vegetation and replanting with indigenous plants. Bushwillow Road runs parallel to the stream along the park, and not a single one of these iconic riparian tree species was observed at the site assessed. The banks are completely invaded. This area is included in the Eastleigh River rehabilitation plan, but the interventions related to alien vegetation for this site are unknown and require review.	Eastleigh	2
Maintenance of infrastructure	1. Flood debris must be cleared away from the bridge at 1st Avenue on Eastleigh Stream (Site E3: Lat. -26.132445°, Lon. 28.141052°) as it will reduce the flow capacity during the next high rainfall season. It is quite likely that a similar exercise should be carried out for the bridges upstream of this	Eastleigh	1

	site. 2. Manhole covers have been stolen / lost and not replaced in Protea Park leaving hazardous open holes in a public space. These should be replaced with concrete covers.		

9.4 WILLOW PARK

9.4.1 Summary of problems affecting Willow Park

The impacts affecting aquatic ecosystem health in Willow Park affect critical aspects of flow, habitat, biota, and water quality. This is reflected in the ecological category of **E/F, Seriously to Critically Modified**. A summary of major impacts affecting the integrity of the system include:

- Poor water quality reflected in by historic fish kills in the dam and water chemistry results in this study.
- Extensive modification of the instream and riparian environment which has been concreted for length of the park and then impounded at the dam.
- Vegetation highly modified with the presence of alien tree species and mown grass along the stream edges.
- Diatom communities reflect the above impacts as they are dominated by species with a moderate pollution tolerance.

9.4.2 Rehabilitation recommendations for Willow Park

The major impact affecting habitat at Willow Park is the impoundment of the stream at this site, however it seems unlikely that this impact will be removed. There are a number of opportunities to improve the ecological health of the stream and vegetation present in the park. Suggested interventions have been identified in Figure 21 and discussed in Table 20.

Figure 21. Locations of the proposed interventions at Willow Park.

Table 20. Site-specific rehabilitation interventions recommended for Willow Park Stream.

Problem	Description and Interventions	Priority
Water quality	As an impoundment with limited outflow, Willow Park will always be susceptible to the effects of eutrophication if effluent containing high nutrients (e.g. sewage) enters the dam. Fish kills are another outcome which has occurred in the past. Therefore, every effort should be made to prevent sewage from entering the dam.	1
Enhance stream substrate and flow heterogeneity	Habitat variability (or lack there-of) reflects in the diversity of aquatic life that can occur in a stream. The current concrete stream bed is similar to bedrock habitat, and is homogenous in the lower reaches. It is recommended that stream substrates and flows be diversified. Alternations in flow (e.g. rocky riffles / slow-flowing pool sequences) and the manipulation of substrate and gradient would be an improvement and may be implemented in sections without removal of all the existing concrete.	2
Alien vegetation removal	A stand of *Acacia mearnsii* along the dam wall should be eradicated along with isolated alien trees and plants such as *Populus* sp., *Salix babylonica, Amaranthus hybridus* and *Solanum mauritianum* around the dam. A large number of indigenous trees already occur in the park and should be preserved.	1
Re-vegetation of the riparian zone	For most of the length of the stream the riparian zone consists of mown grass to the stream edge and riparian vegetation has been completely cleared. It is recommended to re-establish suitable native vegetation in order to restore a more natural character of the stream. The aim is to provide a more diverse habitat to attract and support macroinvertebrates and provide cover for small mammals along the stream length.	2

9.5 GLENDOWER STREAM

9.5.1 Summary of problems affecting Glendower Stream

The impacts affecting aquatic ecosystem health in Glendower Stream affect critical aspects of flow, habitat, biota, and water quality. This is reflected in the ecological category of **E/F, Seriously to Critically Modified**. A summary of major impacts affecting the integrity of the system include:

- Poor water quality due to sewage and industrial wastewater inflows.
- Extensive modification of the instream and riparian environment due to multiple impoundments at the golf course and stabilization of banks with gabions.
- Vegetation highly modified with the presence of alien tree species and mown grass along the stream edges in the golf course. Complete removal of vegetation in places where the stream has been channeled.
- Diatom communities indicated that water quality upstream of the golf course was worse than downstream.

9.5.2 Rehabilitation recommendations for Glendower Stream

The impoundments present at Glendower Golf Club both detract and enhance ecological integrity of the stream. While they have modified the flow and permanently modified the stream channel and bed, they act as sediment and pollution traps. This is reflected in the diatom communities which were more pollution tolerant at Site G1 than downstream at Site G2. The dams are silting up however, which is going to limit their ability to attenuate both floods and pollutants in the future. A list of the recommended interventions along with their locations is provided in Table 21 and Figure 22 respectively.

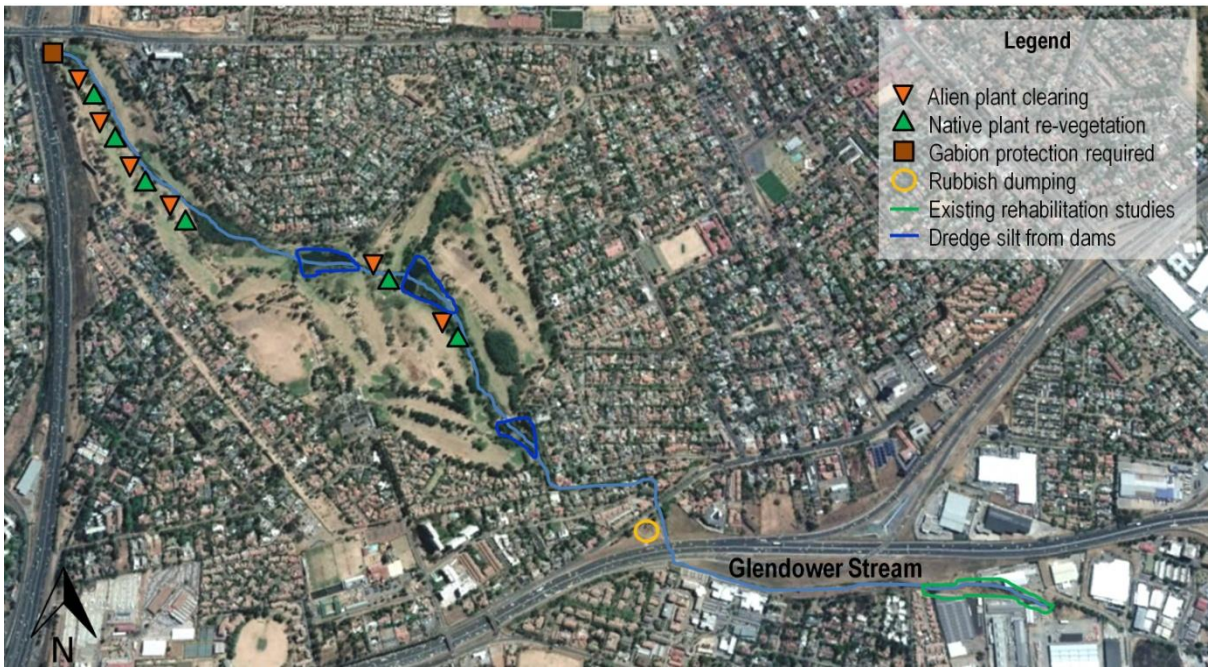

Figure 22. Locations of the proposed interventions at Glendower Stream

Table 21. Site-specific rehabilitation interventions recommended for Glendower Stream.

Problem	Description and Interventions	Priority
Water quality	1. Water quality is negatively impacted by sewage and industrial wastewater. Pollution events should be attended to as soon as possible and all efforts made to prevent their re-occurrence. The overflow of sewage at Glendower Golf Course adjacent to Linksfield Road is a recurring problem that was observed while visiting the site for this study. It took at least a week for this to be stopped. 2. Industrial pollution originates in Wilbart. Pollution reports should be investigated and traced as far as possible.	1
Silting up of golf course dams	The dams in Glendower Golf Club are retaining pollutants and silt originating upstream. Siltation has significantly reduced their volume and it is recommended that dredging of the dams be considered. Provided upstream erosion sites have been addressed, thus preventing siltation from recurring.	3
Gabion streambank protection required or needs repairs.	1. The lower end of Glendower Stream in the golf course (G2) must be investigated in terms of the stability of existing stream bank protection. Existing gabions appear to be slumping following floods (Lat. -26.149872°, Lon. 28.131847°). 2. The upper reaches of the stream in Wilbart / Solheim were badly damaged in floods and banks urgently required stabilization. This led to large volumes of sediment being washed downstream and retained in dams in the Glendower Golf Course. A Basic Assessment was submitted for the proposed upgrade and rehabilitation of the stream in 2015, but the	1

	outcome of this process is unknown and should be confirmed (Ecotone, 2014). If the upgrades have not yet occurred, then the project should be further pursued.	
Rubbish dumping	A field adjacent to Site G1 is being used for dumping, and there are currently large volumes of building rubble. The site is located at Lat: -26.163252°, Lon. 28.149998°. The area should preferably be secured by fencing and gated to prevent further access.	2
Re-vegetation of the riparian zone	Many areas of the golf course have mown grass to the stream edge with no established riparian buffer zone. This exacerbates surface runoff reaching streams, increasing the amount of nutrients and pesticides that enter the stream. It is therefore recommended that suitable areas are selected for the establishment of a riparian buffer zone using native plants. This would also increase the ecological value of the golf course as a green space and corridor for the movement of wildlife.	2
Removal of alien plants	1. There are a large number of exotic trees in the riparian zone throughout the golf course, mostly dominated by *Salix babylonica*. A plan should be in place to systematically remove and replace these trees with suitable indigenous trees. 2. Significant alien vegetation should be removed along the banks at Site G1 dominated by *Arundo donax*, *Solanum mauritianum* and *Amaranthus hybridus.*	3

9.6 ORIEL STREAM

9.6.1 Summary of problems affecting Oriel Stream

The impacts affecting aquatic ecosystem health in Oriel Stream affect critical aspects of flow, habitat, biota, and water quality. This is reflected in the ecological category of **E/F, Seriously to Critically Modified**. A summary of major impacts affecting the integrity of the system include:

- Poor water quality due to sewage wastewater inflows which are ongoing in the upper reach. Historic fish kills due to poor water quality have occurred at Gillooly's Dam.
- Extensive modification of the instream and riparian environment has occurred due to impoundment at Gillooly's Farm along with channeling of the watercourse downstream of Oriel Park.
- Vegetation is highly modified mown grass along the stream edges in Oriel Park. Complete removal of vegetation has occurred in places where the stream has been channelled, and alien vegetation present in the middle and lower reaches of the stream.
- Diatom communities indicated that water quality upstream of Gillooly's Dam was worse than downstream, but overall were indicative of polluted conditions mainly related to eutrophication and organic pollution (sewage).

9.6.2 Rehabilitation recommendations for Oriel Stream

A list of the recommended interventions along with their locations is provided in Table 22 and Figure 23 respectively.

Figure 23. Locations of the proposed interventions at Oriel Stream

Table 22. Site-specific rehabilitation interventions recommended for Oriel Stream.

Problem	Description and Interventions	Priority
Water quality	Sewage is having a major impact on water quality. The elimination of sources of sewage must be prioritized (e.g. the western inflow to Oriel Park). 1. Devise short-term and long-term strategies to remove the pollution source. Short-term treatment could include the on-site treatment of wastewater with portable, containerized sewage treatment systems while the source is identified. These can then be used elsewhere as the need arises. While the long-term solution will include the maintenance and replacement of infrastructure, or removal of blockages.	1
Existing rehabilitation studies	A Basic Assessment to rehabilitate sections of the Oriel Stream was submitted in 2012 and received approval (Gaut 002/11-12/E0052). The upper site (Oriel Park) has been rehabilitated to a large extent and now has two flood attenuation dams and less alien vegetation. The extent to which the recommendations have been implemented must be determined, and if not fully complete, then the project should be continued.	1
Gabion streambank protection required or needs repairs.	Severe erosion is taking place downstream of Gillooly's Dam wall and upstream of the confluence with the Jukskei River. The river banks at this point are severely undercut, threatening adjacent properties and prone to collapse. The site is difficult to access, but stabilization is necessary.	1
Re-vegetation of the riparian zone	Stream-banks in Oriel Park are mown to the edges limiting the growth of naturally occurring wetland plants. This site could also benefit from augmenting the growth of native wetland plants with a planting plan which would provide more dense cover for aquatic species. Locations where water is seeping from the ground (E.g. Lat. -26.184303°, Lon. 28.131257°) should not be mown, and be allowed to return to a more natural wetland vegetation cover.	2
Removal of alien plants	1. Along the banks of the inflow to Gillooly's Dam, there is dense growth of alien plants such as *Salix babylonica, Amaranthus hybridus* and *Solanum mauritianum* which should be cleared. 2. Downstream of the outflow from Gillooly's Dam, there is extensive growth of *Acacia mearnsii* and *Eucalyptus* sp. which are currently the only trees holding the banks together due to severe erosion described above. If the erosion can be stablisised and high flows attenuated, then these trees should be removed.	3
Flood debris	Abundant flood debris is present in the stream downstream of the Gillooly's dam wall. This consists of a huge variety of materials which are caught up in the tree branches and boulders alongside the river. This debris should be removed following floods to prevent it from entering the Jukskei River.	3
Flood attenuation	Downstream of Gillooly's dam wall is a braided river channel which descends a relatively steep gradient to the confluence with the Jukskei River. This section is severely eroded (as described above) and would benefit from attenuation of flood waters during high flows. One option would be to construct a flood attenuation dam immediately downstream of the dam wall to prevent high flows from plunging downstream and causing erosion.	2

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11 APPENDICES

11.1 DIATOM RESULTS

Taxon	Site												
	O1	O2	O3	M1	M2	M3	M4	E1	E2	E3	G1	G2	W1
Abnormal diatom valves or sum of deformities			7	4	1	10	25	11	6	1	10	9	3
Achnanthidium catenatum (Bily & Marvan) Lange-Bertalot	1		3										
Achnanthidium eutrophilum (Lange-Bertalot) Lange-Bertalot			199									7	
Achnanthidium saprophilum (Kobayasi & Mayama) Round & Bukhtiyarova		24	1					3	296		227	100	6
Achnanthidium sp.	1												
Amphora montana Krasske				2			1		2	1			
Amphora normanii Rabenhorst						1							
Amphora pediculus (Kützing) Grunow			5				10		5			2	
Amphora veneta Kützing				5									19
Aulacoseira granulata var. angustissima (O.Müller) Simonsen			30										
Caloneis bacillum (Grunow) Cleve									5				
Cocconeis pediculus Ehrenberg			4									78	
Cocconeis placentula var. euglypta (Ehrenberg) Grunow			2						14				
Cyclotella meneghiniana Kützing			1							235		7	27
Cymbella aspera (Ehrenberg) H.Peragallo	1												
Cymbella kolbei Hustedt													1
Cymbella subleptoceros Krammer			4										
Cymbella tumida (Brébisson) Van Heurck		4	1										
Denticula sundayensis Archibald						3							
Discostella pseudostelligera (Hustedt) Houk & Klee			7										
Eolimna minima (Grunow) Lange-Bertalot		2	15					1					6
Eolimna subminuscula (Manguin) Moser, Lange-Bertalot & Metzeltin				4						2			
Eunotia flexuosa (Brébisson) Kützing	2												
Fistulifera saprophila (Lange-Bertalot & Bonik) Lange-Bertalot					74		10	12					
Fragilaria biceps (Kützing) Lange-Bertalot			1										
Fragilaria capucina Desmazieres												2	
Fragilaria capucina var. vaucheriae (Kützing) Lange-Bertalot			56									2	
Fragilaria tenera (W.Smith) Lange-Bertalot	19												
Fragilaria ulna (Nitzsch) Lange-Bertalot			2									99	
Frustulia vulgaris (Thwaites) De Toni			3										
Gomphonema insigne Gregory		1											2
Gomphonema lagenula Kützing													
Gomphonema parvulum (Kützing) Kützing	2	4	6	1	85	12	6	32	1	5		61	14
Gomphonema pseudoaugur Lange-Bertalot										5			
Melosira varians Agardh		1											
Navicula antonii Lange-Bertalot							3						
Navicula arvensis var. maior Lange-Bertalot							16	2					
Navicula capitatoradiata Germain													1
Navicula cryptocephala Kützing	4	4	1						4	18			
Navicula cryptotenella Lange-Bertalot			1									8	
Navicula cryptotenelloides Lange-Bertalot			14										
Navicula gregaria Donkin		3							4				
Navicula recens (Lange-Bertalot) Lange-Bertalot								1					
Navicula reichardtiana Lange-Bertalot	1		17										
Navicula rostellata Kützing		1	1										
Navicula schroeteri Meister		3											
Navicula sp.	8												
Navicula symmetrica Patrick			9										
Navicula trivialis Lange-Bertalot			1										
Navicula veneta Kützing		12		5		10	15	13		4			5

Navicula zanoni Hustedt	28											
Nitzschia acicularis (Kützing) W.M.Smith	302											
Nitzschia amphibia Grunow	3		3	8	21		30	14	2	32	5	2
Nitzschia archibaldii Lange-Bertalot	19											
Nitzschia communis Rabenhorst				2								
Nitzschia filiformis (W.M.Smith) Van Heurck	1											
Nitzschia frustulum (Kützing) Grunow		1		350		309	107					
Nitzschia liebetruthii Rabenhorst				21								
Nitzschia linearis(Agardh) W.M.Smith		125	1				2		47	4	16	5
Nitzschia palea (Kützing) W.Smith	2	189	1	2	88		29	196	1	19	135	12	5
Nitzschia paleacea (Grunow) Grunow													267
Nitzschia sinuata var. delognei (Grunow) Lange-Bertalot													5
Nitzschia sp.	1		5									
Nitzschia umbonata (Ehrenberg) Lange-Bertalot			1									
Pinnularia acrospheria W. Smith			1									
Pinnularia subgibba Krammer	3											
Pinnularia subgibba var. sublinearis Krammer		1										
Planothidium frequentissimum (Lange-Bertalot) Lange-Bertalot	1	2	1			26		100	5	41			35
Planothidium rostratum (Oestrup) Round & Bukhtiyarova			2										
Rhoicosphenia abbreviata (C.Agardh) Lange-Bertalot		3				38	1		6				
Rhopalodia gibba (Ehrenberg) O.Müller	1												
Sellaphora pupula (Kützing) Mereschkowksy		15			3				2	3		1	
Sellaphora seminulum (Grunow) D.G. Mann		1			128	1	170	26	1	29	30		
Sellaphora sp.		1											
Surirella angusta Kützing		3	1						5	2	8		

11.2 SASS5 SHEETS

Site: M1

Date (dd-mm-yr):	27-Jun-18							(dd.ddddd)		**Biotopes Sampled (tick & rate)**	**Rating (1 - 5)**		**Time (min)**
Site Code:	M1			**Grid reference (dd mm ss.s)**	**Lat:**	**S**		#VALUE!		**Stones In Current (SIC)**	3		
Collector/Sampler:	Jackie Dabrowski				**Long:**	**E**		#VALUE!		**Stones Out Of Current (SOOC)**	2		
River:	Modderfontein Stream				**Datum (WGS84/Cape):**		WGS84			**Bedrock**	0		
Level 1 Ecoregion:					**Altitude (m):**					**Aquatic Veg**	0		
Quaternary Catchment:					**Zonation:**					**MargVeg In Current**	4		
	Temp (°C):	15.2		**Routine or Project? (circle one)**		**Flow:**	Zero			**MargVeg Out Of Current**	2		
Site Description:	**pH:**	8.5		**Project Name:**		**Clarity (cm):**				**Gravel**	2		
Kelvin Stream before the confluence upstream of Illiondale wetland.	**DO (mg/L):**	7.5				**Turbidity:**	High			**Sand**	1		
	Cond (uS/cm):	1467.0				**Colour:**	Light Brown			**Mud**	1		
	Riparian Disturbance:									**Hand picking/Visual observation**	3		
	Instream Disturbance:									**Biotope Score (%)**	33		

Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5				
COELENTERATA (Cnidaria)	1				
TURBELLARIA (Flatworms)	3				
ANNELIDA					
Oligochaeta (Earthworms)	1	1		B	B
Hirudinea (Leeches)	3				
CRUSTACEA					
Amphipoda (Scuds)	13				
Potamonautidae* (Crabs)	3				
Atyidae (Freshwater Shrimps)	8				
Palaemonidae (Freshwater Prawns)	10				
HYDRACARINA (Mites)	8				
PLECOPTERA (Stoneflies)					
Notonemouridae	14				
Perlidae	12				
EPHEMEROPTERA (Mayflies)					
Baetidae 1sp	4				
Baetidae 2 sp	6				
Baetidae > 2 sp	12				
Caenidae (Squaregills/Cainfles)	6				
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuridae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Telloganodidae SWC (Spiny Crawlers)	12				
Tricorythidae (Stout Crawlers)	9				
ODONATA (Dragonflies & Damselflies)					
Calopterygidae ST,T (Demoiselles)	10				
Chlorocyphidae (Jewels)	10				
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4		A	A	B
Lestidae (Emerald Damselflies/Spreadwings)	8				
Platycnemidae (Stream Damselflies)	10				
Protoneuridae (Threadwings)	8				
Aeshnidae (Hawkers & Emperors)	8				
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6	1			1
Libellulidae (Darters/Skimmers)	4				
LEPIDOPTERA (Aquatic Caterpillars/Moths)					
Crambidae (Pyralidae)	12				

Taxon	QV	S	Veg	GSM	TOT
HEMIPTERA (Bugs)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3				
Gerridae* (Pond skaters/Water striders)	5				
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3				
Notonectidae* (Backswimmers)	3				
Pleidae* (Pygmy backswimmers)	4				
Veliidae/M...veliidae* (Ripple bugs)	5				
MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)					
Corydalidae (Fishflies & Dobsonflies)	8				
Sialidae (Alderflies)	6				
TRICHOPTERA (Caddisflies)					
Dipseudopsidae	10				
Ecnomidae	8				
Hydropsychidae 1 sp	4				
Hydropsychidae 2 sp	6				
Hydropsychidae > 2 sp	12				
Philopotamidae	10				
Polycentropodidae	12				
Psychomyiidae/Xiphocentronidae	8				
Cased caddis:					
Barbarochthonidae SWC	13				
Calamoceratidae ST	11				
Glossosomatidae SWC	11				
Hydroptilidae	6				
Hydrosalpingidae SWC	15				
Lepidostomatidae	10				
Leptoceridae	6				
Petrothrincidae SWC	11				
Pisuliidae	10				
Sericostomatidae SWC	13				
COLEOPTERA (Beetles)					
Dytiscidae/Noteridae* (Diving beetles)	5				
Elmidae/Dryopidae* (Riffle beetles)	8				
Gyrinidae* (Whirligig beetles)	5				
Haliplidae* (Crawling water beetles)	5				
Helodidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles)	5				
Limnichidae (Marsh-Loving Beetles)	10				
Psephenidae (Water Pennies)	10				

Taxon	QV	S	Veg	GSM	TOT
DIPTERA (Flies)					
Athericidae (Snipe flies)	10				
Blepharoceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5				
Chironomidae (Midges)	2	1	A		A
Culicidae* (Mosquitoes)	1				
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3				
Muscidae (House flies, Stable flies)	1				
Psychodidae (Moth flies)	1				
Simuliidae (Blackflies)	5				
Syrphidae* (Rat tailed maggots)	1				
Tabanidae (Horse flies)	5				
Tipulidae (Crane flies)	5				
GASTROPODA (Snails)					
Ancylidae (Limpets)	6				
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3	A	B		B
Planorbinae* (Orb snails)	3				
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (Bivalvles)					
Corbiculidae (Clams)	5				
Sphaeriidae (Pill clams)	3				
Unionidae (Perly mussels)	6				
SASS Score					16
No. of Taxa					5
ASPT					3.2
Other biota:					

Comments/Observations:
While on-site, a plume of turbid water flowed through for about 10 mins before clearing up.

Site: M2

Date (dd-mm-yr):	27-Jun-18												
Site Code:	M2												
Collector/Sampler:	Jackie Dabrowski												
River:	Modderfontein - Sebenza Stream												
Level 1 Ecoregion:													
Quaternary Catchment:													
Site Description:	**Temp (°C):**	12.8											
City of Ekurhuleni monitoring poin upstream of the confluence with the Kelvin Stream before the Illiondale Wetland.	**pH:**	7.6											
	DO (mg/L):	7.9											
	Cond (uS/cm):	289.0											
	Riparian Disturbance:												
	Instream Disturbance:												

			(dd.ddddd)
Grid reference (dd mm ss.s)	**Lat:**	**S**	#VALUE!
	Long:	**E**	#VALUE!
	Datum (WGS84/Cape):		WGS84
	Altitude (m):		
	Zonation:		

Routine or Project? (circle one)	**Flow:**	Low	
Project Name:	**Clarity (cm):**		
	Turbidity:	Low	
	Colour:	Light Brown	

Biotopes Sampled (tick & rate)	**Rating (1 - 5)**	**Time (min)**
Stones In Current (SIC)	3	
Stones Out Of Current (SOOC)	2	
Bedrock	0	
Aquatic Veg	1	
MargVeg In Current	3	
MargVeg Out Of Current	2	
Gravel	1	
Sand	1	
Mud	0	
Hand picking/Visual observation	3	
Biotope Score (%)	29	

Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5				
COELENTERATA (Cnidaria)	1				
TURBELLARIA (Flatworms)	3			A	A
ANNELIDA					
Oligochaeta (Earthworms)	1	B		B	C
Hirudinea (Leeches)	3	A			A
CRUSTACEA					
Amphipoda (Scuds)	13				
Potamonautidae* (Crabs)	3				
Atyidae (Freshwater Shrimps)	8				
Palaemonidae (Freshwater Prawns)	10				
HYDRACARINA (Mites)	8				
PLECOPTERA (Stoneflies)					
Notonemouridae	14				
Perlidae	12				
EPHEMEROPTERA (Mayflies)					
Baetidae 1sp	4				
Baetidae 2 sp	6				
Baetidae > 2 sp	12				
Caenidae (Squaregills/Cainfles)	6				
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuriidae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Teloganodidae SWC (Spiny Crawlers)	12				
Tricorythidae (Stout Crawlers)	9				
ODONATA (Dragonflies & Damselflies)					
Calopterygidae ST,T (Demoiselles)	10				
Chlorocyphidae (Jewels)	10				
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4	1	A		A
Lestidae (Emerald Damselflies/Spreadwings)	8				
Platycnemidae (Stream Damselflies)	10				
Protoneuridae (Threadwings)	8				
Aeshnidae (Hawkers & Emperors)	8				
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6	B			B
Libellulidae (Darters/Skimmers)	4				
LEPIDOPTERA (Aquatic Caterpillars/Moths)					
Crambidae (Pyralidae)	12				

Taxon	QV	S	Veg	GSM	TOT
HEMIPTERA (Bugs)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3				
Gerridae* (Pond skaters/Water striders)	5				
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3				
Notonectidae* (Backswimmers)	3				
Pleidae* (Pygmy backswimmers)	4				
Veliidae/M...veliidae* (Ripple bugs)	5				
MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)					
Corydalidae (Fishflies & Dobsonflies)	8				
Sialidae (Alderflies)	6				
TRICHOPTERA (Caddisflies)					
Dipseudopsidae	10				
Ecnomidae	8				
Hydropsychidae 1 sp	4				
Hydropsychidae 2 sp	6				
Hydropsychidae > 2 sp	12				
Philopotamidae	10				
Polycentropodidae	12				
Psychomyiidae/Xiphocentronidae	8				
Cased caddis:					
Barbarochthonidae SWC	13				
Calamoceratidae ST	11				
Glossosomatidae SWC	11				
Hydroptilidae	6				
Hydrosalpingidae SWC	15				
Lepidostomatidae	10				
Leptoceridae	6				
Petrothrincidae SWC	11				
Pisuliidae	10				
Sericostomatidae SWC	13				
COLEOPTERA (Beetles)					
Dytiscidae/Noteridae* (Diving beetles)	5				
Elmidae/Dryopidae* (Riffle beetles)	8				
Gyrinidae* (Whirligig beetles)	5				
Haliplidae* (Crawling water beetles)	5				
Helodidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles)	5				
Limnichidae (Marsh-Loving Beetles)	10				
Psephenidae (Water Pennies)	10				

Taxon	QV	S	Veg	GSM	TOT
DIPTERA (Flies)					
Athericidae (Snipe flies)	10				
Blepharoceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5				
Chironomidae (Midges)	2	B	A		B
Culicidae* (Mosquitoes)	1	A			A
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3				
Muscidae (House flies, Stable flies)	1				
Psychodidae (Moth flies)	1				
Simuliidae (Blackflies)	5				
Syrphidae* (Rat tailed maggots)	1				
Tabanidae (Horse flies)	5				
Tipulidae (Crane flies)	5				
GASTROPODA (Snails)					
Ancylidae (Limpets)	6				
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3	1	1		A
Planorbinae* (Orb snails)	3				
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (Bivalvles)					
Corbiculidae (Clams)	5				
Sphaeriidae (Pill clams)	3				
Unionidae (Perly mussels)	6				
SASS Score					23
No. of Taxa					8
ASPT					2.9
Other biota:					

Comments/Observations:

Site: M3

Date (dd-mm-yr):			(dd.ddddd)	Biotopes Sampled (tick & rate)	Rating (1 - 5) / Time (min)
Site Code:	M3	Grid reference (dd mm ss.s) Lat: S	#VALUE!	Stones In Current (SIC)	3
Collector/Sampler:	Jackie Dabrowski	Long: E	#VALUE!	Stones Out Of Current (SOOC)	1
River:	Modderfontein Stream	Datum (WGS84/Cape):	WGS84	Bedrock	0
Level 1 Ecoregion:		Altitude (m):		Aquatic Veg	0
Quaternary Catchment:		Zonation:		MargVeg In Current	0
	Temp (°C):	Routine or Project? (circle one)	Flow: Trickle	MargVeg Out Of Current	1
Site Description:	pH:	Project Name:	Clarity (cm):	Gravel	1
Stream flows from wetland area in City of Joburg. Origins in an industrial area in City of Ekurhuleni. Tributary of the Modderfontein Stream.	DO (mg/L):		Turbidity: Low	Sand	0
	Cond (mS/m):		Colour: Normal Transparent	Mud	0
	Riparian Disturbance:			Hand picking/Visual observation	3
	Instream Disturbance:			Biotope Score (%)	13

Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5					**HEMIPTERA (Bugs)**						**DIPTERA (Flies)**					
COELENTERATA (Cnidaria)	1					Belostomatidae* (Giant water bugs)	3					Athericidae (Snipe flies)	10				
TURBELLARIA (Flatworms)	3					Corixidae* (Water boatmen)	3	A			A	Blepharoceridae (Mountain midges)	15				
ANNELIDA						Gerridae* (Pond skaters/Water striders)	5					Ceratopogonidae (Biting midges)	5				
Oligochaeta (Earthworms)	1					Hydrometridae* (Water measurers)	6					Chironomidae (Midges)	2				
Hirudinea (Leeches)	3					Naucoridae* (Creeping water bugs)	7					Culicidae* (Mosquitoes)	1				
CRUSTACEA						Nepidae* (Water scorpions)	3					Dixidae* (Dixid midge)	10				
Amphipoda (Scuds)	13					Notonectidae* (Backswimmers)	3					Empididae (Dance flies)	6				
Potamonautidae* (Crabs)	3					Pleidae* (Pygmy backswimmers)	4					Ephydridae (Shore flies)	3				
Atyidae (Freshwater Shrimps)	8					Veliidae/M...veliidae* (Ripple bugs)	5					Muscidae (House flies, Stable flies)	1				
Palaemonidae (Freshwater Prawns)	10					**MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)**						Psychodidae (Moth flies)	1				
HYDRACARINA (Mites)	8					Corydalidae (Fishflies & Dobsonflies)	8					Simuliidae (Blackflies)	5				
PLECOPTERA (Stoneflies)						Sialidae (Alderflies)	6					Syrphidae* (Rat tailed maggots)	1				
Notonemouridae	14					**TRICHOPTERA (Caddisflies)**						Tabanidae (Horse flies)	5				
Perlidae	12					Dipseudopsidae	10					Tipulidae (Crane flies)	5				
EPHEMEROPTERA (Mayflies)						Ecnomidae	8					**GASTROPODA (Snails)**					
Baetidae 1sp	4					Hydropsychidae 1 sp	4					Ancylidae (Limpets)	6				
Baetidae 2 sp	6	A			A	Hydropsychidae 2 sp	6					Bulininae*	3				
Baetidae > 2 sp	12					Hydropsychidae > 2 sp	12					Hydrobiidae*	3				
Caenidae (Squaregills/Cainfles)	6					Philopotamidae	10					Lymnaeidae* (Pond snails)	3				
Ephemeridae	15					Polycentropodidae	12					Physidae* (Pouch snails)	3				
Heptageniidae (Flatheaded mayflies)	13					Psychomyiidae/Xiphocentronidae	8					Planorbinae* (Orb snails)	3				
Leptophlebiidae (Prongills)	9					**Cased caddis:**						Thiaridae* (=Melanidae)	3				
Oligoneuridae (Brushlegged mayflies)	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
Polymitarcyidae (Pale Burrowers)	10					Calamoceratidae ST	11					**PELECYPODA (Bivalvles)**					
Prosopistomatidae (Water specs)	15					Glossosomatidae SWC	11					Corbiculidae (Clams)	5				
Teloganodidae SWC (Spiny Crawlers)	12					Hydroptilidae	6					Sphaeriidae (Pill clams)	3				
Tricorythidae (Stout Crawlers)	9					Hydrosalpingidae SWC	15					Unionidae (Perly mussels)	6				
ODONATA (Dragonflies & Damselflies)						Lepidostomatidae	10					**SASS Score**					14
Calopterygidae ST,T (Demoiselles)	10					Leptoceridae	6					**No. of Taxa**					3
Chlorocyphidae (Jewels)	10					Petrothrincidae SWC	11					**ASPT**					4.7
Synlestidae (Chlorolestidae)(Sylphs)	8					Pisuliidae	10					**Other biota:**					
Coenagrionidae (Sprites and blues)	4					Sericostomatidae SWC	13					*Tadpoles*					
Lestidae (Emerald Damselflies/Spreadwings)	8					**COLEOPTERA (Beetles)**											
Platycnemidae (Stream Damselflies)	10					Dytiscidae/Noteridae* (Diving beetles)	5										
Protoneuridae (Threadwings)	8					Elmidae/Dryopidae* (Riffle beetles)	8										
Aeshnidae (Hawkers & Emperors)	8					Gyrinidae* (Whirligig beetles)	5					**Comments/Observations:**					
Corduliidae (Cruisers)	8					Haliplidae* (Crawling water beetles)	5					Not good conditions for SASS. Abandoned it after collecting sample from the Stones biot					
Gomphidae (Clubtails)	6					Helodidae (Marsh beetles)	12										
Libellulidae (Darters/Skimmers)	4					Hydraenidae* (Minute moss beetles)	8										
LEPIDOPTERA (Aquatic Caterpillars/Moths)						Hydrophilidae* (Water scavenger beetles)	5	1			1						
Crambidae (Pyralidae)	12					Limnichidae (Marsh-Loving Beetles)	10										
						Psephenidae (Water Pennies)	10										

Site: M4

Date (dd-mm-yr):	27-Jun-18		(dd.ddddd)	Biotopes Sampled (tick & rate)	Rating (1 - 5)
Site Code:	M4	Grid reference (dd mm ss.s) Lat: S	#VALUE!	Stones In Current (SIC)	4
Collector/Sampler:	Jackie Dabrowski	Long: E	#VALUE!	Stones Out Of Current (SOOC)	3
River:	Modderfontein Stream	Datum (WGS84/Cape):	WGS84	Bedrock	1
Level 1 Ecoregion:		Altitude (m):		Aquatic Veg	0
Quaternary Catchment:		Zonation:		MargVeg In Current	3
	Temp (°C): 15.3	Routine or Project? (circle one)	Flow: Medium	MargVeg Out Of Current	1
Site Description:	pH: 8.6	Project Name:	Clarity (cm):	Gravel	2
Downstream of the malfunctioning pump station and Founders Hill South outflow	DO (mg/L): 8.1		Turbidity: Medium	Sand	1
	Cond (uS/cm): 817.0		Colour: Grey	Mud	1
	Riparian Disturbance:			Hand picking/Visual observation	2
	Instream Disturbance:			Biotope Score (%)	36

Time (min)

Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5				
COELENTERATA (Cnidaria)	1				
TURBELLARIA (Flatworms)	3				
ANNELIDA					
Oligochaeta (Earthworms)	1	A		1	A
Hirudinea (Leeches)	3	1			1
CRUSTACEA					
Amphipoda (Scuds)	13				
Potamonautidae* (Crabs)	3				
Atyidae (Freshwater Shrimps)	8				
Palaemonidae (Freshwater Prawns)	10				
HYDRACARINA (Mites)	8				
PLECOPTERA (Stoneflies)					
Notonemouridae	14				
Perlidae	12				
EPHEMEROPTERA (Mayflies)					
Baetidae 1sp	4		A		
Baetidae 2 sp	6	B		B	C
Baetidae > 2 sp	12				
Caenidae (Squaregills/Cainfles)	6				
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuridae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Teloganodidae SWC (Spiny Crawlers)	12				
Tricorythidae (Stout Crawlers)	9				
ODONATA (Dragonflies & Damselflies)					
Calopterygidae ST,T (Demoiselles)	10				
Chlorocyphidae (Jewels)	10				
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4		B	A	B
Lestidae (Emerald Damselflies/Spreadwings)	8				
Platycnemidae (Stream Damselflies)	10				
Protoneuridae (Threadwings)	8				
Aeshnidae (Hawkers & Emperors)	8				
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6				
Libellulidae (Darters/Skimmers)	4				
LEPIDOPTERA (Aquatic Caterpillars/Moths)					
Crambidae (Pyralidae)	12				

Taxon	QV	S	Veg	GSM	TOT
HEMIPTERA (Bugs)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3				
Gerridae* (Pond skaters/Water striders)	5				
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3				
Notonectidae* (Backswimmers)	3				
Pleidae* (Pygmy backswimmers)	4				
Veliidae/M...veliidae* (Ripple bugs)	5				
MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)					
Corydalidae (Fishflies & Dobsonflies)	8				
Sialidae (Alderflies)	6				
TRICHOPTERA (Caddisflies)					
Dipseudopsidae	10				
Ecnomidae	8				
Hydropsychidae 1 sp	4				
Hydropsychidae 2 sp	6				
Hydropsychidae > 2 sp	12				
Philopotamidae	10				
Polycentropodidae	12				
Psychomyiidae/Xiphocentronidae	8				
Cased caddis:					
Barbarochthonidae SWC	13				
Calamoceratidae ST	11				
Glossosomatidae SWC	11				
Hydroptilidae	6				
Hydrosalpingidae SWC	15				
Lepidostomatidae	10				
Leptoceridae	6				
Petrothrincidae SWC	11				
Pisuliidae	10				
Sericostomatidae SWC	13				
COLEOPTERA (Beetles)					
Dytiscidae/Noteridae* (Diving beetles)	5				
Elmidae/Dryopidae* (Riffle beetles)	8				
Gyrinidae* (Whirligig beetles)	5				
Haliplidae* (Crawling water beetles)	5				
Helodidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles)	5				
Limnichidae (Marsh-Loving Beetles)	10				
Psephenidae (Water Pennies)	10				

Taxon	QV	S	Veg	GSM	TOT
DIPTERA (Flies)					
Athericidae (Snipe flies)	10				
Blepharoceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5				
Chironomidae (Midges)	2	A		A	B
Culicidae* (Mosquitoes)	1				
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3				
Muscidae (House flies, Stable flies)	1				
Psychodidae (Moth flies)	1				
Simuliidae (Blackflies)	5				
Syrphidae* (Rat tailed maggots)	1				
Tabanidae (Horse flies)	5				
Tipulidae (Crane flies)	5				
GASTROPODA (Snails)					
Ancylidae (Limpets)	6				
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3	A	C	A	C
Planorbinae* (Orb snails)	3			1	1
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (Bivalvles)					
Corbiculidae (Clams)	5				
Sphaeriidae (Pill clams)	3				
Unionidae (Perly mussels)	6				
SASS Score					20
No. of Taxa					7
ASPT					2.9
Other biota:					

Comments/Observations:

Site: E1

Date (dd-mm-yr):	28-Jun-18			(dd.ddddd)	Biotopes Sampled (tick & rate)	Rating (1 - 5)	Time (min)
Site Code:	E1	Grid reference (dd mm ss.s) Lat:	S	#VALUE!	Stones In Current (SIC)	2	
Collector/Sampler:	Jackie Dabrowski	Long:	E	#VALUE!	Stones Out Of Current (SOOC)	1	
River:	Eastleigh Stream	Datum (WGS84/Cape):	WGS84		Bedrock	0	
Level 1 Ecoregion:		Altitude (m):			Aquatic Veg	0	
Quaternary Catchment:		Zonation:			MargVeg In Current	1	
	Temp (°C): 10.0	Routine or Project? (circle one)	Flow:	Low	MargVeg Out Of Current	1	
Site Description:	pH: 7.5	Project Name:	Clarity (cm):		Gravel	0	
Eastleigh Stream tributary through Highway Gardens	DO (mg/L): 2.6		Turbidity:	High	Sand	0	
	Cond (uS/cm): 489.0		Colour:	Grey	Mud	1	
	Riparian Disturbance:				Hand picking/Visual observation	3	
	Instream Disturbance:				Biotope Score (%)	13	

Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5					**HEMIPTERA (Bugs)**						**DIPTERA (Flies)**					
COELENTERATA (Cnidaria)	1					Belostomatidae* (Giant water bugs)	3					Athericidae (Snipe flies)	10				
TURBELLARIA (Flatworms)	3					Corixidae* (Water boatmen)	3					Blepharoceridae (Mountain midges)	15				
ANNELIDA						Gerridae* (Pond skaters/Water striders)	5					Ceratopogonidae (Biting midges)	5				
Oligochaeta (Earthworms)	1	A	1	A		Hydrometridae* (Water measurers)	6					Chironomidae (Midges)	2			A	
Hirudinea (Leeches)	3			1		Naucoridae* (Creeping water bugs)	7					Culicidae* (Mosquitoes)	1				
CRUSTACEA						Nepidae* (Water scorpions)	3					Dixidae* (Dixid midge)	10				
Amphipoda (Scuds)	13					Notonectidae* (Backswimmers)	3					Empididae (Dance flies)	6				
Potamonautidae* (Crabs)	3					Pleidae* (Pygmy backswimmers)	4					Ephydridae (Shore flies)	3				
Atyidae (Freshwater Shrimps)	8					Veliidae/M...veliidae* (Ripple bugs)	5					Muscidae (House flies, Stable flies)	1				
Palaemonidae (Freshwater Prawns)	10					**MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)**						Psychodidae (Moth flies)	1				
HYDRACARINA (Mites)	8					Corydalidae (Fishflies & Dobsonflies)	8					Simuliidae (Blackflies)	5		A		
PLECOPTERA (Stoneflies)						Sialidae (Alderflies)	6					Syrphidae* (Rat tailed maggots)	1				
Notonemouridae	14					**TRICHOPTERA (Caddisflies)**						Tabanidae (Horse flies)	5				
Perlidae	12					Dipseudopsidae	10					Tipulidae (Crane flies)	5				
EPHEMEROPTERA (Mayflies)						Ecnomidae	8					**GASTROPODA (Snails)**					
Baetidae 1sp	4					Hydropsychidae 1 sp	4					Ancylidae (Limpets)	6				
Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
Baetidae > 2 sp	12					Hydropsychidae > 2 sp	12					Hydrobiidae*	3				
Caenidae (Squaregills/Cainfles)	6					Philopotamidae	10					Lymnaeidae* (Pond snails)	3				
Ephemeridae	15					Polycentropodidae	12					Physidae* (Pouch snails)	3				
Heptageniidae (Flatheaded mayflies)	13					Psychomyiidae/Xiphocentronidae	8					Planorbinae* (Orb snails)	3				
Leptophlebiidae (Prongills)	9					**Cased caddis:**						Thiaridae* (=Melanidae)	3				
Oligoneuridae (Brushlegged mayflies)	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
Polymitarcyidae (Pale Burrowers)	10					Calamoceratidae ST	11					**PELECYPODA (Bivalvles)**					
Prosopistomatidae (Water specs)	15					Glossosomatidae SWC	11					Corbiculidae (Clams)	5				
Teloganodidae SWC (Spiny Crawlers)	12					Hydroptilidae	6					Sphaeriidae (Pill clams)	3				
Tricorythidae (Stout Crawlers)	9					Hydrosalpingidae SWC	15					Unionidae (Perly mussels)	6				
ODONATA (Dragonflies & Damselflies)						Lepidostomatidae	10					**SASS Score**					11
Calopterygidae ST,T (Demoiselles)	10					Leptoceridae	6					**No. of Taxa**					4
Chlorocyphidae (Jewels)	10					Petrothrincidae SWC	11					**ASPT**					2.8
Synlestidae (Chlorolestidae)(Sylphs)	8					Pisuliidae	10					**Other biota:**					
Coenagrionidae (Sprites and blues)	4					Sericostomatidae SWC	13					*Dead snails (Physidae); Dead chironomids in S and Veg; Dead Hirudinea in Veg.*					
Lestidae (Emerald Damselflies/Spreadwings)	8					**COLEOPTERA (Beetles)**											
Platycnemidae (Stream Damselflies)	10					Dytiscidae/Noteridae* (Diving beetles)	5										
Protoneuridae (Threadwings)	8					Elmidae/Dryopidae* (Riffle beetles)	8										
Aeshnidae (Hawkers & Emperors)	8					Gyrinidae* (Whirligig beetles)	5					**Comments/Observations:**					
Corduliidae (Cruisers)	8					Haliplidae* (Crawling water beetles)	5					Large volume of sewage in the water. Terrible smell, anoxic (black) sediment. Dead inverte					
Gomphidae (Clubtails)	6					Helodidae (Marsh beetles)	12										
Libellulidae (Darters/Skimmers)	4					Hydraenidae* (Minute moss beetles)	8										
LEPIDOPTERA (Aquatic Caterpillars/Moths)						Hydrophilidae* (Water scavenger beetles)	5										
Crambidae (Pyralidae)	12					Limnichidae (Marsh-Loving Beetles)	10										
						Psephenidae (Water Pennies)	10										

Site: E2

Date (dd-mm-yr):	28-Jun-18		(dd.ddddd)	Biotopes Sampled (tick & rate)	Rating (1 - 5)	Time (min)
Site Code:	E2	Grid reference (dd mm ss.s) Lat: S	#VALUE!	Stones In Current (SIC)	3	
Collector/Sampler:	Jackie Dabrowski	Long: E	#VALUE!	Stones Out Of Current (SOOC)	2	
River:	Eastleigh Stream	Datum (WGS84/Cape):	WGS84	Bedrock	1	
Level 1 Ecoregion:		Altitude (m):		Aquatic Veg	1	
Quaternary Catchment:		Zonation:		MargVeg In Current	3	
	Temp (°C): 12.4	Routine or Project? (circle one)	Flow: Low	MargVeg Out Of Current	1	
Site Description:	pH: 8.0	Project Name:	Clarity (cm):	Gravel	3	
Site upstream of Horwood Farm	DO (mg/L): 7.5		Turbidity: Low	Sand	4	
	Cond (uS/cm): 844.0		Colour: Light Brown	Mud	4	
	Riparian Disturbance:			Hand picking/Visual observation		
	Instream Disturbance:			Biotope Score (%)	49	

Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5				
COELENTERATA (Cnidaria)	1				
TURBELLARIA (Flatworms)	3				
ANNELIDA					
Oligochaeta (Earthworms)	1	A			A
Hirudinea (Leeches)	3				
CRUSTACEA					
Amphipoda (Scuds)	13				
Potamonautidae* (Crabs)	3				
Atyidae (Freshwater Shrimps)	8				
Palaemonidae (Freshwater Prawns)	10				
HYDRACARINA (Mites)	8				
PLECOPTERA (Stoneflies)					
Notonemouridae	14				
Perlidae	12				
EPHEMEROPTERA (Mayflies)					
Baetidae 1sp	4	A		B	B
Baetidae 2 sp	6		1	B	B
Baetidae > 2 sp	12				
Caenidae (Squaregills/Cainfles)	6				
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuridae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Teloganodidae SWC (Spiny Crawlers)	12				
Tricorythidae (Stout Crawlers)	9				
ODONATA (Dragonflies & Damselflies)					
Calopterygidae ST,T (Demoiselles)	10				
Chlorocyphidae (Jewels)	10				
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4		A	A	
Lestidae (Emerald Damselflies/Spreadwings)	8				
Platycnemidae (Stream Damselflies)	10				
Protoneuridae (Threadwings)	8				
Aeshnidae (Hawkers & Emperors)	8				
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6				
Libellulidae (Darters/Skimmers)	4				
LEPIDOPTERA (Aquatic Caterpillars/Moths)					
Crambidae (Pyralidae)	12				

Taxon	QV	S	Veg	GSM	TOT
HEMIPTERA (Bugs)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3				
Gerridae* (Pond skaters/Water striders)	5		A		A
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3				
Notonectidae* (Backswimmers)	3				
Pleidae* (Pygmy backswimmers)	4				
Veliidae/M...veliidae* (Ripple bugs)	5				
MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)					
Corydalidae (Fishflies & Dobsonflies)	8				
Sialidae (Alderflies)	6				
TRICHOPTERA (Caddisflies)					
Dipseudopsidae	10				
Ecnomidae	8				
Hydropsychidae 1 sp	4				
Hydropsychidae 2 sp	6				
Hydropsychidae > 2 sp	12				
Philopotamidae	10				
Polycentropodidae	12				
Psychomyiidae/Xiphocentronidae	8				
Cased caddis:					
Barbarochthonidae SWC	13				
Calamoceratidae ST	11				
Glossosomatidae SWC	11				
Hydroptilidae	6				
Hydrosalpingidae SWC	15				
Lepidostomatidae	10				
Leptoceridae	6				
Petrothrincidae SWC	11				
Pisuliidae	10				
Sericostomatidae SWC	13				
COLEOPTERA (Beetles)					
Dytiscidae/Noteridae* (Diving beetles)	5				
Elmidae/Dryopidae* (Riffle beetles)	8				
Gyrinidae* (Whirligig beetles)	5				
Haliplidae* (Crawling water beetles)	5				
Helodidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles)	5				
Limnichidae (Marsh-Loving Beetles)	10				
Psephenidae (Water Pennies)	10				

Taxon	QV	S	Veg	GSM	TOT
DIPTERA (Flies)					
Athericidae (Snipe flies)	10				
Blepharoceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5	1		A	A
Chironomidae (Midges)	2	A		A	B
Culicidae* (Mosquitoes)	1			A	A
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3				
Muscidae (House flies, Stable flies)	1				
Psychodidae (Moth flies)	1				
Simuliidae (Blackflies)	5	B		A	B
Syrphidae* (Rat tailed maggots)	1				
Tabanidae (Horse flies)	5				
Tipulidae (Crane flies)	5				
GASTROPODA (Snails)					
Ancylidae (Limpets)	6			1	1
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3				
Planorbinae* (Orb snails)	3				
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (Bivalvles)					
Corbiculidae (Clams)	5				
Sphaeriidae (Pill clams)	3				
Unionidae (Perly mussels)	6				
SASS Score					35
No. of Taxa					9
ASPT					3.9
Other biota:					
Tadpoles					
Comments/Observations:					

Site: E3

Date (dd-mm-yr):	29-Jun-18			(dd.ddddd)	Biotopes Sampled (tick & rate)	Rating (1 - 5)	Time (min)
Site Code:	E3	Grid reference (dd mm ss.s) Lat:	S	#VALUE!	Stones In Current (SIC)	4	
Collector/Sampler:	Jackie Dabrowski	Long:	E	#VALUE!	Stones Out Of Current (SOOC)	3	
River:	Eastleigh Stream	Datum (WGS84/Cape):	WGS84		Bedrock	1	
Level 1 Ecoregion:		Altitude (m):			Aquatic Veg	1	
Quaternary Catchment:		Zonation:			MargVeg In Current	4	
	Temp (°C): 9.7	Routine or Project? (circle one)	Flow:	Low	MargVeg Out Of Current	3	
Site Description:	pH: 8.0	Project Name:	Clarity (cm):		Gravel	2	
Eastleigh Stream upstream of 1st Avenue Bridge	DO (mg/L): 6.8		Turbidity:	Low	Sand	2	
	Cond (uS/cm): 515.0		Colour:	Light Brown	Mud	2	
	Riparian Disturbance:				Hand picking/Visual observation	4	
	Instream Disturbance:				Biotope Score (%)	49	

Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5					**HEMIPTERA (Bugs)**						**DIPTERA (Flies)**					
COELENTERATA (Cnidaria)	1					Belostomatidae* (Giant water bugs)	3					Athericidae (Snipe flies)	10				
TURBELLARIA (Flatworms)	3					Corixidae* (Water boatmen)	3					Blepharoceridae (Mountain midges)	15				
ANNELIDA						Gerridae* (Pond skaters/Water striders)	5					Ceratopogonidae (Biting midges)	5				
Oligochaeta (Earthworms)	1	B	A	A	B	Hydrometridae* (Water measurers)	6					Chironomidae (Midges)	2	B	1	C	
Hirudinea (Leeches)	3					Naucoridae* (Creeping water bugs)	7					Culicidae* (Mosquitoes)	1	1			
CRUSTACEA						Nepidae* (Water scorpions)	3					Dixidae* (Dixid midge)	10				
Amphipoda (Scuds)	13					Notonectidae* (Backswimmers)	3					Empididae (Dance flies)	6				
Potamonautidae* (Crabs)	3					Pleidae* (Pygmy backswimmers)	4					Ephydridae (Shore flies)	3				
Atyidae (Freshwater Shrimps)	8					Veliidae/M...veliidae* (Ripple bugs)	5					Muscidae (House flies, Stable flies)	1				
Palaemonidae (Freshwater Prawns)	10					**MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)**						Psychodidae (Moth flies)	1				
HYDRACARINA (Mites)	8					Corydalidae (Fishflies & Dobsonflies)	8					Simuliidae (Blackflies)	5				
PLECOPTERA (Stoneflies)						Sialidae (Alderflies)	6					Syrphidae* (Rat tailed maggots)	1				
Notonemouridae	14					**TRICHOPTERA (Caddisflies)**						Tabanidae (Horse flies)	5				
Perlidae	12					Dipseudopsidae	10					Tipulidae (Crane flies)	5				
EPHEMEROPTERA (Mayflies)						Ecnomidae	8					**GASTROPODA (Snails)**					
Baetidae 1sp	4		B	B		Hydropsychidae 1 sp	4					Ancylidae (Limpets)	6				
Baetidae 2 sp	6	C			C	Hydropsychidae 2 sp	6					Bulininae*	3				
Baetidae > 2 sp	12					Hydropsychidae > 2 sp	12					Hydrobiidae*	3				
Caenidae (Squaregills/Cainfles)	6					Philopotamidae	10					Lymnaeidae* (Pond snails)	3				
Ephemeridae	15					Polycentropodidae	12					Physidae* (Pouch snails)	3				
Heptageniidae (Flatheaded mayflies)	13					Psychomyiidae/Xiphocentronidae	8					Planorbinae* (Orb snails)	3				
Leptophlebiidae (Prongills)	9					**Cased caddis:**						Thiaridae* (=Melanidae)	3				
Oligoneuridae (Brushlegged mayflies)	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
Polymitarcyidae (Pale Burrowers)	10					Calamoceratidae ST	11					**PELECYPODA (Bivalvles)**					
Prosopistomatidae (Water specs)	15					Glossosomatidae SWC	11					Corbiculidae (Clams)	5				
Teloganodidae SWC (Spiny Crawlers)	12					Hydroptilidae	6					Sphaeriidae (Pill clams)	3				
Tricorythidae (Stout Crawlers)	9					Hydrosalpingidae SWC	15					Unionidae (Perly mussels)	6				
ODONATA (Dragonflies & Damselflies)						Lepidostomatidae	10					**SASS Score**					10
Calopterygidae ST,T (Demoiselles)	10					Leptoceridae	6					**No. of Taxa**					4
Chlorocyphidae (Jewels)	10					Petrothrincidae SWC	11					**ASPT**					2.5
Synlestidae (Chlorolestidae)(Sylphs)	8					Pisuliidae	10					**Other biota:**					
Coenagrionidae (Sprites and blues)	4					Sericostomatidae SWC	13					*Tadpoles in Veg*					
Lestidae (Emerald Damselflies/Spreadwings)	8					**COLEOPTERA (Beetles)**											
Platycnemidae (Stream Damselflies)	10					Dytiscidae/Noteridae* (Diving beetles)	5										
Protoneuridae (Threadwings)	8					Elmidae/Dryopidae* (Riffle beetles)	8										
Aeshnidae (Hawkers & Emperors)	8					Gyrinidae* (Whirligig beetles)	5					**Comments/Observations:**					
Corduliidae (Cruisers)	8					Haliplidae* (Crawling water beetles)	5					Vagrants in park, crime hotspot, lots of litter, manhole lids stolen					
Gomphidae (Clubtails)	6					Helodidae (Marsh beetles)	12										
Libellulidae (Darters/Skimmers)	4					Hydraenidae* (Minute moss beetles)	8										
LEPIDOPTERA (Aquatic Caterpillars/Moths)						Hydrophilidae* (Water scavenger beetles)	5										
Crambidae (Pyralidae)	12					Limnichidae (Marsh-Loving Beetles)	10										
						Psephenidae (Water Pennies)	10										

Site: G1

Date (dd-mm-yr):	27-Jun-18			(dd.ddddd)	Biotopes Sampled (tick & rate)	Rating (1 - 5)	Time (min)
Site Code:	G1	Grid reference (dd mm ss.s) Lat:	S	#VALUE!	Stones In Current (SIC)	3	
Collector/Sampler:	Jackie Dabrowski	Long:	E	#VALUE!	Stones Out Of Current (SOOC)	2	
River:	Glendower Stream	Datum (WGS84/Cape):	WGS84		Bedrock	0	
Level 1 Ecoregion:		Altitude (m):			Aquatic Veg	0	
Quaternary Catchment:		Zonation:			MargVeg In Current	3	
	Temp (°C): 19.2	Routine or Project? (circle one)	Flow:	Low	MargVeg Out Of Current	2	
Site Description:	pH: 8.6	Project Name:	Clarity (cm):		Gravel	2	
In the dip next to the R24 highway along Boeing Road.	DO (mg/L): 8.2		Turbidity:	Low	Sand	3	
	Cond (mS/m): ??		Colour:	Light Green	Mud	3	
	Riparian Disturbance:				Hand picking/Visual observation	4	
	Instream Disturbance:				Biotope Score (%)	40	

Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5				
COELENTERATA (Cnidaria)	1				
TURBELLARIA (Flatworms)	3	1			1
ANNELIDA					
Oligochaeta (Earthworms)	1	A		B	B
Hirudinea (Leeches)	3				
CRUSTACEA					
Amphipoda (Scuds)	13				
Potamonautidae* (Crabs)	3				
Atyidae (Freshwater Shrimps)	8				
Palaemonidae (Freshwater Prawns)	10				
HYDRACARINA (Mites)	8				
PLECOPTERA (Stoneflies)					
Notonemouridae	14				
Perlidae	12				
EPHEMEROPTERA (Mayflies)					
Baetidae 1sp	4				
Baetidae 2 sp	6				
Baetidae > 2 sp	12				
Caenidae (Squaregills/Cainfles)	6				
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuridae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Teloganodidae SWC (Spiny Crawlers)	12				
Tricorythidae (Stout Crawlers)	9				
ODONATA (Dragonflies & Damselflies)					
Calopterygidae ST,T (Demoiselles)	10				
Chlorocyphidae (Jewels)	10				
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4		A		A
Lestidae (Emerald Damselflies/Spreadwings)	8				
Platycnemidae (Stream Damselflies)	10				
Protoneuridae (Threadwings)	8				
Aeshnidae (Hawkers & Emperors)	8				
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6			1	1
Libellulidae (Darters/Skimmers)	4				
LEPIDOPTERA (Aquatic Caterpillars/Moths)					
Crambidae (Pyralidae)	12				

Taxon	QV	S	Veg	GSM	TOT
HEMIPTERA (Bugs)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3				
Gerridae* (Pond skaters/Water striders)	5				
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3				
Notonectidae* (Backswimmers)	3				
Pleidae* (Pygmy backswimmers)	4				
Veliidae/M...veliidae* (Ripple bugs)	5				
MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)					
Corydalidae (Fishflies & Dobsonflies)	8				
Sialidae (Alderflies)	6				
TRICHOPTERA (Caddisflies)					
Dipseudopsidae	10				
Ecnomidae	8				
Hydropsychidae 1 sp	4				
Hydropsychidae 2 sp	6				
Hydropsychidae > 2 sp	12				
Philopotamidae	10				
Polycentropodidae	12				
Psychomyiidae/Xiphocentronidae	8				
Cased caddis:					
Barbarochthonidae SWC	13				
Calamoceratidae ST	11				
Glossosomatidae SWC	11				
Hydroptilidae	6				
Hydrosalpingidae SWC	15				
Lepidostomatidae	10				
Leptoceridae	6				
Petrothrincidae SWC	11				
Pisuliidae	10				
Sericostomatidae SWC	13				
COLEOPTERA (Beetles)					
Dytiscidae/Noteridae* (Diving beetles)	5				
Elmidae/Dryopidae* (Riffle beetles)	8				
Gyrinidae* (Whirligig beetles)	5				
Haliplidae* (Crawling water beetles)	5				
Helodidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles)	5		1		1
Limnichidae (Marsh-Loving Beetles)	10				
Psephenidae (Water Pennies)	10				

Taxon	QV	S	Veg	GSM	TOT
DIPTERA (Flies)					
Athericidae (Snipe flies)	10				
Blepharoceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5				
Chironomidae (Midges)	2	B		B	B
Culicidae* (Mosquitoes)	1		1		1
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3				
Muscidae (House flies, Stable flies)	1				
Psychodidae (Moth flies)	1				
Simuliidae (Blackflies)	5	1			1
Syrphidae* (Rat tailed maggots)	1				
Tabanidae (Horse flies)	5		1		1
Tipulidae (Crane flies)	5				
GASTROPODA (Snails)					
Ancylidae (Limpets)	6				
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3				
Planorbinae* (Orb snails)	3				
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (Bivalvles)					
Corbiculidae (Clams)	5				
Sphaeriidae (Pill clams)	3				
Unionidae (Perly mussels)	6				
SASS Score					35
No. of Taxa					10
ASPT					3.5
Other biota:					
Comments/Observations:					

Site: G2

Field	Value
Date (dd-mm-yr):	29-Jun-18
Site Code:	G2
Collector/Sampler:	Jackie Dabrowski
River:	Glendower Stream
Level 1 Ecoregion:	
Quaternary Catchment:	
Site Description:	Glendower Golf Course just before the stream goes under the highway.
Temp (°C):	13.0
pH:	8.1
DO (mg/L):	8.14 / 94.3%
Cond (uS/cm):	515.0
Riparian Disturbance:	
Instream Disturbance:	

Grid reference (dd mm ss.s)			(dd.ddddd)
Lat:	S		#VALUE!
Long:	E		#VALUE!
Datum (WGS84/Cape):		WGS84	
Altitude (m):			
Zonation:			

Routine or Project? (circle one)	
Project Name:	
Flow:	Zero
Clarity (cm):	
Turbidity:	High
Colour:	Grey

Biotopes Sampled (tick & rate)	Rating (1 - 5)	Time (min)
Stones In Current (SIC)	3	
Stones Out Of Current (SOOC)	1	
Bedrock	1	
Aquatic Veg	1	
MargVeg In Current	4	
MargVeg Out Of Current	4	
Gravel	0	
Sand	1	
Mud	1	
Hand picking/Visual observation		
Biotope Score (%)	36	

Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5				
COELENTERATA (Cnidaria)	1				
TURBELLARIA (Flatworms)	3			B	B
ANNELIDA					
Oligochaeta (Earthworms)	1		1	1	A
Hirudinea (Leeches)	3			A	A
CRUSTACEA					
Amphipoda (Scuds)	13				
Potamonautidae* (Crabs)	3				
Atyidae (Freshwater Shrimps)	8				
Palaemonidae (Freshwater Prawns)	10				
HYDRACARINA (Mites)	8				
PLECOPTERA (Stoneflies)					
Notonemouridae	14				
Perlidae	12				
EPHEMEROPTERA (Mayflies)					
Baetidae 1sp	4	C	A	B	C
Baetidae 2 sp	6				
Baetidae > 2 sp	12				
Caenidae (Squaregills/Cainfles)	6				
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuridae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Teloganodidae SWC (Spiny Crawlers)	12				
Tricorythidae (Stout Crawlers)	9				
ODONATA (Dragonflies & Damselflies)					
Calopterygidae ST,T (Demoiselles)	10				
Chlorocyphidae (Jewels)	10				
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4	1	B		B
Lestidae (Emerald Damselflies/Spreadwings)	8				
Platycnemidae (Stream Damselflies)	10				
Protoneuridae (Threadwings)	8				
Aeshnidae (Hawkers & Emperors)	8				
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6				
Libellulidae (Darters/Skimmers)	4				
LEPIDOPTERA (Aquatic Caterpillars/Moths)					
Crambidae (Pyralidae)	12				

Taxon	QV	S	Veg	GSM	TOT
HEMIPTERA (Bugs)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3				
Gerridae* (Pond skaters/Water striders)	5				
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3				
Notonectidae* (Backswimmers)	3		A		A
Pleidae* (Pygmy backswimmers)	4				
Veliidae/M...veliidae* (Ripple bugs)	5				
MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)					
Corydalidae (Fishflies & Dobsonflies)	8				
Sialidae (Alderflies)	6				
TRICHOPTERA (Caddisflies)					
Dipseudopsidae	10				
Ecnomidae	8				
Hydropsychidae 1 sp	4				
Hydropsychidae 2 sp	6				
Hydropsychidae > 2 sp	12				
Philopotamidae	10				
Polycentropodidae	12				
Psychomyiidae/Xiphocentronidae	8				
Cased caddis:					
Barbarochthonidae SWC	13				
Calamoceratidae ST	11				
Glossosomatidae SWC	11				
Hydroptilidae	6				
Hydrosalpingidae SWC	15				
Lepidostomatidae	10				
Leptoceridae	6				
Petrothrincidae SWC	11				
Pisuliidae	10				
Sericostomatidae SWC	13				
COLEOPTERA (Beetles)					
Dytiscidae/Noteridae* (Diving beetles)	5				
Elmidae/Dryopidae* (Riffle beetles)	8				
Gyrinidae* (Whirligig beetles)	5				
Haliplidae* (Crawling water beetles)	5				
Helodidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles)	5				
Limnichidae (Marsh-Loving Beetles)	10				
Psephenidae (Water Pennies)	10				

Taxon	QV	S	Veg	GSM	TOT
DIPTERA (Flies)					
Athericidae (Snipe flies)	10				
Blepharoceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5		1		1
Chironomidae (Midges)	2	A			A
Culicidae* (Mosquitoes)	1	1	A		A
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3				
Muscidae (House flies, Stable flies)	1				
Psychodidae (Moth flies)	1				
Simuliidae (Blackflies)	5	A		1	A
Syrphidae* (Rat tailed maggots)	1				
Tabanidae (Horse flies)	5				
Tipulidae (Crane flies)	5				
GASTROPODA (Snails)					
Ancylidae (Limpets)	6				
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3		1		1
Planorbinae* (Orb snails)	3				
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (Bivalvles)					
Corbiculidae (Clams)	5				
Sphaeriidae (Pill clams)	3				
Unionidae (Perly mussels)	6				
SASS Score					34
No. of Taxa					11
ASPT					3.1

Other biota:
Tadpoles

Comments/Observations:
Sewage stream entering from Linksfield Road.

Site: O2

Date (dd-mm-yr):	26-Jun-18				(dd.ddddd)	Biotopes Sampled (tick & rate)	Rating (1 - 5)	Time (min)
Site Code:	O2	Grid reference (dd mm ss.s) Lat:	S		#VALUE!	Stones In Current (SIC)	4	
Collector/Sampler:	Jackie Dabrowski	Long:	E		#VALUE!	Stones Out Of Current (SOOC)	1	
River:	Oriel Stream	Datum (WGS84/Cape):		WGS84		Bedrock	0	
Level 1 Ecoregion:		Altitude (m):				Aquatic Veg	0	
Quaternary Catchment:		Zonation:				MargVeg In Current	3	
	Temp (°C):	Routine or Project? (circle one)	Flow:	Medium		MargVeg Out Of Current	2	
Site Description:	pH:	Project Name:	Clarity (cm):	20		Gravel	2	
Upper reaches of Oriel Stream in Oriel Park. Site extended from Kloof Road bridge to the embankment. Sewage flowint in from south-western stream.	DO (mg/L):		Turbidity:	V Low		Sand	3	
	Cond (mS/m):		Colour:	Light Brown		Mud	2	
	Riparian Disturbance:					Hand picking/Visual observation	5	
	Instream Disturbance:					Biotope Score (%)	38	

Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5				
COELENTERATA (Cnidaria)	1				
TURBELLARIA (Flatworms)	3		1		
ANNELIDA					
Oligochaeta (Earthworms)	1	B	A	A	
Hirudinea (Leeches)	3	1		1	
CRUSTACEA					
Amphipoda (Scuds)	13				
Potamonautidae* (Crabs)	3				
Atyidae (Freshwater Shrimps)	8				
Palaemonidae (Freshwater Prawns)	10				
HYDRACARINA (Mites)	8				
PLECOPTERA (Stoneflies)					
Notonemouridae	14				
Perlidae	12				
EPHEMEROPTERA (Mayflies)					
Baetidae 1sp	4				
Baetidae 2 sp	6	B	B	B	
Baetidae > 2 sp	12				
Caenidae (Squaregills/Cainfles)	6				
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuridae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Teloganodidae SWC (Spiny Crawlers)	12				
Tricorythidae (Stout Crawlers)	9				
ODONATA (Dragonflies & Damselflies)					
Calopterygidae ST,T (Demoiselles)	10				
Chlorocyphidae (Jewels)	10				
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4	A	1		
Lestidae (Emerald Damselflies/Spreadwings)	8				
Platycnemidae (Stream Damselflies)	10				
Protoneuridae (Threadwings)	8				
Aeshnidae (Hawkers & Emperors)	8				
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6	1			
Libellulidae (Darters/Skimmers)	4				
LEPIDOPTERA (Aquatic Caterpillars/Moths)					
Crambidae (Pyralidae)	12				

Taxon	QV	S	Veg	GSM	TOT
HEMIPTERA (Bugs)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3				
Gerridae* (Pond skaters/Water striders)	5				
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3				
Notonectidae* (Backswimmers)	3				
Pleidae* (Pygmy backswimmers)	4				
Veliidae/M...veliidae* (Ripple bugs)	5				
MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)					
Corydalidae (Fishflies & Dobsonflies)	8				
Sialidae (Alderflies)	6				
TRICHOPTERA (Caddisflies)					
Dipseudopsidae	10				
Ecnomidae	8				
Hydropsychidae 1 sp	4	1			
Hydropsychidae 2 sp	6				
Hydropsychidae > 2 sp	12				
Philopotamidae	10				
Polycentropodidae	12				
Psychomyiidae/Xiphocentronidae	8				
Cased caddis:					
Barbarochthonidae SWC	13				
Calamoceratidae ST	11				
Glossosomatidae SWC	11				
Hydroptilidae	6				
Hydrosalpingidae SWC	15				
Lepidostomatidae	10				
Leptoceridae	6				
Petrothrincidae SWC	11				
Pisuliidae	10				
Sericostomatidae SWC	13				
COLEOPTERA (Beetles)					
Dytiscidae/Noteridae* (Diving beetles)	5				
Elmidae/Dryopidae* (Riffle beetles)	8				
Gyrinidae* (Whirligig beetles)	5				
Haliplidae* (Crawling water beetles)	5				
Helodidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles)	5				
Limnichidae (Marsh-Loving Beetles)	10				
Psephenidae (Water Pennies)	10				

Taxon	QV	S	Veg	GSM	TOT
DIPTERA (Flies)					
Athericidae (Snipe flies)	10				
Blepharoceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5				
Chironomidae (Midges)	2	B	B	B	
Culicidae* (Mosquitoes)	1	A	1	1	
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3				
Muscidae (House flies, Stable flies)	1				
Psychodidae (Moth flies)	1				
Simuliidae (Blackflies)	5	B	B	A	
Syrphidae* (Rat tailed maggots)	1				
Tabanidae (Horse flies)	5				
Tipulidae (Crane flies)	5				
GASTROPODA (Snails)					
Ancylidae (Limpets)	6				
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3	B	B	1	
Planorbinae* (Orb snails)	3				
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (Bivalvles)					
Corbiculidae (Clams)	5				
Sphaeriidae (Pill clams)	3				
Unionidae (Perly mussels)	6				
SASS Score					38
No. of Taxa					11
ASPT					3.5
Other biota:					
Comments/Observations:					

Site: 03

Date (dd-mm-yr):	29-Jun-18		(dd.ddddd)	**Biotopes Sampled (tick & rate)**	Rating (1 - 5) / Time (min)
Site Code:	O3	Grid reference (dd mm ss.s) Lat: S	#VALUE!	Stones In Current (SIC)	3
Collector/Sampler:	Jackie Dabrowski	Long: E	#VALUE!	Stones Out Of Current (SOOC)	2
River:	Oriel Stream	Datum (WGS84/Cape):	WGS84	Bedrock	0
Level 1 Ecoregion:		Altitude (m):		Aquatic Veg	1
Quaternary Catchment:		Zonation:		MargVeg In Current	4
	Temp (°C): 12.0	**Routine or Project? (circle one)**	Flow: Low	MargVeg Out Of Current	4
Site Description:	pH: 8.7	Project Name:	Clarity (cm):	Gravel	0
Downstream of Gillooly's Dam	DO (mg/L): 8.4		Turbidity: Low	Sand	2
	Cond (uS/cm): 420.0		Colour: Light Brown	Mud	2
	Riparian Disturbance:			Hand picking/Visual observation	3
	Instream Disturbance:			Biotope Score (%)	40

Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT	Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5					**HEMIPTERA (Bugs)**						**DIPTERA (Flies)**					
COELENTERATA (Cnidaria)	1					Belostomatidae* (Giant water bugs)	3					Athericidae (Snipe flies)	10				
TURBELLARIA (Flatworms)	3					Corixidae* (Water boatmen)	3			A	A	Blepharoceridae (Mountain midges)	15				
ANNELIDA						Gerridae* (Pond skaters/Water striders)	5		1		1	Ceratopogonidae (Biting midges)	5				
Oligochaeta (Earthworms)	1	A	1	1	B	Hydrometridae* (Water measurers)	6					Chironomidae (Midges)	2	A			A
Hirudinea (Leeches)	3	A	B	B	B	Naucoridae* (Creeping water bugs)	7					Culicidae* (Mosquitoes)	1	1			1
CRUSTACEA						Nepidae* (Water scorpions)	3					Dixidae* (Dixid midge)	10				
Amphipoda (Scuds)	13					Notonectidae* (Backswimmers)	3					Empididae (Dance flies)	6				
Potamonautidae* (Crabs)	3					Pleidae* (Pygmy backswimmers)	4					Ephydridae (Shore flies)	3				
Atyidae (Freshwater Shrimps)	8					Veliidae/M...veliidae* (Ripple bugs)	5					Muscidae (House flies, Stable flies)	1				
Palaemonidae (Freshwater Prawns)	10					**MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)**						Psychodidae (Moth flies)	1				
HYDRACARINA (Mites)	8					Corydalidae (Fishflies & Dobsonflies)	8					Simuliidae (Blackflies)	5	A		1	A
PLECOPTERA (Stoneflies)						Sialidae (Alderflies)	6					Syrphidae* (Rat tailed maggots)	1				
Notonemouridae	14					**TRICHOPTERA (Caddisflies)**						Tabanidae (Horse flies)	5				
Perlidae	12					Dipseudopsidae	10					Tipulidae (Crane flies)	5				
EPHEMEROPTERA (Mayflies)						Ecnomidae	8					**GASTROPODA (Snails)**					
Baetidae 1sp	4	A			A	Hydropsychidae 1 sp	4					Ancylidae (Limpets)	6				
Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
Baetidae > 2 sp	12					Hydropsychidae > 2 sp	12					Hydrobiidae*	3				
Caenidae (Squaregills/Cainfles)	6					Philopotamidae	10					Lymnaeidae* (Pond snails)	3				
Ephemeridae	15					Polycentropodidae	12					Physidae* (Pouch snails)	3		A		A
Heptageniidae (Flatheaded mayflies)	13					Psychomyiidae/Xiphocentronidae	8					Planorbinae* (Orb snails)	3				
Leptophlebiidae (Prongills)	9					**Cased caddis:**						Thiaridae* (=Melanidae)	3				
Oligoneuridae (Brushlegged mayflies)	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
Polymitarcyidae (Pale Burrowers)	10					Calamoceratidae ST	11					**PELECYPODA (Bivalvles)**					
Prosopistomatidae (Water specs)	15					Glossosomatidae SWC	11					Corbiculidae (Clams)	5				
Teloganodidae SWC (Spiny Crawlers)	12					Hydroptilidae	6					Sphaeriidae (Pill clams)	3				
Tricorythidae (Stout Crawlers)	9					Hydrosalpingidae SWC	15					Unionidae (Perly mussels)	6				
ODONATA (Dragonflies & Damselflies)						Lepidostomatidae	10					**SASS Score**					34
Calopterygidae ST,T (Demoiselles)	10					Leptoceridae	6					**No. of Taxa**					11
Chlorocyphidae (Jewels)	10					Petrothrincidae SWC	11					**ASPT**					3.1
Synlestidae (Chlorolestidae)(Sylphs)	8					Pisuliidae	10					**Other biota:**					
Coenagrionidae (Sprites and blues)	4	A		A	B	Sericostomatidae SWC	13					*Lots of ostracods, juvenile T. sparrmanii, and other fry (Carp?)*					
Lestidae (Emerald Damselflies/Spreadwings)	8					**COLEOPTERA (Beetles)**											
Platycnemidae (Stream Damselflies)	10					Dytiscidae/Noteridae* (Diving beetles)	5										
Protoneuridae (Threadwings)	8					Elmidae/Dryopidae* (Riffle beetles)	8										
Aeshnidae (Hawkers & Emperors)	8					Gyrinidae* (Whirligig beetles)	5					**Comments/Observations:**					
Corduliidae (Cruisers)	8					Haliplidae* (Crawling water beetles)	5										
Gomphidae (Clubtails)	6					Helodidae (Marsh beetles)	12										
Libellulidae (Darters/Skimmers)	4					Hydraenidae* (Minute moss beetles)	8										
LEPIDOPTERA (Aquatic Caterpillars/Moths)						Hydrophilidae* (Water scavenger beetles)	5										
Crambidae (Pyralidae)	12					Limnichidae (Marsh-Loving Beetles)	10										
						Psephenidae (Water Pennies)	10										