CONTRACT

RESOLUTION C–RTCW (19-2006)

DETAILED STUDY INTO MEASURES FOR THE REHABILITATION OF EROSION CHANNEL IN THE OLIFANTSFONTEIN WETLAND – EKURHULENI METROPOLITAN MUNICIPALITY

George Orr & Associates	Ninham Shand Consulting Services (Pty) Ltd	Wetland Consulting Services (Pty) Ltd

Report No: 401365/4339

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REPORT TITLE	**:**	Detailed Study into Remedial Measures For The Rehabilitation for the Erosion Channel in the Olifantsfontein Wetland
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EXECUTIVE SUMMARY

In terms of a letter received from the Executive Director of the Department of Roads , Transport and Civil Works, of the Ekurhuleni Metropolitan Municipality dated 07/2/2006, Messer's George Orr and Associates were appointed, in terms of Municipal RESOLUTION C – RTCW (19-2006)T, to undertake *a detailed study into measures for the rehabilitation of the erosion channel in the Olifantsfontein wetland*.

For the study, George Orr and Associates formed a Joint Venture with two other firms of consultants, namely Ninham Shand Consulting Services and Wetlands Consulting. The professional team who conducted the study were, Dr. Allan Batchelor of Wetlands Consulting, in association with Mr Sean Pols of Ninham Shand Consulting Services and Dave George of George Orr and Associates.

The detailed study commenced with field investigations and a number of internal JV workshops. The purpose of this initial work was to obtain consensus in the JV on the approach to the study.

Following the completion of the initial work, a series of meetings was held, between the professional team, and Messer's J.C.Prinsloo and N. Smal of the Ekurhuleni Department of Roads, Transport & Civil Works. The purpose of the meetings, was to define more accurately, from the Client side, the project goals and objectives, than had been set out in the letter of appointment. The "Project Goals and Objectives" agreed on, at the culmination of these meetings was as set out in section 1 .5 of this report.

A list of *desirable results* and or *factors which needed to be taken into account* was drawn up to assist in the evaluation of the pros and cons of the various remedial measures(see section 4 .4 of the report). With reference to this list, the remedial works would ideally:

- Prevent any further erosion of the Olifantsfontein wetland.
- Allow the wetland to resume one of its original functions namely trapping silt, thereby ensuring that clean, silt free water flows down the Kaalspruit.
- Attenuate flood flows.
- Improve the water quality in the Kaalspruit by recreating the bacteriological filter previously provided by the wetland.
- Remove urban litter and vegetation debris from the Kaalspruit.
- Protect the groundwater from pollution by poor quality surface water.
- Facilitate the recharge of the underlying groundwater from the wetland.
- Reduce the downstream hydrological impacts
- Support biodiversity
- Take cognisance of the fact that the area is currently used for cropping
- Make allowance for public open space
- Minimise the risk of odours

EKURHULENI METROPOLITAN MUNICIPALITY

DETAILED STUDY INTO MEASURES FOR THE REHABILITATION OF THE EROSION CHANNEL IN THE OLIFANTSFONTEIN WETLAND

CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

LIST OF ABBREVIATIONS

DWAF	Department of Water Affairs and Forestry
EMP	Environmental Management Plan
kW	kilo Watt
kWh	kilo Watt hour
m	metres
m^2	square metres
m^3/day	cubic metres per day
Mℓ/d	mega-litres per day (10^6 ℓ/d)
m/s	metres per second
m AMSL	metres above mean sea level
kPa	kilo Pascals (Pressure)
ℓ/s	litres per second
TWL	top water level

DETAILED STUDY INTO MEASURES FOR THE REHABILITATION OF THE EROSION CHANNEL IN THE OLIFANTSFONTEIN WETLAND

1. INTRODUCTION

1.1. APPOINTMENT

In terms of a letter received from the Executive Director of the Department of Roads , Transport and Civil Works, of the Ekurhuleni Metropolitan Municipality dated 07/2/2006, Messer's George Orr and Associates were appointed, in terms of Municipal RESOLUTION C – RTCW (19-2006)T, to undertake *a detailed study into measures for the rehabilitation of the erosion channel in the Olifantsfontein wetland*.

1.2. PROFESSIONAL TEAM

For the study, George Orr and Associates formed a Joint Venture with two other firms of consultants, namely Ninham Shand Consulting Services and Wetlands Consulting.

The professional team who conducted the study were, Dr. Allan Batchelor of Wetlands Consulting, in association with Mr Sean Pols of Ninham Shand Consulting Services and Dave George of George Orr and Associates.

1.3. TERMS OF REFERENCE / SCOPE OF WORK

The letter of appointment referred to in section 1.1 above defined the scope of the work as follows:

The scope of work includes, but is not limited to the following:

- To assess and propose measures to prevent further unnaturally large quantities of sand and silt being carried downstream of the Olifantsfontein wetland into the Kaalspruit and Hennops rivers.
- To assess the status quo with regard to water quality, the surface geology, sediment loads and the existing vegetation.
- To assess and recommend remedial measures to rehabilitate the erosion channel in the Olifantsfontein wetland.
- To establish contacts with interested and affected parties (including service providers and land owners).
- To provide detailed planning drawings, maps and charts, relevant for the proposed interventions.

1.4. DELIVERABLES

The letter of appointment referred to in section 1.1 above defined the scope of the work as follows:

The deliverables for this study will include a report (with drawings and maps as appropriate) including:

- A detailed description of the methodologies and assumptions applied in carrying out the study.
- Description of any field study, testing or sampling undertaken and discussion of the results
- Description of any analyses undertaken and discussion of the results.
- Recommendations for remedial work, including time and cost estimates.
- Detail drawings and maps as part of the report.
- The business plan with the relevant correspondence and agreements of the various stakeholders.

1.5. REASSESSMENT OF THE PROJECT OBJECTIVES / SCOPE OF WORK

Phase 1 of the detailed study commenced with two days of field investigations, followed by a number of internal JV workshops. The purpose of the Phase 1 work was to obtain consensus in the JV's on the approach to the study.

Following the completion of Phase 1, a series of meetings was held, between the professional team, and Messer's J.C.Prinsloo and N. Smal of the Ekurhuleni Department of Roads, Transport & Civil Works. The purpose of the meetings, which were held at the request of the Ekuruhuleni Metropolitan Municipality, was to define more accurately, from the Client side, the project goals and objectives, than had been set out in the letter of appointment.

The "Project Goals and Objectives" agreed on, at the culmination of these meetings was as follows:

The goals and objectives listed below must form the basis for consideration of options for the rehabilitation of the Kaalspruit at Olifantsfontein. In addition to, and in support of these goals, consideration should also be given to the over-arching goal for the rehabilitation of the Kaalspruit as set out in the "Masterplan" report – "An overview of the State of the Catchment of the Kaalspruit / Hennops River System with a view to implementing Specific Rehabilitation Projects" (George Orr & Associates, Wetland Consulting Services and Ninham Shand Consulting Services, August 2005).

The goals and objectives of the detailed study into measures for the rehabilitation of the erosion channel in the Olifantsfontein wetland

Water Quality

- *Improve the chemical and bacteriological quality of the water in the Kaalspruit.*
- *Reduce the sediment load (normalization).*

Water Quantity

- *Attenuate and / or normalize storm water runoff.*
- *Improve or re-establish seasonal wetting of the floodplain and wetland and thereby enable the consequent improvement in quality and quantity of "lateral flows" entering the watercourse.*

Economic Viability

- *Endeavor to ensure cost effectiveness in the implementation of the capital works.*
- *Endeavor to minimise operation and maintenance costs.*
- *Try to design the rehabilitation measures, such, that they comprise a number of individual components, which will allow phased construction, and very importantly, allow individual components to be sponsored by potential funding agencies other than the Ekurhuleni Metropolitan municipality.*

Sustainability

- *Socially acceptable and not in conflict with the existing infrastructure development. Great stress was placed on this aspect, and it was emphasised, that the proposed rehabilitation measures should be presented to and discussed with all stakeholders and interested and affected parties, to ensure that the rehabilitation measures proposed at the culmination of the study, have, as far as possible, the support of the majority of all stakeholders and interested and affected parties.*
- *Environmentally sound.*
- *No adverse health of safety implications.*
- *Aesthetically pleasing and in harmony with surroundings.*
- *Technically sound (bearing in mind hydrology and watercourse hydraulics).*

ERWAT Requirements

- *Recognise the potential for re-routing of ERWAT effluent discharge through wetland.*
- *Pose no risk to ERWAT main outfall sewer line.*

Legislation

- *Compliance with the National Water Act.*
- *Compliance with current (as well as proposed amended) Environmental legislation.*

It was noted that many of the stated goals and objectives would appear to be contradictory or in conflict and that the goals would not all be equally achievable. The proposed engineering solutions should therefore strive to strike a workable / practical balance between the goals, noting that the improvement of water quality, and in particular the reduction in sediment load, will remain the primary objectives.

2. BACKGROUND

2.1. KAALSPRUIT REHABILITATION MASTER PLAN

Recent reports (in particular *The Rehabilitation of The Kaalspruit and Upper Hennops River* by George, Orr & Associates Ref.1 and the *Kaalspruit Rehabilitation Master Plan* by the Joint Venture Consultants Ninham Shand, Wetlands Consulting and George Orr and Assoc. Ref 2) have highlighted the serious degradation of Kaalspruit and the Upper Hennops River. In particular three serious problems have been identified, with these rivers namely:

2.1.1 SILTATION

There has been a dramatic increase in the silt brought down by the Kaalspruit. This has had major negative environmental and economic impacts on both the Kaalspruit and the Hennops. Siltation has filled many of the deep pools and channels with sand and silt in both the stream and the river thereby either destroying or seriously degrading the habitat and life-support systems of fish and invertebrates. This, in turn, has impacted negatively on the animals higher up the food chain, such as birds, otters, etc.

On the economic front, this has resulted in the silting up of the Centurion Lake, degrading a top-class commercial area and requiring significant expenditure to restore the lake. The threat of siltation is also inhibiting other potential commercial developments based on the Hennops River, as investors are reluctant to commit themselves to any such project until the siltation problem is resolved.

The above-mentioned two reports, (Ref.1 & 2) identified erosion of the Olifantsfontein Wetland as the major source of sediment in the lower Kaalspruit and Upper Hennops River.

In terms of the National Water Act, urgent measures need to be taken to stabilize the situation and prevent further unnaturally large quantities of sand and silt being carried into the Kaalspruit and Hennops rivers downstream of the wetland.

The underlying cause of the erosion of the Olifantsfontein Wetland is the increased urbanisation and the rapid development of the upper reaches of the catchment, which have lead to progressively increased flood peaks.

It is speculated that, between 1970 and 1978, these increased flood peaks, following closely after a prolonged period of drought, contributed to severe erosion of portions of the wetland directly upstream of the Olifantsfontein Spruit. Headward expansion of this erosion has continued unchecked since that period, and the result is an incised channel approximately 2,5km long and averaging 22m wide and 6m deep.

2.1.2 BACTERIAL CONTAMINATION

The upper Kaalspruit catchment is already heavily urbanised, and further developments are ongoing. Inadequate sewers (broken/overloaded sewers) in formal housing areas together a complete lack of services in the many informal settlements in the area have resulted in the Kaalspruit being subject to very high levels of bacterial contamination, particularly during periods of low-flow (winter) and after the first flush of summer rains. This, in turn, contaminates the Hennops River and, consequently, Centurion Lake.

The levels of contamination in the Kaalspruit Hennops River and Centurion Lake are so high that the water is no longer safe for recreational use, even at intermediate contact level.

Although the return water flows from the sewage outfall of the Olifantsfontein sewage works generally dilute and therefore improve the quality of the water in the lower Kaalspruit, this sewage works is periodically subjected to illegal industrial discharges which disrupt the treatment works and result in additional poor quality water entering the lower Kaalspruit.

2.1.3 DEBRIS

The Kaalspruit is also subject to a severe debris problem carried downstream by flood water flows. Two categories can be identified, viz,

- litter debris from the urban areas ranging from plastic bags through to dead animals
- vegetation debris, derived largely from alien trees growing on the stream banks.

2.1.4 SOURCE AREAS OF THE UNNATURALLY HIGH SEDIMENT LOADS, BACTERIAL CONTAMINATION, AND DEBRIS.

The George Orr and Associates report Ref 1 estimated (for the year 2000) the extent to which the problems of unnaturally high silt load, bacterial contamination and debris were generated along the length of the Kaalspruit and Upper Hennops River catchments and allocated these estimates into 3 zones or areas, the boundaries of which were defined as:

- **The Upper Kaalspruit** - extending from the headwaters of the Kaalspruit in the Birchleigh North/Chloorkop area down to the Olifantsfontein /Midrand road bridge.

- **The Central Kaalspruit** extending from the Olifantsfontein /Midrand road bridge down to the Olifantsfontein /Irene the road bridge.

- **The Lower Kaalspruit / Upper Hennops River** extending from the Olifantsfontein/Irene road bridge down to Centurion Lake.

The extent to which the environmental problems of the Hennops River were generated within these three zones was estimated in George Orr & Assoc. report Ref.1 for the year 2000 to be as set out in Table 1 below.

Environmental problem	The Upper Kaalspruit Percentage of total problem	The Central Kaalspruit Percentage of total problem	Kaalspruit / Upper Hennops River Percentage of total problem	Total
Sediment load	23%	73%	4%	100%
Debris Urban litter Vegetation litter	 70% 0%	 25% 50%	 5% 50%	 100% 100%
Bacterial Contamination of Water Waste flows Effluent return flows	 13% 0%	 85% 100%	 2% 0%	 100% 100%

Table 1: Estimated respective contribution of three zones to the total environmental problem in the study area.

The estimates above are expressed as a percentage of the total problem in the year 2000.

As can be seen:

- **Zone 1 -** produced an estimated 23% of the sediment load, 50% of the urban litter and 13% of the waste water flows in the year 2000. There has however been a significant increase in the amount of wastewater flows from Zone 1, due to an ever-increasing number of surcharging sewers. As a result, Zone I, probably now produces approximately 50% of the highly polluted waste water flows.
- **Zone 2 -** was (and still is) the biggest source of the environmental problems of the Hennops River, and in the year 2000 produced an estimated 73% of the sediment load, 40% of the urban litter, 50% of the vegetation debris, 85% of the waste water flows and 100% of the effluent return flows. Although the quantity of waste water flows originating in Zone 2 has probably increased over the last six years, if this quantity is expressed as a percentage of the total waste water problem in the Kaalspruit, then, Zone 2's contribution to the total, has probably reduced from the estimated 85% in the year 2000 to approximately 40%- 50% in the year 2006, as a result of the increasing waste water flows from Zone 1.

- **Zone 3 -** was, and still is the least problematic of the three zones, producing an estimated 4% of the sediment load and 2% of the wastewater flows. It does however, have a significant debris problem, producing an estimated 10% of the urban litter and 50% of the vegetation debris. Further, erosion of riverbanks is a growing problem, which needs to be addressed.

The master plan for the rehabilitation of the Kaalspruit and Hennops river recommended a series of interventions along the length of these rivers to address the three principal environmental problems outlined above.

As shown in Table 1` above, Zone 2 is the biggest source of the environmental problems of the Hennops River. Within Zone 2, **the master plan identified the rehabilitation of the Olifantsfontein wetland as the highest priority intervention for the rehabilitation of the Kaalspruit and Hennops River.**

This report details the intervention required to rehabilitate the Olifantsfontein wetland.

3. THE OLIFANTSFONTEIN WETLAND

3.1. PROJECT LOCALITY

The approximately 2.5 km long Olifantsfontein wetland lies between the confluence of the Kaalspruit and its Clayville tributary and the confluence of the Kaalspruit and the Olifantspruit. The general locality of the wetland is illustrated in Figure 1 (!:50 000 topographical map) while the specific wetland area is delineated on the aerial photograph (Figure 2). The delineation follows the interpreted original extent of the wetland and includes the floodplain.

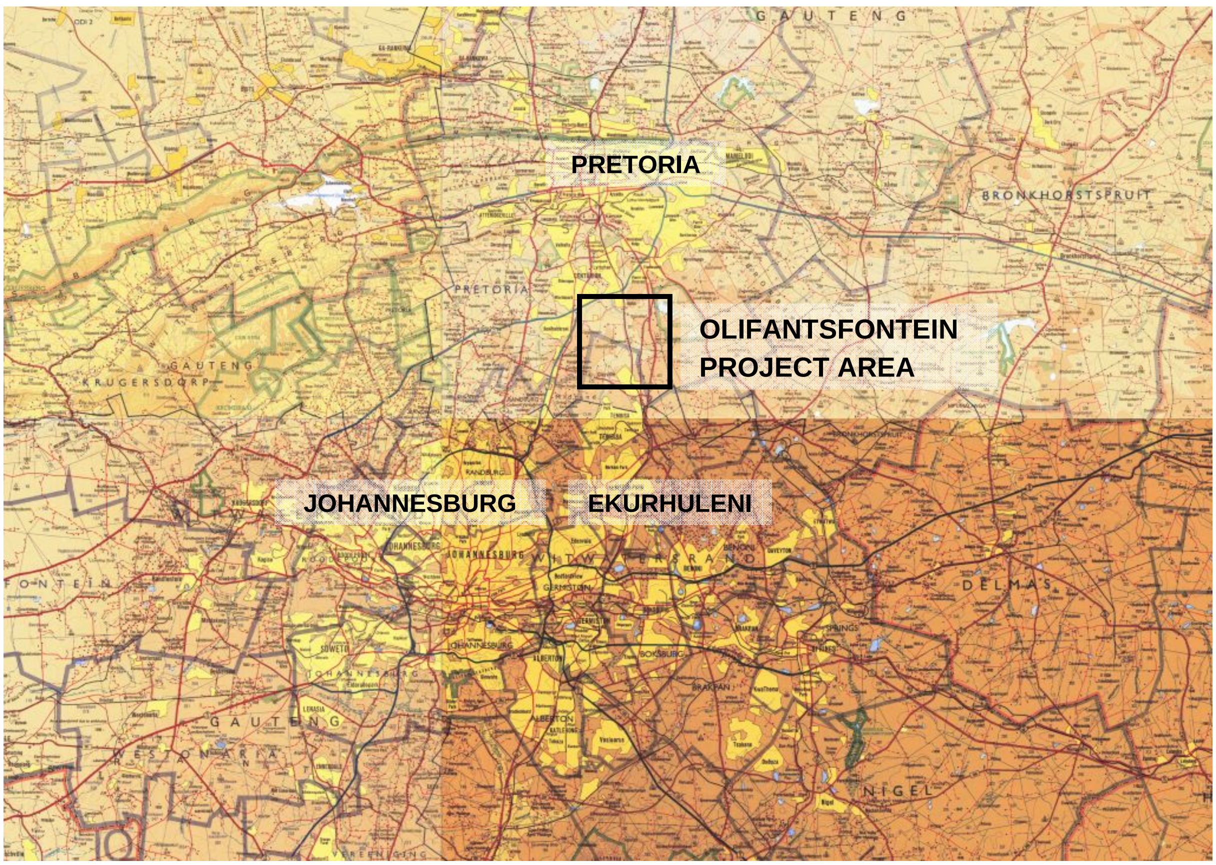

Figure 1: Locality Plan (Not to Scale)

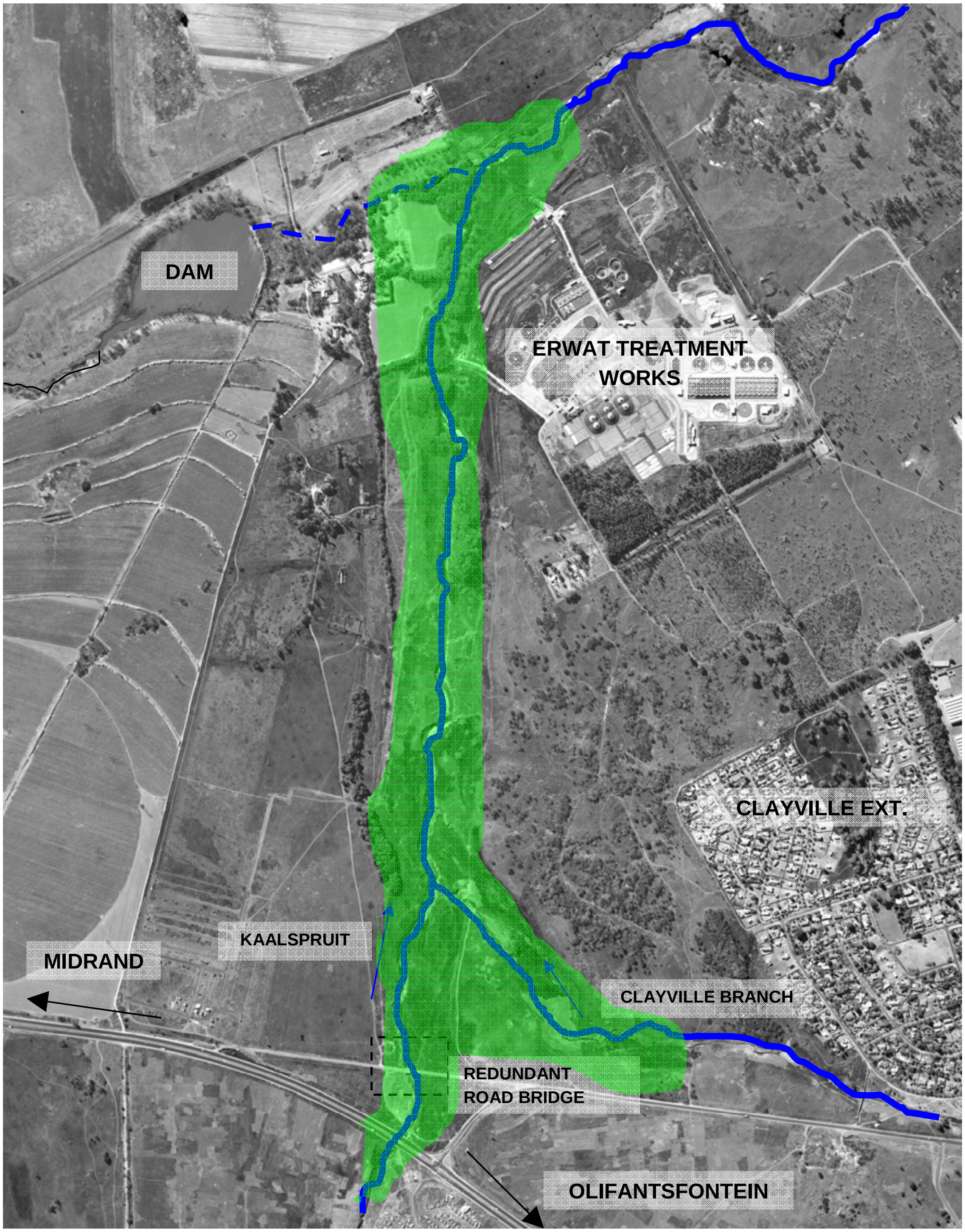

Figure 2: Aerial Photo (circa 2000) Indicating Approximate Extent of Former Wetland

3.2. GEOLOGICAL SETTING

The Kaalspruit, the principle stream flowing into the wetland, arises to the south, on the granites underlying Kempton Park (See Figure 3). From here it continues northwards on the these rocks until these granites give way to a small outcrop of quartzites of the Black Reef Series, which overlie the granites just North of Ivory Park (See T1 on Fig 3).
These quartzites in turn give way to the overlying dolomites of the Transvaal series (See T2 and T2J on Fig 3), which rocks underlie the rest of the course of the Kaalspruit down to its confluence with the Sesmylspruit in Irene. Dolomites therefore also underlie the Olifantsfontein wetland.

Examination of Figure 3 [from 1:50 000 Geological Mapping] shows that the dolomites are:

- Intruded by occasional dolerite / syenite dykes.
- Overlain by occasional deposits of alluvial soils.

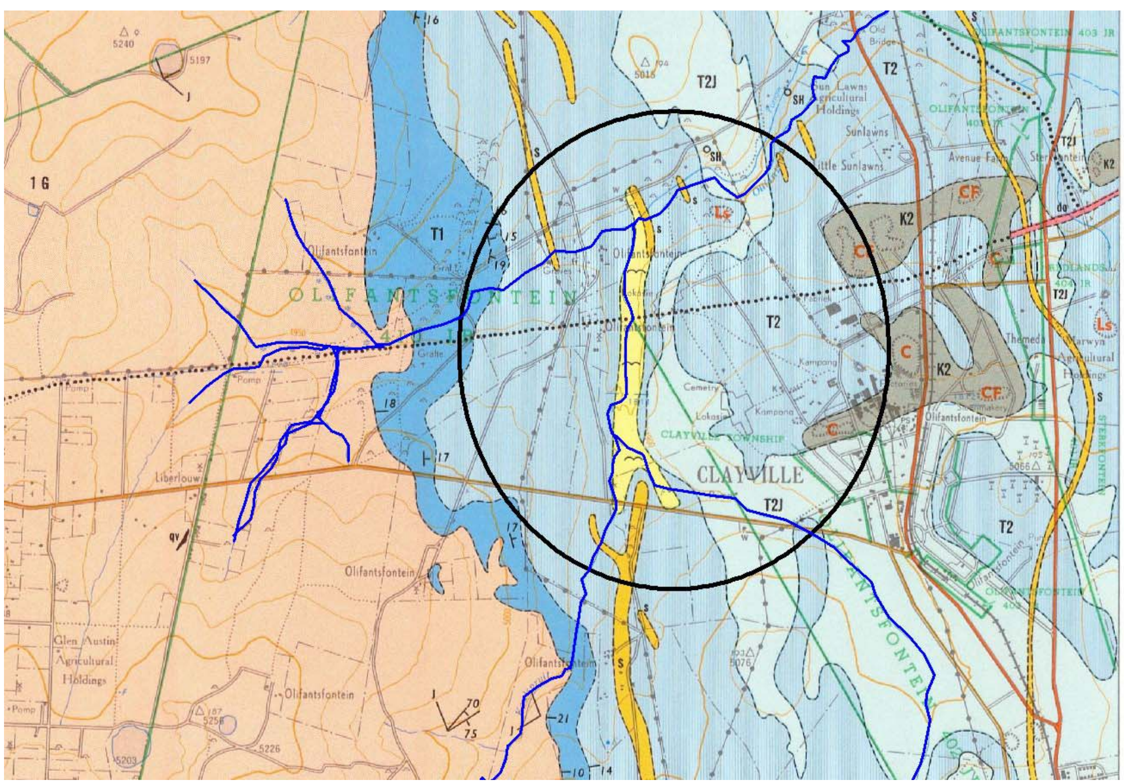

Figure 3: Section of the 1:50 000 Geological Map, Lyttleton 2528CC

Most of these alluvial soils, which occur downstream of the granites, are, derived from these rocks and therefore, contain significant amounts of sand. These soils can therefore be expected to be moderately to highly permeable.

The largest of these alluvial deposits occurs immediately north of the Olifantsfontein-Midrand road bridge across the Kaalspruit and extends 2.5 km northwards down to the confluence of the Olifantsfonteinspruit and the Kaalspruit. The average width of this alluvial deposit is estimated at 200 m. The alluvial deposit therefore has a surface area of approximately 50 hectares.

The thickness of the alluvial deposit has not been determined but is believed to have a maximum thickness of at least 10 m and an average thickness of at least 5m.

The deposition of sediments in this particular area is probably due to the following factors:

- The shallowing of the Kaalspruit gradient in this stretch of river.
- The reduction in flow velocities at the confluences of the Kaalspruit with its Clayville and the Olifantsfonteinspruit tributaries,
- **Possible subsidence in the Dolomites beneath this part of the Kaalspruit,(Doeline).**

The Olifantsfontein wetland is developed on the extensive alluvial deposit described above. The field inspection suggests that the wetland originally occupied the entire alluvial deposit, and was therefore also some 50 hectares in extent.

Although the present day wetland is very much reduced in size and severely degraded the Olifantsfontein wetland is still the most important wetland in the Kaalspruit catchment.

Although this wetland was, and still is to some degree, a single wetland, three distinct types of wetlands, can be recognised, based on the hydrogeomorphic classification system (Brinson et al, Marneweck & Batchelor, 2001) (Figure 4) These are unchannelled valley bottom wetlands, hillslope seepage wetlands, one of which is supported by a permanent spring and a floodplain wetland.

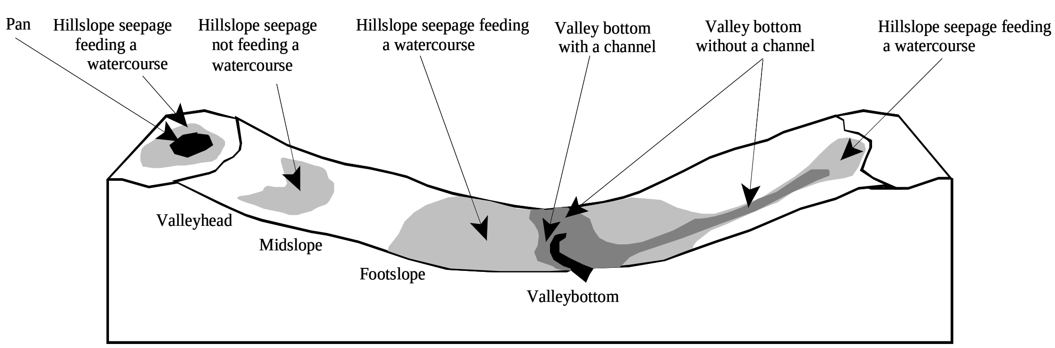

Figure 4: Schematic of types of wetlands classified in terms of their hydrogeomorphic characteristics in the landscape. (© Wetland Consulting Services)

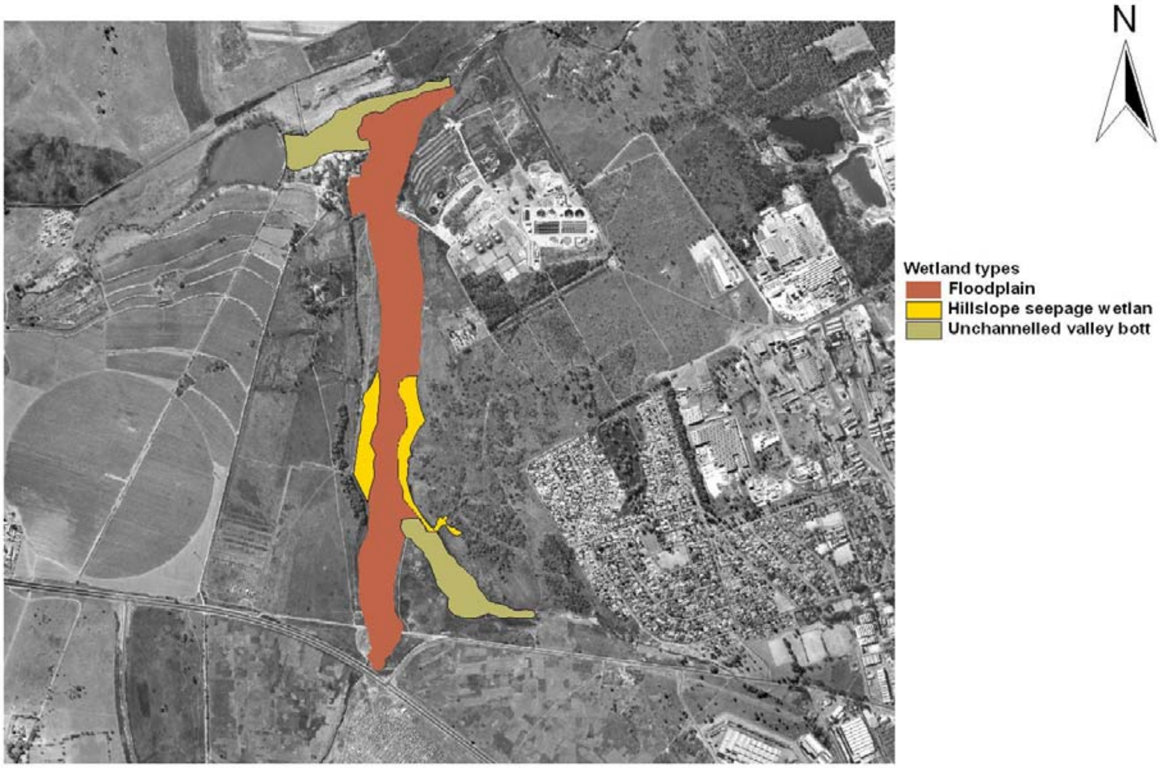

Figure 5: Wetland types Present in the Olifantsfontein Wetland

The most extensive of the wetlands is the floodplain. Typically floodplains are supported, hydrologically, primarily by overtopping of banks during high flow events with additional diffuse surface or seepage flows off the lateral slopes. As a consequence of erosion and incision of the Kaalspruit stream, overtopping of its banks hardly ever, if ever occurs. The consequence of this is the progressive drying out of the accumulated alluvial deposits and subsequent loss of wetland conditions, in dominant part, of the Olifantsfontein wetland which is that portion developed on the Kaalspruit. This part is now therefore severely degraded and much smaller than it was in the past.

The smaller part, which is still reasonably well-preserved, was/is developed on the Clayville tributary stream which emerges from the Tembisa North/Clayville area.

A smaller but well developed valley bottom wetland, formerly unchannelled but now with sections with well defined channels known as the Clayville tributary developed and continues to exist at the confluence of the Kaalspruit and Clayville streams. As a consequence of the rapid erosion and incision of the Kaalspruit, this tributary is now a “hanging” tributary. An extensive and deep head cut has developed at the confluence of this stream with the Kaalspruit as the system attempts to reach a new equilibrium with the changed conditions. Attempts have been made to stabilise the advancing head cut through the construction of gabions largely as a means of protecting the integrity of an outfall sewer that is threatened by the erosion. However changes in the hydrology of this catchment have also occurred as a consequence of both urbanisation and industrial development that threatens its existing form. The erosion channels at the head of the wetland and the lateral expansion of the channel below and attempts to bypass the protective gabions provide some evidence of the systems attempts to adjust to the changes.

The margins of sections of the Olifantsfontein floodplain received both seep and surface flows off the adjacent hillslopes. One of the seepage wetlands developed in response to a permanent spring located on the higher lying area on the east of the floodplain. The flows from this spring, together with rainfall contributions during the summer months, was sufficient to permit the development of a well defined flow line and wetland area on the perimeter of the floodplain. This stream is now perched, as in the case of the Clayville tributary, as a consequence of the Kaalspruit incision into the floodplain. A head cut has developed at its confluence with the Kaalspruit, which as in the Clayville tributary is advancing up the catchment and if left unattended is likely to threaten roads and other infrastructure, including the outfall sewer that crosses it.

The future of seepage wetlands that existed on the western perimeter of the floodplain as well as on the north eastern section of the Olifanstfontein spruit and Kaalspruit confluence is doubtful, given the degree of transformation of the landscape to housing. This activity significantly increases the impervious areas reducing infiltration and increasing surface runoff. The nett effect of this is an increase in the rate and volumes of rainfall run off which increases the risk of erosion as previous diffuse flows now discharge as point discharges through a formalised stormwater pipe network. The consequences of these discharges are evident at various discharge points on the western perimeter of the floodplain.

In addition to this primary wetland, various secondary wetland systems are developed along seepage and spring lines along the eastern slopes of the Clayville tributary.

3.3. VEGETATION

The wetland was dominated by the common reed *Phragmites australis.* Large areas formerly occupied by the common reed are now cultivated as a consequence of less frequent to no flooding where the reeds on the Kaalspruit, have been replaced by maize, *Zea mais*. Both the common reed and bulrush *Typha capensis* continue to occupy the Clayville wetland. Other species that occur on the floodplain are Juncus sp., *Imperata cylindrica, Setaria sphacelata* and *Cyperus esculenta* . The presence of *Carex cernua* provides evidence of the presence of old oxbows and back swamp areas in the lower most terraces. The lower sections of the floodplain have been transformed to planted pastures, while extensive exotic poplar plantations occupy sections of both the eastern and western banks of the Kaalspruit. (Figure 6)

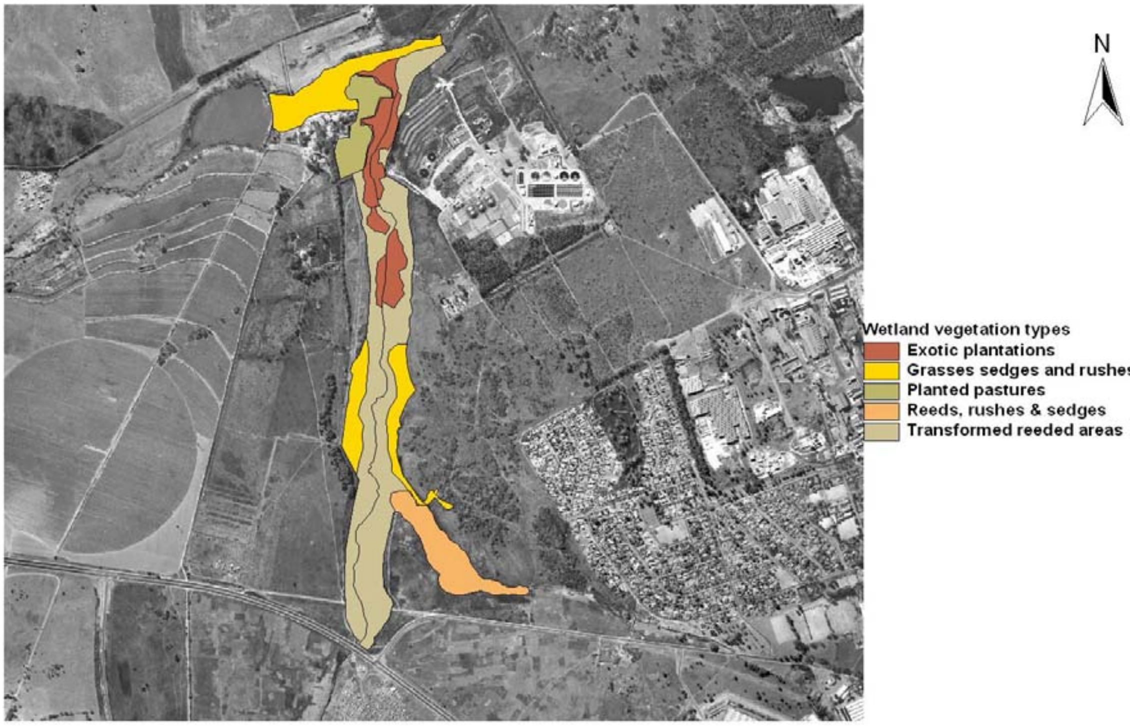

Figure 6: Wetland Vegetation

3.4. WETLAND FUNCTIONALITY

Despite the widely held notions about wetland functionality, extensive literature searches reveal that very few practitioners have actually quantified these benefits (Batchelor, 2002). Moreover, it appears that these functions are highly variable depending on the characteristics of the wetlands and the landscape.

For example floodplains are commonly considered to be valuable in that they perform a number of beneficial functions to society. Due to the nature of the vegetation and the topography they occupy, they are considered important for flood attenuation. Their function in relation to enhancing water quality specifically with regard to dissolved nutrients however is less clear. Since the dominant source of water on floodplains occurs during flood events, the volume of water flowing over the surface of the floodplain is large, resulting in low concentrations of nutrients due to dilution effects. This together with shorter retention time, reduces the chance of contact between the bulk of the water and the wetland sediments and this limits the opportunity for the removal of certain dissolved nutrients.

One exception to this is suspended solids, the concentration of which may be high due to the ability of floodwaters to carry high suspended loads. Once flows overtop river banks, the velocity of the floodwaters reduces and permits the deposition of sediments and their associated adsorbed nutrients.

Investigations undertaken by George Orr & associates, suggest that, this wetland is likely to have played a very significant factor in :

- reducing the silt load of the Kaalspruit as evidenced by the depth of accumulated sediment;
- regulating the hydrology of the Kaalspruit,
- serving as a significant recharge point for dolomitic groundwater due to its generally porous structure
- maintaining the environmental balance and well-being of the Kaalspruit.

Arguments presented by George Orr & associates in support of the above are as follows.

This 50 hectare wetland, developed on such a substantial deposit of alluvium, made up of layers of sand, silt and clay, would have provided opportunity for, trapping and retaining run-off water from the granites. From this sponge, part of this retained water would have emerged at the downstream end of the wetland, sustaining (low flows in the Kaalspruit, whilst part of it seeped into the underlying dolomite aquifer and another fraction would've been lost to evapotranspiration.

There would clearly have been limits to this wetland's ability to absorb the summer run-off. In addition to the low flows emerging at the downstream end of the Olifantsfontein Wetland, periodic large floods would have passed through the wetland, probably also reaching the Hennops. The frequency and degree to which this happened would, compared to present conditions, have been attenuated by:

- The good flood retention capacity of the undisturbed veld/grass cover in the catchment.
- The flood absorption capacity of the 50 hectare Olifantsfontein Wetland.

Further, with regard to the key issue of siltation, the combination of good vegetation cover in the catchment, together with the filtering action of the Olifantsfontein Wetland would have ensured that the flood flows, which did pass through the wetland carried very little silt into the Hennops.

Under pristine conditions, the Hennops River and Centurion Lake would, therefore, have been subjected to very little siltation from the granite areas of the Kaalspruit catchment.

Regarding the importance of this wetland as a source of water supply to the dolomites aquifer, it seems likely that it was significant since it appears to have been directly connected with two major springs in the Kaalspruit catchment, viz,:

- Sterkfontein.
- Olifantsfontein.

The connection between the Olifantsfontein Wetland and the 'Sterkfontein' spring, which lies east of Clayville, would have been via the Sterkfontein dyke on which the Sterkfontein spring emerges and which dyke also extends westward beneath the Olifantsfontein Wetland. Refer to George Orr & Associates report.

The presence of these largely unconsolidated sediments would also assist in water quality improvement through processes such as physical filtration, adsorption, microbially enhanced biogeochemical transformations e.g. nitrification/denitrification and precipitation processes.

3.5. PRESENT STATUS

The Olifantsfontein wetland is presently in the severely degraded state.

The degradation of this wetland is believed to have been brought about by a combination of factors, including :

- Agricultural encroachment by drainage, ploughing, grazing and burning.
- The construction of the Olifantsfontein/Midrand bridge across the Kaalspruit. The road bridge which crosses the river immediately upstream of the start of the Olifantsfontein Wetland is believed to have channelled and concentrated the Kaalspruit storm water flows through a restricted part of the wetland, resulting in loss of the protective reed-bed along this channel and consequent erosion of the underlying sediments. Note that inspection of the area immediately downstream of the road bridge shows that old flood channels which, no doubt, spread and dissipated the flood-flows over a wider area, have been cut off from the river by the construction of the road.
- The concrete lining of the small tributary stream, which flows through Clayville. This tributary, which now serves Clayville as a storm/waste water drain, also receives storm/waste water flows from the northeastern part of Tembisa and Hospital View. The high intensity storm-flows from this entire area are, clearly, vastly different to the natural/virgin conditions which pertained prior to urbanisation. These flows have contributed significantly to the erosion and destruction of the Kaalspruit portion of the Olifantsfontein Wetland and are in the process of eroding and destroying the Clayville arm of this wetland as well. Destruction of the Clayville arm of this wetland is in a process, at both the upper end and the lower end of this wetland. The central part of the Clayville arm is however still in a relatively good condition. At the upper end, a scour channel has been eroded through the protective vegetation cover over a distance of approximately 500 m. The lower end of the Clayville arm is severely eroded, by back cutting from the low flows level established by the Kaalspruit. Gabions erected to protect the Ivory Park sewer line, which passes through the wetland close to the confluence of the Clayville contributory and the Kaalspruit are themselves being undercut.
- The Kaalspruit river course, which is now a 5 - 8 metre deep erosion channel cutting through the Olifantsfontein Wetland, and has, by virtue of this deep cut into the wetland, lowered the water table in the flood-plain/wetland areas adjoining the river and, consequently, drying up the adjoining wetlands.
- Under these conditions, the remaining reed-beds are being further damaged by fires.
- Flows from the Kaalspruit tributary still partially filter through the reed-beds of the small Clayville part of the wetland. This is no longer the case on the Kaalspruit portion of the

Olifantsfontein Wetland. Here, all the Kaalspruit flows are confined to the deep erosion channel which isolates the wetland from the Kaalspruit.

It is as a consequence of these changes that the requirement to remediate this site was recognised, supported by the following legal and other requirements:

- Contravention of the Water Act, in terms of contributing to pollution of a watercourse.
- Contravention of the Water Act in terms of Section 21. Wetlands are regarded as part of the water resources in the country, are common property resources, and since riparian rights were abolished with the introduction of the new Water Act (Act 36 of 1998) any activity that changes the state of the resource requires a permit.
- Increased risk of sinkhole development. The Kaalspruit flows over dolomite formations shortly after flowing under Olifantsfontein/Midrand road. One of the factors causing sinkholes is the point application of water. The extensive former wetland deposits effectively provided a low permeability broad interface between the surface water and underlying dolomites, ensuring that water flow seeping into the dolomites is diffuse, thus substantially reducing the sinkhole risk. The subsequent erosion of these sediments down to the dolomites, together with high rates of groundwater abstraction, has increased this risk.
- Increased risk of groundwater contamination. The loss of the wetland sediments has removed a very effective filter that previously filtered out/and or transformed possible contaminants from migrating into the groundwater. The loss of this filter has considerably increased the risk of groundwater contamination.
- Increasing the risk of sewerage pollution. The erosion of the Clayville tributary is threatening the large outfall sewer line that runs along the eastern bank of the Kaalspruit to the Olifantsfontein water care works. If this line breaks, thousands of liters of sewerage will flow into the river and cause a major pollution problem.
- The erosion in the medium to longer term also threatens the bridge that has recently been built to link developments on both sides of the river

4. THE DETAILED STUDY

4.1. SCOPE OF THE STUDY

As mentioned earlier, the detailed study commenced with two days of field investigations, followed by a number of internal JV workshops. The purpose of this initial work was to obtain consensus in the JV on the approach to the study.

Following the completion of the initial work, a series of meetings was held, between the professional team, and Messer's J.C.Prinsloo and N. Smal of the Ekurhuleni Department of Roads, Transport & Civil Works. The purpose of the meetings, which were held at the request of the Ekuruhuleni Metropolitan Municipality, was to define more accurately, from the Client side, the project goals and objectives, than had been set out in the letter of appointment.

The "Project Goals and Objectives" agreed on, at the culmination of these meetings was as set out in section 1 .5 of this report.

The professional team then evaluated a range of remedial measures, considering their pros and cons in relation to the project goals and objectives. This work culminated in the production of a plan showing the draft remedial proposals. During this work, it became apparent that the available survey plans of the wetland were insufficiently accurate to allow a suitable definition of the width and depth of the erosion channel. With the approval of the Client tenders were then requested for a survey of the channel. Once these had been obtained, an appropriate extension to the initial contract amount, was approved by the Client, which allowed the survey to be conducted.

Following the production of the plan showing the draft remedial measures, a series of meetings was held, with the co-operation of the Client, with all interested and affected parties, at which meetings the draft proposals were presented and comment/feedback obtained from all attending parties. Details of all the meetings held as well as those held previously during the formulation of the masterplan for the rehabilitation of the Kaalspruit (See Ref 2) are presented in Appendix L.

Following these meetings, and taking cognisance of the comments and observations made by the interested and affected parties, a revised plan of the proposed remedial measures was produced, the revised plan was again presented as evidence of these meetings is provided in the minutes of the Eighth meeting of the Kaalspruit and Hennops River Task Team held on the 25th October 2006 at the Ekurhaleni Council Chambers, at which meeting a wide range of interested and affected parties were represented. Positive comments were obtained on the revised plan from all parties attending these meetings, and affected parties of interested and affected parties are represented. this revised plan is the one presented in this report as *the proposed remedial measures*. A general layout of the proposed interventions as well as generic and schematic details are presented in Appendix J, whilst design specifications are presented in Appendix K.

4.2. FIELD INVESTIGATIONS

Numerous filed visits have been carried out by the project team, both prior to and subsequent to this appointment. The findings of these site visits are briefly as follows:

- The site visits indicated that the erosion channel has grown significantly during the last year since the study for the master plan was conducted, becoming wider and deeper along the entire length of the erosion channel.
- These changed topographical conditions are not reflected on the contour plans, which are available for the area. A survey of the erosion canal was therefore required as a matter of urgency to allow the scale of the problem as well as the scope and cost of the alternative remedial measures to be determined.
- The ongoing lowering of the water table large areas adjacent to the erosion channel has resulted in large areas of the erstwhile wetland drying out. These dried out areas are now being used extensively for the cultivation of maize and some other crops (urban agriculture).
- The litter problem has become worse and the construction of the litter traps at the upstream end of the wetland on both the Kaalspruit and the Clayville tributary is essential.
- The quality of the water entering the erstwhile wetland is extremely poor and, as judged by the eye worse than during previous wet seasons.
- The new Olifantsfontein link bridge together with the new housing developments, which extend to the eastern and western edges of the Olifantsfontein wetland are complicating factors in the remedial measures.
- Various alternative remedial and or rehabilitation measures were discussed at some length and it was generally agreed that the scale of the problem is growing by the year, and that a range of remedial / rehabilitation measures will probably be required for the successful rehabilitation of the wetland.

4.3. POSSIBLE COURSES OF ACTION CONSIDERED FOR THE OLIFANTSFONTEIN WETLAND

At the start of the detailed study a range of possible courses of action, to address the problems of the Olifantsfontein wetland were discussed. These were as follows.

- Maintain the status quo. (I.e. do nothing.) and allow the Kaalspruit to, in due course. (50 years?) Establish a stable watercourse in place of the previous wetland.
- Accept the existing erosion channel through the wetland, but prevent further erosion of soil from it. Two possible ways of protecting the existing erosion channel from further ongoing erosion were discussed, namely, firstly constructing a reinforced concrete trapezoidal storm water canal along the entire length of the erosion channel or, secondly trimming the banks of the erosion channel back to a stable slope angle, and then lining the entire erosion channel with Armour flex.
- Construct a number of back-to-back weirs (in the region of 4-6 weirs) along the length of the erosion channel. These weirs would serve to firstly prevent further erosion of the channel, and secondly would raise the groundwater in the soils adjacent to the erosion canal thereby creating suitable conditions for the partial re establishment of the wetland.

- Backfill the erosion channel with soil excavated from the adjacent erstwhile wetland areas and create a new engineered rehabilitated wetland, constructed in such a way that it would be capable of passing very large floods (one in a 100 year flood) without being eroded again.
- Construct litter traps at the upstream end of the wetland.
- Some or other combination of the above alternatives.

Relevant factors discussed in relation to these alternatives are as set out below.

4.3.1 MAINTAIN THE STATUS QUO

This “alternative” proposes the status quo be maintained (i.e. do nothing.) and the Kaalspruit be allowed to, in due course (50 years?) establish an incised stable watercourse in the place of the previous wetland.

This was considered to not be a viable option as it is firstly in violation of existing environmental legislation, and secondly will for many decades yet continue to cause major environmental problems in the Kaalspruit and Hennops rivers downstream of the wetland.

4.3.2 ACCEPT THE EROSION CHANNEL BUT PREVENT FURTHER EROSION

This alternative proposes that the existing erosion channel through the wetland be accepted, but that measures be put in place to prevent further erosion of soil from the former wetland.

Two possible ways of protecting the existing erosion channel from further ongoing erosion were discussed, namely, firstly by constructing a reinforced concrete trapezoidal storm water canal along the entire length of the erosion channel or, secondly by trimming the banks of the erosion channel back to a stable slope angle, and then lining the entire erosion channel with Armour flex.

- Both of these alternatives will result in stabilization of the banks and riverbed of the Kaalspruit in the erosion channel and thereby prevent any more sediment being eroded out of the wetland and being carried downstream. These measures would therefore address the major environmental problem currently being experienced downstream of the wetland, namely the excessive sediment loads which have silted up the Kaalspruit and Hennops rivers as well as Centurion Lake.
- However neither of these two options contributes to the re establishment of the degraded Olifantsfontein wetland which is a stated objective of the Master Plan for the Rehabilitation of the Kaalspruit and Hennops River, and which objective has been accepted by GDACE.
- The reinforced concrete storm water canal option will not result in any meaningful improvement in water quality over its length. The armour flex option is better in this regard, as reeds will establish themselves in the riverbed of this option and the flow of water through these reeds will result in an improvement of the water quality over the length of, the armour flex canal.
- Both of these options will continue to drain the surrounding erstwhile wetland thereby reducing the water table levels in this area and therefore also reduce the recharge of the groundwater reserves in the underlying dolomite. This groundwater is an important source of water to Tshwane.
- Neither of these options is likely to be supported by any environmental group or potential

funder / donor.

4.3.3 CONSTRUCT BACK-TO-BACK WEIRS

This alternative requires the construction of a number of back to back weirs (in the region of 4-6 weirs) along the length of the erosion channel and subsequent backfilling of the erosion channel between the weirs. The backfilling should be effected with soil excavated from the adjacent erstwhile wetland.

The effect of this would be *a new stepped watercourse* established at a level of approximately 3-5 m above the floor level of the current erosion channel, but which will be somewhat lower level than the surface level of the original wetland. Relevant factors of this option are as follows:

- This solution will also prevent the removal of further sediment from the Olifantsfontein wetland and therefore also address the above-mentioned major environmental problem currently being experienced downstream of the wetland namely excessive sediment loads in the Kaalspruit and Hennops River.
- In addition to preventing further erosion of the wetland, the weirs would have the further advantage of partially re-establishing the surface / near surface groundwater levels in the wetland soils adjacent to the erosion canal thereby creating suitable conditions for the partial re establishment of the wetland.
- The raised water levels will have the benefit of increasing the recharge of the underlying groundwater.
- The reeds, which will establish themselves in this new raised riverbed would also contribute to an improvement of the water quality over the length of this remedial option.
- The results of drilling for the bridge foundations for the recently constructed road through the wetland suggest that good hard rock dolomite foundations, suitable for the construction of such weirs, exist approximately 1 and 2 m below the level of the current erosion channel. According to the engineering geologist who conducted the investigations for the bridge site it is unlikely that the construction of such a weir would result in the development of sinkholes beneath the wetland, but this issue highly sensitive and would require extensive geological investigation, before this view could be accepted.

4.3.4 RE-ENGINEERED WETALND

This alternative requires the backfilling of the erosion channel with soil excavated from the adjacent erstwhile wetland areas to create a new engineered rehabilitated wetland, constructed in such a way that it will be capable of passing very large floods (1:100 year flood) without being eroded again. The construction of 2 weirs, one at the upstream end and one at the downstream end of the engineered wetland are part of this proposal.

Relevant factors of this option are as follows:

- This remedial option is in accord with the proposals presented in the master plan for the rehabilitation of the Kaalspruit and Hennops rivers.
- This option has the potential of markedly improving the water quality of the low flows in the Kaalspruit.

- This option will re-establish the groundwater recharge potential of this area to that prevailing with the original Olifantsfontein wetland.
- Implementation of this option has been encumbered by the construction of the new road and bridge across the wetland.

4.3.5 CONSTRUCT LITTER TRAPS

Litter traps will have to be constructed at the upstream end of the wetland in combination with any of the above options.

Large amounts of litter are carried downstream by the flood waters of the Kaalspruit every year. What ever remediation option is decided on, it will be absolutely essential to trap this litter before it enters the wetland area where, it will otherwise either be trapped and foul up the wetland or alternatively it will be carried through the wetland and from there further downstream to be trapped by Centurion Lake.

4.3.6 COMBINATION OF ALTERNATIVES.

Given the range of environmental problems experienced in the Olifantsfontein wetland it was concluded that a range of remediation measures would have to be implemented.

4.3.7 ENVIRONMENTAL ADVANGATES AND DISADVANTAGES OF OPTIONS

The goals of the Olifantsfontein remediation plan as presented to and supported by interested and affected parties and stakeholders are:

- Restore aspects of the functionality of the Olifantsfontein wetland with respect to:
  - Sediment trapping
  - Water quality improvement, in particular reduction in suspended solids concentrations particularly during high flow events and faecal coliform numbers
  - Ground water protection
  - Flood attenuation
- Incorporate recreational areas on the floodplain that would not compromise the attainment of the goals stated above
- Increase opportunities for biodiversity support.

Detailed scoping study/EIA of the options outlined above was not included in this project. However a broad scoping exercise of each of the alternatives formed an integral part of the development and influenced the selection of the option that is considered to be the preferred option.

In our opinion the construction related impacts of each one of the options, with the exception of doing nothing, are likely to be similar. The major risk to the integrity of the stream during the construction of the proposed weirs distribution channel and the high flow diversion channels (Clayville wetland) is the destruction of vegetation and the introduction and disturbance of sediment into and in the affected streams.

This will occur as a result of:

- Vegetation removal exposing the cleared areas to erosion and sediment runoff, including the approach roads.
- The direct disturbance of the river channel during the construction phase causing gross sediment movement during the excavation process.
- Sediment introduction into the stream due to bank collapse primarily as a result of the steep banks.
- Accidental spillage of concrete into the stream during the casting of platforms and structures.
- Intentional wasting of concrete into the stream during washing of equipment including the vehicles delivering the ready mix or if not ready mix then the washing of the concrete mixers.
- Driving vehicles across streams.
- Washing construction vehicles in the stream.

In addition to the above other risks include the introduction of other contaminants associated with the construction activities. These include:

- Plastic and bags, particularly cement bags that are discarded in the vicinity of the stream.
- Polystyrene food punnets and plastic wrappers.
- Urine and faeces, either deposited directly into the stream or on the banks.
- Accidental leakage of hydraulic fluids from vehicles.
- Intentional disposal of surplus concrete.

The extent and scale of these impacts can however in the short to medium term be successfully mitigated through the incorporation of appropriate controls in the Environmental Management Plan that will be required before the project can be initiated, examples of which are presented in Appendix O (Generic EMP).

However when the scale of benefits associated with each of the projects is assessed it is apparent that each of the considered options offers more or less environmental benefits. A qualitative assessment of these environmental benefits (+) and possible negative aspects (-) of the evaluated options is summarized in the following table.

PROPOSED ACTIVITY	Downstream Water Quality Enhancement		Groundwater recharge		Hydrology	Other			Total Score
	Suspended solids removal	Faecal colifom removal	Groundwater recharge	Quality protection and/or enhancement	Flood attenuation	Odours	Mosquitoes & midges	Biodiversity support	
Take no action	0	0	5	0	0	-1	0	0	**4**
Concrete line trapezoidal channel	0	0	0	5	0	-1	0	0	**4**
Lined trapezoidal channel	1	2	3	3	1	-1	0	1	**10**
Back to back weirs	5	3	3	3	2	-2	-2	1	**13**
Wetland paddocks	5	5	2	5	3	-2	-2	3	**19**
A combination of the above	5	5	2	5	4	-2	-2	5	**22**

Table 2: Summary of environmental benefits and "costs" associated with each of the remediation options.

The option that includes the combination of approaches followed by the wetland paddock configuration offer the most environmental benefits and exceed the values obtained for doing nothing. Not included in this table is the real cost of doing nothing, which includes the costs of desilting Centurion Lake which incurs an annual cost of in excess of R4m/annum.

The inclusion of the treated effluent from the Olifantsfontein will to a large extent reduce the potential for both odour and mosquito problems due to its diluting effect on the poor quality water entering the system from the upper catchment.

4.3.8 PROJECT NOTIFICATION

Formal notice of the proposed project was given to GDACE (See Appendix N). Who responded?

4.4. FACTORS FOR CONSIDERATION

To assist in the evaluation of the pros and cons of the various remedial measures outlined above, a list of *desirable results* and or *factors which needed to be taken into account* was drawn up. These factors are listed below.

- Erosion Prevention
- Sediment Trapping
- Flood Attenuation
- Water Quality improvement
- Litter and debris removal
- Groundwater Protection
- Groundwater recharge
- Downstream Hydrological Impacts
- Biodiversity support
- Change in area used for cropping
- Area for public open space
- Risk of odours
- Risk of midges & mosquitoes

A number of alternative rehabilitation/remediation plans were then devised, and their ability to achieve *the desired results of the rehabilitation works* was compared.

The alternative providing the most favourable result was selected for the draft remedial works proposal, which was then presented to and discussed with the interested and affected parties. Using the feedback received, the final proposed rehabilitation works were designed and are as set out in section 5 of this report.

4.5. DESCRIPTION OF EXISTING INFRASTRUCTURE

Investigations revealed, that the following infrastructure has already been established in the Olifantsfontein wetland.

- The old Olifantsfontein –Midrand road bridge was constructed at the top end of the original wetland.
- The new Olifantsfontein extension link bridge which crosses through the heart of the original wetland.
- The main sewer line from the Kempton Park/Tembisa area which crosses the lower part of the Clayville arm of the Olifantsfontein wetland.
- Two smaller sewer lines constructed for the new housing developments.
- Various stormwater out falls from the new housing developments.

4.6. HYDROLOGY: KAALSPRUIT AT R511 (K46) ZEVENFONTEIN

4.6.1 AVAILABLE DATA

Maps and Ortho-photos:

The catchment area for this study was determined from 1:50 000 maps of the area. These maps were captured electronically and the catchment area and length of the watercourses were determined using CAD. The following 1:50 000 maps were used:

- 2528 CC – Centurion
- 2528 CD – Rietvleidam
- 2628 AA – Johannesburg
- 2628 AB – Benoni

A catchment map, also indicating the positions of gauging stations (see below) is attached as Appendix C. (refer also Figure 7)

Available Flow Data:

There are no flow gauging stations on the Kaalspruit, and no stations within close proximity to the Olifantsfontein area. There is evidence (in the form of a gauge plate and recorder enclosure) that flow measurement may have been undertaken at some stage on the old (now redundant) bridge on the Olifantsfontein-Midrand road.

Table 1 contains a summary of the flow stations which are available on the Hennops River (to which the Kaalspruit and later the Sesmylspruit are tributaries), and also indicates the period for which data is available at each station.

It is evident that the catchments represented by these stations are considerably larger than that under consideration for the Kaalspruit at Olifantsfontein. As such, there would be little sense in extrapolating data from these stations to the Kaalspruit.

Station	Place	Area	Lat	Long	Period for which Data available
		km²	D M S	D M S	
A2H005	Hennops River @ Zwartkop	808	25 49 44	28 08 25	1904-11-16 1950-10-01
A2H009	Hennops River @ Rietvlei	481	25 52 35	28 15 55	1918-06-07 1989-06-12
A2H014	Hennops River @ Skurweberg		25 47 42	27 59 31	1922-11-13 2006-03-14
A2H076	Hennops River @ Zwartkop	808	25 49 44	28 08 25	1905-12-16 1945-03-06

Table 3: Summary of River Flow Gauging Stations in the Jukskei River

Catchment Location:

This catchment is located primarily across the north of the Ekurhuleni Metropolitan Municipality, and includes the suburbs of Clayville, Tembisa, Ivory Park, Birch Acres, Norkem Park and Birchleigh North. The area extends from Olifantsfontein in the north to Birchacres in the south and west from Kaalfontein to Rabie Ridge..

Topography:

The average slope of this catchment 1 shown in Table 3 below, is approximately 7%, with 50% of the catchment area slope exceeding 3% but not exceeding 10%. The average slope of the longest watercourse is 0, 74%.

Slope %	Area Fraction %
<=1%	0.0%
1-3%	30.0%
3-10%	50.0%
10-30%	20.0%
30-50%	0.0%
>50%	0.0%

Table 4: Catchment Slope Categories

4.6.2 ASSESSMENT OF THE CATCHMENT

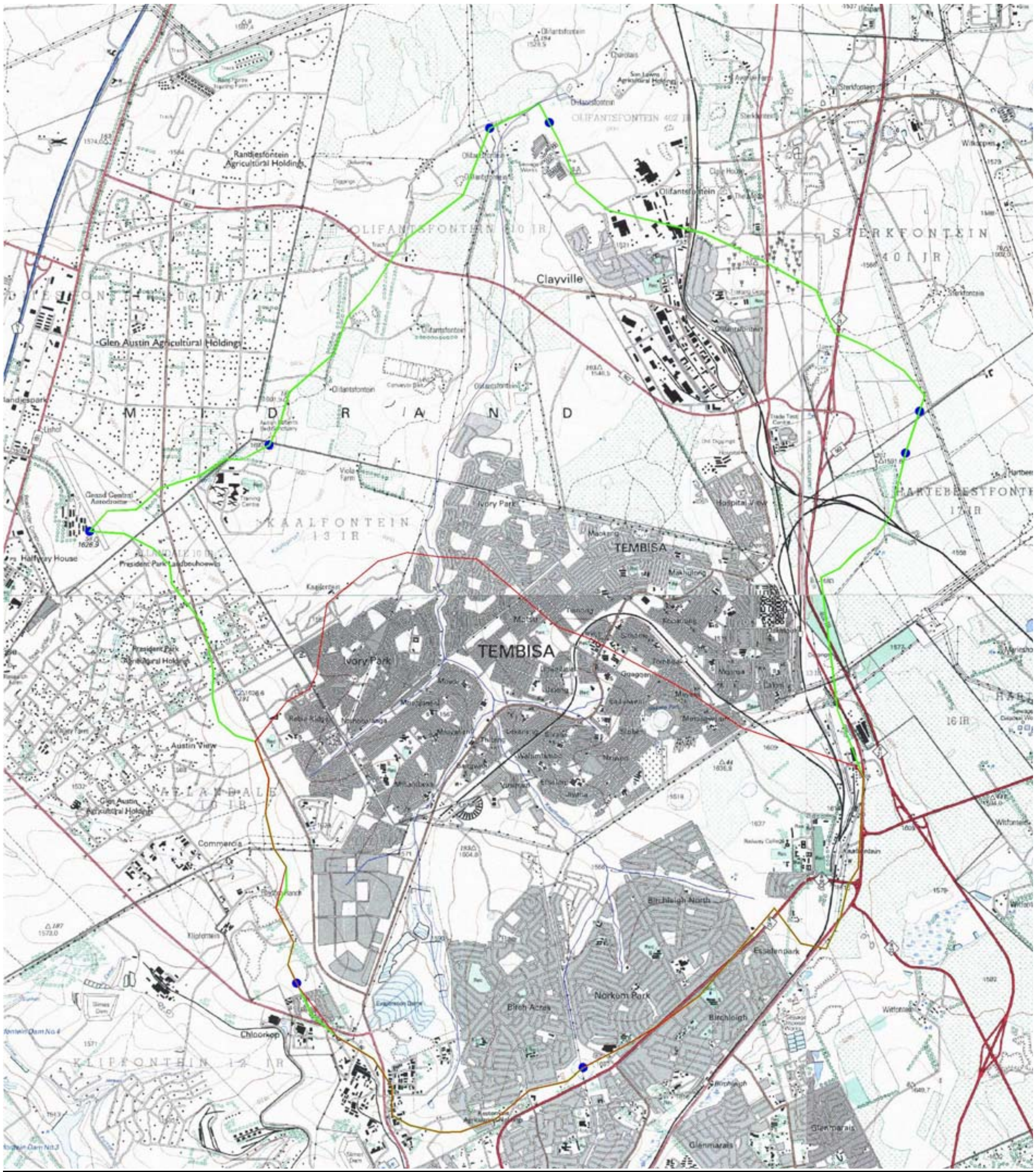

Figure 7: Catchment Map

Vegetation:

Vegetation in the catchment (outside of the residential areas) is generally sparse veld interspersed with occasional trees and shrubs.

Vegetation adjoining the watercourse consists alternately of relatively dense large trees and shrubs on either side of the river banks, as seen on the lower reaches opposite the ERWAT Treatment Works where dense stands of Poplar trees prevail, and grassed banks. The floodplains generally consist of sparse grassland.

Land Use Characteristics and Ratios:

A significant portion of this catchment comprises the residential suburbs, business and the industrial areas of Olifantsfontein.

Climate Characteristics:

This area is a summer rainfall area typical of the Gauteng highveld. The mean annual rainfall is approximately 598mm (average MAP as measured at SA Weather Services station number 513417 – Olifantsfontein).

Catchment Area:

The area has a catchment area of approximately 112 km². This catchment was determined from 1:50 000 maps of the area and is represented in Appendix C.

Information for Determining the Design Peak Discharge:

The following table 4 contains a summary of all information pertinent to the calculation of the design peak discharge.

No	Description	Value	
1	River Name:	Kaalspruit	
2	Position:	Downstream of old road bridge	
3	Latitude (DMS):	S 25° 56' 50"	
4	Longitude (DMS):	S 28° 12' 10"	
5	Area of Catchment:	112	km²
6	Length of longest water course:	17.10	km
7	Slope of longest water course (1085slope):	0.009	m/m
8	Length of overland flow:	0.546	km
9	Slope of overland flow:	0.037	m/m
10	Height difference along "1085" slope:	123.021	m
11	Distance to catchment centroid:	8.141	km
12	Distance along water course to a point adjacent to the centroid of the catchment: (Approx.)	1.114	km
13	RMF K-factor:	4.6	
14	Lightning ground flash density:	7	
15	Mean annual Rainfall:	598	mm
16	SDF Basin number:	4	
17	Weather bureau station number:	513 417	
18	Weather bureau station location:	Olifantsfontein	
21	Urban area:	86.6	km²

Table 5: Summary of Catchment Parameters

4.6.3 DESIGN PEAK DISCHARGE CALCULATIONS

Statistical Methods (Probabilistic)

Due to the lack of usable data, no probabilistic methods were employed.

Deterministic Methods Employed

The following deterministic methods were employed:

- Rational Method
- Soil Conservation Service (SCS) Method
- Standard Design Flood (SDF) Method

- Regional Maximum Flood (RMF)

4.6.4 SUMMARY OF FLOOD HYDROLOGY

A tabulated summary of the flood hydrology results is presented in Table 4: Comparison of Flood Hydrology Results.

CALCULATIVE METHOD		Catchment Runoff m³/s					
Return Period (Years)		**10**	**20**	**50**	**100**	**200**	**RMF**
A	**Deterministic Methods**						-
1	Rational Method	113	141	189	239	244	-
2	SCS Method	150	207	307	407	534	-
3	SDF Method	176	259	384	490	602	-
4	RMF			215	284		-
	Design Q			**280**			

Table 6: Comparison of Flood Hydrology Results

4.6.5 WEIGHTING OF FLOOD HYDROLOGY RESULTS

It will be noted that multiple deterministic methods have been employed in the calculation of the design flood. The Rational Method is not preferred for catchments as large as this, while the SDF method is widely viewed as yielding conservative results. The flood hydrology results were therefore weighted to achieve a sensible design flood within the limits provided by the aforementioned methods.

4.6.6 CONCLUSION

The design hydrology as set out above is required in order to obtain some idea as to the required scale and flood handling capability of the various structures. In principle, the following applies:

- The “low notches” on all water retaining structures should be capable of passing the spate flow (or 1:1 year event). A flood with a recurrence interval of 1:2 years has been calculated, and this flood varies between 25 m³/s and 68 m³/s.
- The non overtopped crests (NOC’s) of the water retaining structures should be capable of passing the design flood. This has been determined as the 1:50 year flood, which has been calculated (weighted) as 280m³/s.
- Flood attenuation together with very effective silt trapping is highly recommended upstream of the rehabilitated wetland as this will reduce the flood demand placed on the wetland and drastically reduce the maintenance costs which will otherwise be required if the wetland is forced to trap the upstream generated silt load.

4.7. FINANCIAL IMPLICATIONS OF CONTINUED DEGRADATION

The financial implications of continued degradation are addressed in Section 6. Table 6 provides a summary of environmental benefits and “costs” associated with each of the various remediation options discussed in this document.

5. PUBLIC PARTICIPATION

The objective of the public partition process was to:

- Inform the local community about the nature and scope of the project
- Ensure that in development of the options, that no stakeholders requirements and/or objections were overlooked
- Provide feedback on the state of the investigations
- Ensure that the option carried forward to the design and construction phase reflected as far possible the requirements of all interested and affected parties.

It is hoped that the support of the business forum and the community in general may ultimately lead to financial support through public-private co-funding or through direct private sponsorship of project components. To date no commitments for funding have however been made.

It is essential that this consultative process with all interested and affected parties, as well as potential Donors / Co Tenders is actively pursued as part of the detailed design of the rehabilitation measures.

5.1. STAKEHOLDER MEETING

Stakeholder meetings have been held with local community representatives, including ward councillors, and interested parties at various forums. These include:

- Presentations to council representatives, ward councillors, property developers and business representatives at the Ekurhuleni Metropolitan Municipality offices (meeting and presentation held on 14 June 2006)
- Presentations on two separate occasions to the Olifantsfontein (1 August 2006 and 5 September 2006)
- Presentations and representations to the Kaalspruit Forum at their various monthly meetings.

Minutes of meetings as well as agendas and attendance registers (where available) have been included as Appendix L (Stakeholder Meetings). A copy of one of the presentations made to the various stakeholders is presented in Appendix M.

5.2. PRESENTATION TO OLIFANTSFONTEIN BUSINESS FORUM

As noted above, the purpose, objectives and proposed rehabilitation initiatives for this rehabilitation project were presented to the Olifantsfontein Business forum on two occasions. The content of this presentation has been included as Appendix M.

The purpose of these presentations was twofold, namely to inform and gather comments as well as to gain support for the project in initiatives. It is ultimately hoped that the support of the business forum and the community in general may ultimately lead to financial support through public-private co-funding or through direct private sponsorship of project components. To date no commitments for funding have however been made.

As mentioned above, ongoing interaction with the business forum is an essential part of the subsequent obtained design phase.

5.3. STAKEHOLDER FEEDBACK

Stakeholder feedback has to date been fairly limited. There have however been few objections to the proposed interventions, and in particular the listed “Factors for Consideration” (Section 4) have been well received. Where stakeholders have made use of the interactions and presentations to provide feedback, this has been noted and where relevant, incorporated into the proposal.

Given the scale and extent of the proposed interventions, it is anticipated that the stakeholder feedback (as well as potential objections) will escalate as the time for implementation draws nearer. Sufficient flexibility should therefore be allowed in the detail design stages to accommodate potential scope and design changes that may arise from the project approval process.

5.4. STAKEHOLDER COMMITMENTS

Whilst there has been fairly widespread support for the rehabilitation initiatives, to date, no commitments have been made by any of the stakeholders or potential private sector financiers. The financial support for the initiatives therefore presently still rests with the Ekurhuleni Metro, but as mentioned above ongoing efforts will have to be made during the design phase to obtain co-funding or donor funds for this project.

6. PROPOSED REMEDIATION MASTER PLAN FOR THE OLIFANTSFONTEIN WETLAND

6.1. GENERAL DESCRIPTION OF THE MAJOR COMPONENTS OF THE PROPOSED REHABILITATION / REMEDIATION MASTER PLAN

As mentioned earlier in Section 4 a list of *desirable results* and or *factors which needed to be taken into account* was drawn up to assist in the evaluation of the pros and cons of the various remedial measures. With reference to this list, the remedial works would ideally:

- Prevent any further erosion of the Olifantsfontein wetland.
- Allow the wetland to resume one of its original functions namely trapping silt, thereby ensuring that clean, silt free water flows down the Kaalspruit.
- Attenuate flood flows.
- Improve the water quality in the Kaalspruit by recreating the bacteriological filter previously provided by the wetland.
- Remove urban litter and vegetation debris from the Kaalspruit.
- Protect the groundwater from pollution by poor quality surface water.
- Facilitate the recharge of the underlying groundwater from the wetland.
- Reduce the downstream hydrological impacts
- Support biodiversity
- Take cognisance of the fact that the area is currently used for cropping
- Make allowance for public open space
- Minimise the risk of odours
- Minimise the risk of midges & mosquitoes

The plan devised to meet the above objectives is shown in Appendix J (Figure 3). Inspection of this plan shows that it comprises the following major components:

- The rehabilitation or remediation of of Olifantsfontein Wetland. Given, that the conditions under which this wetland will have to operate now, are very different to those under which it originally established itself (very much larger floods), and further, that various man made structures have been imposed on its area, such, as amongst others, the construction of the Olifantsfontein extension road and bridge link through the heart of the original wetland, it is no longer possible to rehabilitate it in its original form. Inspection of Fig 3 shows that the proposed new wetland, comprises three discrete but interconnected parts. The upstream component effectively re-establishes the top end of the original wetland. Large-scale earth works will be required to infill the existing erosion channel and to establish an even and very shallow gradient in this portion of the wetland. This shallow gradient, in combination with the weirs (described more fully here under) which will be constructed at the upstream ends of this portion of the wetland, will protect it from future flood erosion. This top portion of the rehabilitated Olifantsfontein wetland, is terminated at its downstream end by a weir (described more fully here under). This weir and associated stilling basin will prevent headward erosion of this upper portion of the wetland and will allow flood waters to be passed safely, via an armourflex canal, (described more fully below) under the new Olifantsfontein extension bridge and past a proposed new recreation area constructed downstream of this bridge.

- The second portion of the rehabilitated/remediated wetland adjoins the downstream end of the proposed new recreation area and comprises six meanders or loops, which will also be created by extensive earth works. These meander wetlands will create a longer flow path facilitating the bacteriological filter action of this portion of the wet land. The downstream end of the meander wetlands will be protected from headward erosion by the construction of another weir (described more fully here under).
- This weir will also serve to divert water into a perforated pipe which will be used to discharge low flows into the third portion of the rehabilitated / remediated Olifantsfontein wetland. As can be seen on drawing Fig 3 this third portion of the rehabilitated / remediated Olifantsfontein wetland will be constructed at the downstream end of the Olifantsfontein spruit. No earthworks are required for the establishment of this third portion of the wetland.
- The construction of the two concrete or rubble masonry weirs (mentioned above), at the upstream end of the upstream portion of the wetland. One of these weirs will be constructed on the Kaalspruit, and the other on the Clayville tributary (See points 1 & 2 of Figure 3, Appendix D). The purpose of these two weirs is, as mentioned above, to protect the top end of the wetland, from flood flows. In the case of weir number 1 this will be achieved by spreading the flood flows of the Kaalspruit over a wide spillway as they enter the wetland. In the case of weir number 2 this will be achieved by diverting the flood flows, which discharge from the concrete lined stormwater canal in Clayville into an armourflex lined canal (refer to points 1 and 2 of Figure 3, Appendix D). This canal will bypass the top end of this portion of the wetland, where the gradient is fairly steep, and allow this Clayville flood water to be safely discharged in a stilling basin constructed where the gradient in the wetland is shallow. Low flows from Clayville will continue to pass through the Clayville arm of the wetland unrestricted.
- The construction of two large litter traps at weirs numbers 1 and 2, which will prevent urban litter and vegetation debris being carried into the wetland.
- The construction of 3 concrete or rubble masonry weirs on the Kaalspruit, (mentioned in the description of the wetlands above) and shown on the plan as weir numbers 3, 9 and 10. The purpose of these three weirs is to provide erosion resistant structures at the downstream ends of the three individual wetlands, described above. These structures will allow safe energy dissipation of the flood waters passing through and discharging from the downstream end of these wet lands.
- The construction of an approximately 1300 metre long armourflex canal between weirs number 3 and weir number 9 (See point 8 on Fig 3) together with 6 small low flow diversion weirs , constructed in this canal. These low flow diversion weirs will divert the low flows through the meander wetlands. The armourflex canal will allow large floods to be passed safely through this second or middle portion of the rehabilitated / remediated wetland without it being eroded.
- The establishment of a park/recreation area in the flood plain immediately downstream of the new Olifantsfontein extension link bridge, together with the construction of a footbridge across the river (See point 14 on Fig 3). Extensive earth works will be required establish this recreation area.
- The establishment of two bird sanctuaries (See points 12 and 13 on Fig 3), one of the upstream end of the wetland, and the other at its downstream end. These bird sanctuaries together with various stretches of open water created by the weirs as well as the rehabilitated portions of wetland, will contribute significantly to the biodiversity of the area.
- The re-routing of the return water flows from the Olifantsfontein sewage works from their present discharge position position, to a new discharge position constructed near the upstream end of the rehabilitated Olifantsfontein wetland. These return water flows, will by ensure that a strong flow of generally good quality water flows through the rehabilitated

wetlands system thereby enhancing its aesthetic appeal while mitigating the risk of odours as well as mosquitoes and midges.

6.2. CONFORMITY WITH REHABILITAITON OBJECTIVES

An evaluation of the probable impacts and effects of the proposed rehabilitation measures, shows, that they will achieve the desired result of the rehabilitation programme, in that the measures will:

- Prevent any further erosion of the Olifantsfontein wetland.
- Allow the wetland to resume one of its original functions namely trapping fine silt, thereby ensuring that clean, silt free water flows down the Kaalspruit.
- Attenuate flood flows.
- Improve the water quality in the Kaalspruit by recreating the bacteriological filter previously provided by the wetland.
- Remove urban litter and vegetation debris from the Kaalspruit.
- Protect the groundwater from pollution by poor quality surface water.
- Facilitate the recharge of the underlying groundwater from the wetland.
- Reduce the downstream hydrological impacts
- Support biodiversity
- Make allowance for public open space
- Minimise the risk of odours
- Minimise the risk of midges & mosquitoes

6.3. SCOPE OF AND EXTENT OF WORKS

The proposed rehabilitation measures have been divided into 14 separate modules. Each of these modules may be undertaken as a project in their own right. These modules can be summarised as follows:

1. Litter trap and earth berm (max. 1m high, above the flood plain, 40m wide berm) in the Kaalspruit directly downstream of the now redundant Olifantsfontein-Midrand road bridge.
2. Litter trap and concrete weir (max. 1,5m high, 25m wide weir) and a lined stormwater channel (600m long channel, 4m top width and 1,5m deep) and a terminal energy dissipation structure .
3. A retaining structure (weir min. 5m high, approx. 190 m wide) in the Kaalspruit directly upstream of the new Clayville bridge. The purpose of this structure will be to retain the rehabilitated wetland
4. Relocation of the existing ERWAT treated effluent outfall to a point upstream of the rehabilitated wetland (preferably at the energy dissipating/outlet structure as Point #2). The purpose of the relocation would be to provide a buffer for the treated effluent (effectively providing some additional retention and possibly effecting additional post treatment) and to water for the maintenance of the wetlands.
5. Construction of gravel roads and tracks required to maintain access to the various channels and structures (primarily for maintenance and inspection).
6. Backfilling of the erosion channel ,and re-establishment of the requisite vegetation in the two wetland tributaries upstream of the retaining structure noted for module 3.

7. Clearing all alien vegetation and re-establishing suitable grasses, shrubs, trees and wetland vegetation in all areas adjoining the lined channels and meanders.
8. Construction of a lined stormwater channel, infilling of the existing erosion channel and construction meanders and at least 6 small diversion weirs (approximately 0.75m high) downstream of the retaining structure at module 3.
9. The construction of a new rubble masonry weir (approx. 3m high, 50m wide) downstream of the lined channel and meanders.
10. Upgrading the existing weir at the ERWAT treated effluent outfall to a rubble masonry structure of approximately 3m high.
11. Establishment of a wetland and body of open water between the two 3m high rubble masonry weirs, including the diversion and conveyance of water to the fringes of the wetland.
12. Establish a “Clayville Wetland Reserve” around the upstream wetland and structures (including modules 1 to 3).
13. Establish an “Olifantsfontein Bird Sanctuary” to encompass the downstream wetland, an adjoining dam as well as appropriate portions of the ERWAT wastewater treatment works.
14. Establishment of a recreation area and a pedestrian crossing in the vicinity of the lined channels and meanders.

6.4. DESIGN SPECIFICATION

Design specifications have been set out in Appendix K. These design specifications provide a basis for the detail design of the proposed rehabilitation initiatives, and consider inter-alia the following:

- The intended purpose of the structure of intervention
- Proposed or possible materials of construction
- Considerations for foundation conditions and foundation arrangements
- Capacity of the proposed structure (in terms of flood discharge)
- Required outlet arrangements
- Approximate crest level and length
- Erosion protection requirements

6.5. RELATED AND NECESSARY WORKS

As emphasised in the master plan for the rehabilitation of the Kaalspruit and at the Hennops rivers, the successful rehabilitation of these rivers requires that integrated and co-ordinated interventions are implemented at key points along the length of the river.

The rehabilitation of the Olifantsfontein wetland is one of these key interventions. However it cannot in isolation address all the problems of the Kaalspruit.

An essential and complementary intervention is the construction of a flood attenuation dam in the Ivory Park area to reduce the impact of the ever-increasing flood discharges from the ongoing developments in the upper catchment. This dam will simultaneously serve as a vitally important silt and litter trap to protect the rehabilitated wetland from the unnaturally large quantities of silt being brought down by floodwaters.

6.6. MONITORING REQUIREMENT

Monitoring is regarded as an essential component of any rehabilitation plan. The results of the monitoring program provides the only means of assessing whether the rehabilitation objectives have been met. If the objectives have not been met and after applying adaptative management, the objectives are still not met, then the original objectives might have to be revised, specifically for those that were not met. The outcome of the monitoring exercise also provides an objective way of informing stakeholders of both successes and failures. The lessons learnt can be used to inform similar projects so as to avoid perpetuating mistakes.

In this project the measurable objectives included:

- Water quality improvement and specifically sediment trapping and faecal bacterial removal.
- Biodiversity enhancement
- The protection of the Clayville wetland from further degradation.

Based on the above the following monitoring program should be introduced and be maintained for at least five years.

6.6.1 WATER QUALITY IMPROVEMENT

<u>Sediment trapping</u>

Water samples should be collected both upstream and downstream of the site on an ad hoc basis during high flow events and under base flow conditions. At least 4 storm events should be sampled annually, and 10 base flow samples should be collected. The collected samples should be analyzed for suspended solids.

<u>Faecal coliform reduction</u>

Samples should be collected under base flow conditions on an ad hoc basis, once a month both upstream and downstream of the project. These samples should be analyzed for faecal coliform bacteria.

6.6.2 BIODIVERSITY

Photographs should be taken from fixed points on an annual basis to provide a visual interpretation of vegetation establishment and growth. As wetlands are difficult habitats to work biodiversity measurement should be restricted to a semi qualitative assessment of species richness at fixed sites restricted to the margins of the wetland system.

6.6.3 PROTECTION OF THE CLAYVILLE WETLAND

Fixed point photography should be used to assess the condition of the wetland. For example a typical site should include an area where head cutting was a feature. This site could then be monitored using photography to provide a qualitative assessment of the site.

6.6.4 MONITORING FEEDBACK

A web site should be established and maintained by Ekurhuleni where these data are displayed and regularly updated to inform interested and affected parties.

6.6.5 SAMPLING

Ideally monitoring should be undertaken by the members of the community, for example a local schools could be approached and encouraged to sample the sites. The cost of sampling, analyses data capture and updating on the web should be for the account of the local council.

6.7. GENERIC ENVIRONMENTAL MANAGEMENT PLAN

A generic environmental management plan has been prepared for the proposed rehabilitation measures and is presented in Appendix O.

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7. FINANCING

7.1. PRELIMINARY COST ESTIMATES

A preliminary cost estimate has been compiled and is presented in Appendix P. This cost estimate is based on the proposed rehabilitation measures represented in the Site Layout (Fig 3 of Appendix J). These costs have been determined from estimated rates and quantities, and are considered sufficiently accurate to have provided a preliminary cost estimate.

Accurate quantities will need to be determined once a more detailed design has been undertaken. A more accurate cost estimate may then be determined on this basis. The provisional cost estimate gives a figure of R 40 211 687.50. After making an allowance of 15% for contingencies and 14% for VAT, this figure increases to R 52 717 587.50.

7.2. POTENTIAL SOURCES OF FUNDING

Numerous sources of potential funding have been identified. These include both public and private sources of funding, as well as the various metropolitan municipalities (Ekurhuleni, Johannesburg and Tshwane) who share this catchment.

As an indication of the broad level of support which already exists for this project, it is important to note that Tshwane Municipality and JRA of Johannesburg Municipality have already budgeted monies towards it.

In addition to Municipal funding, there are also special Provincial funds which can possibly also be accessed for this project. As yet no specific efforts have been made in this regard, but this matter is due to be followed up by the Kaalspruit Technical Task Team.

Donor Funds from International Environmental Groups are another source of potential funds that still need to be investigated.

Regarding possible funding by large South African businesses, particularly those with factories/plants in the Clayville industrial area, it emerged from meetings held with members of the local business forum, that while they may well contribute to this project, they are unlikely to be involved in the larger more costly components of the project, (the infrastructure parts), and are more likely to contribute to social and aesthetic components. In either event, the opinion was expressed that it will be essential to communicate regularly with this group and to involve them throughout so that they can both assess the commitment of the local authorities to this project as well as its sustainability.

An essential component of the design phase will therefore be to maintain an active ongoing consultative and informative interaction with all potential funders and potential donors and to map out a clear course of action and funding for the implementation of the “final design rehabilitation measures”

8. REFERENCES

1. **George Orr and Associates (2003).** The Rehabilitation of the Kaalspruit and Upper Hennops River *(Report No.). Report prepared for the City of Tshwane Metropolitan Municipality.*

2. **George Orr and Associates, Ninham Shand Consulting Service, Wetland Consulting Services (2005).** An Overview of the State of Catchment of the Kaalspruit/Hennops River System With a View to Implementing Specific Rehabilitation Projects. *(Wetland Consulting Services Ref. 155/2005). Report prepared for the City of Tshwane Metropolitan Municipality (2005).*

APPENDIX A: LOCALITY PLAN

APPENDIX B: SITE LAYOUT

APPENDIX C: CATCHMENT MAP

APPENDIX D: LAYOUT OF PROPOSED AND EXISTING DEVELOPMENTS

APPENDIX E: METEOROLOGICAL DATA

APPENDIX F: FLOOD HYDROLOGY

APPENDIX G: HYDRAULIC ANALYSIS RESULTS

APPENDIX H: GEOTECHNICAL AND GEOLOGICAL DATA

APPENDIX I: DAMAGE ASSESSMENT – PLAN AND SECTIONS

APPENDIX J: DRAWINGS – PROPOSED REHABILITATION MEASURES[FIG 1-FIG4]

APPENDIX K: DESIGN SPECIFICATION TABLES

APPENDIX L: RECORD AND MINUTES OF MEETINGS

APPENDIX M: PROJECT PRESENTATION

APPENDIX N: PROJECT NOTIFICATION

APPENDIX O: GENERIC ENVIRONMENTAL MANAGEMENT PLAN

APPENDIX P: COST ESTIMATES