CITY OF CAPE TOWN SURFACE STORMWATER SYSTEMS
ZANDVLEI ESTUARY IMPACT ASSESSMENT

IMPACT ASSESSMENT

ZANDVLEI ESTUARY

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Prepared for
Stormwater and Sustainability Branch
(Planning Department – Transport for Cape Town)
City of Cape Town

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1 INTRODUCTION

Anchor Environmental Consultants (Pty) Ltd. (AEC) were appointed by GIBB (Pty) Ltd. as marine and estuarine specialists to compile impact assessments for seven estuaries / river outlets within the City of Cape Town (CCT) boundaries, namely, the Diep, Disa, Silvermine, Zandvlei, Eerste, Lourens and Sir Lowry's Pass rivers. The purpose of compiling these impact assessment reports is to guide the CCT's maintenance activities, which mainly cover typical stormwater management activities, within sensitive estuarine environments and to identify suitable mitigation measures that will minimize negative environmental impacts of these activities. These maintenance activities require authorization in terms of the National Environmental Management Act (Act No. 107 of 1998). The desired approval from the competent authority (Provincial Department of Environmental Affairs and Development Planning DEA&DP) will be an amendment to the existing environmental authorisation obtained by the CCT in 2015 for its routine stormwater maintenance programme (EIA Ref No. 16/3/1/3/1/A7/4/2031/12). The impact assessment reports include a delineation of the estuary extent; a summary of available information on conservation importance, health status and sensitivity of each estuary; a description of the required maintenance activities; and an environmental impact assessment of the proposed activities. Site visits to each of the seven estuaries were undertaken over the period 2-4 December 2015 during which a variety of maintenance activities were discussed with CCT officials. These impact assessments are compiled based on information supplied by CCT officials, observations made during the site visits, available information in the scientific literature and other reports (e.g. estuary management plans), and the consultant's previous experience and specialist knowledge. Finally, the impact assessment reports should be read together with the Environmental Management Programme and Technical Assessment Report (GIBB, 2014) which were compiled as part of the original Basic Assessment Report and EIA application for the authorisation for maintenance and management interventions in the City's surface stormwater systems. Chapter 13 of that EMPr deals specifically with estuaries and river mouths.

This impact assessment report is for the various City of Cape Town maintenance and management interventions required on the Zandvlei estuary.

2 ZANDVLEI ESTUARY

2.1 Spatial delineation of estuary extent

An estuary is defined in terms of the National Environmental Management: Integrated Coastal Management Act (ICMA) and the NEMA 2014 EIA Regulations as "a body of surface water—

a) that is permanently or periodically open to the sea;
b) in which a rise and fall of the water level as a result of the tides is measurable at spring tides when the body of surface water is open to the sea; or
c) in respect of which the salinity is higher than fresh water as a result of the influence of the sea, and where there is a salinity gradient between the tidal reach and the mouth of the body of surface water.''

While this definition is in line with those used internationally in respect of estuary water bodies it is considered somewhat limited inasmuch as it encapsulates only the estuary water body and not the adjacent physical and biological processes and habitats required to support estuarine function and health. Thus, as part of the Estuary Component of the National Biodiversity Assessment (van Niekerk & Turpie 2012) a definition for the estuarine functional zone (EFZ) was formulated which extended the lateral boundaries of an estuary up to the 5 m contour, with the downstream boundary taken as the estuary mouth and the upstream boundary taken as the limits of tidal variation or salinity penetration, whichever penetrates furthest. Protection/rehabilitation of the estuarine functional zone is considered essential for protection of estuarine biodiversity and associated ecological processes (van Niekerk & Turpie 2012). The Zandvlei Estuary Management Plan (EMP) had utilized the 100-year floodline to determine the northern and lateral boundaries of the estuary, but this area still included some residential development. The estuarine functional zone definition (i.e. 5 m contour and limits of tidal variation or salinity penetration) was adopted for the purposes of these impact assessments, with the major difference being that housing or industrial developments were excluded; and for practical purposes the borders were aligned with clear features (such as roads or footpaths) where possible. The spatial extent of the Zandvlei estuary as defined for the purposes of this impact assessment is shown in (Figure 1).

The Marina Da Gama canals constitute artificial estuarine habitat, but they are a connected and functioning part of the Zandvlei estuarine system. The CCT undertakes a number of maintenance activities within the canals, including pond weed management, maintenance of stormwater headwalls and outlets, erosion control of embankments alongside public open space, and may be required to undertake sediment management within the canals in the future. The Marina Da Gama Canals are therefore included in the definition of Zandvlei estuary extent for the purposes of this impact assessment (Figure 1).

Figure 1. Spatial extent of the Zandvlei estuary defined for the purposes of this impact assessment Management Plan (yellow polygon) and the 5m contour (red polygon).

2.2 Catchment and hydrology

The catchment of the Zandvlei estuary is approximately 92km^2 and bordered by Muizenberg Mountain, Silvermine Plateau and Constantiaberg to the West, Wynberg Hill to the North with a smaller, less noticeable eastern boundary. The main streams draining the catchment are the Westlake Stream, Keysers River, Langvlei Canal and the Sand River Canal (the latter essentially being the lower end of the Diep River). The Westlake and Keysers rivers converge and enter the north-west of the estuary via a reed filled wetland while the Langvlei and Sand rivers which flow in concrete canals converge and enter the estuary in the north-east (Figure 1).

The geology of the catchment includes a number of different sources including the Peninsula, Springfontyn and Witzand formations. All three of these different formations have the potential to contribute groundwater to the Zandvlei estuary, however most groundwater naturally entering the system would be through the shallow intergranular aquifers of the Springfontyn and Witzand groups along the Sand River. The groundwater from these aquifers likely contains water of a sodium-chloride-calcium-alkaline nature. The current contribution of these aquifers to the hydrology of the system is now likely severely limited due to the extensive canalisation of some of the river courses in their lower reaches which prevents movement of water into the system through interflow or baseflow. This indicates that the majority of the water entering the system is coming from overland flow transported by the inflowing rivers.

While there aren't flow gauge data for each of the rivers, Thornton *et al*. (1995) in CEC (2010) estimated that the mean annual freshwater inflow is approximately 22x10^{6}m^3/annum using data from the single gauging station, rainfall records and water levels from the estuary itself. They estimated that the contribution of flow for each river is about 45%, 43% and 12% coming from the Keysers, Sand and Westlake rivers respectively. Under natural conditions there would have also been a significant tidal influence through the estuary mouth. This tidal influence is now greatly altered due to canalization, weir construction and artificial mouth management. Thornton *et al*. (1995) in CEC (2010) estimated the current tidal inflow at 3.1x10^{6}m^3/annum.

2.3 Physical and chemical components

Some early maps suggest that the mouth of the Zandvlei estuary was much wider than it is today and potentially shifted position periodically. It appears that prior to human interventions, the estuary would have been open to tidal flushing most of the year, maintaining water heights of between 0 m and 0.3 m above Mean Sea Level (aMSL). During late summer months when the river inflow was at its lowest, the mouth would have closed, resulting in a gradual increase in water level, potentially reaching as high as 2.5 - 3 m aMSL, flooding a much larger area than that which is inundated currently. The inflowing freshwater from the rivers, would have then caused the salinity in the estuary to drop. At some point the mouth would be breached by the high water level behind the natural sand berm which would result in flushing out most of the water, transporting a large amount of sediment along with it. The newly opened and widened mouth would then allow a tidal influence, once again increasing the salinity in the estuary.

Since the first time the mouth was artificially closed off in 1886, the water level within the estuary has been manipulated in a number of different ways for different objectives, including protecting sewage infrastructure, allowing recreational activities to occur in the estuary as well as protecting lower lying buildings from potential flood damage. These largely human requirements are also balanced with the need to ensure the system maintains some estuarine characteristics such as saline influence and facilitating the movement of estuarine species into and out of the system. While the natural range of water levels were approximately 0 - 3 m aMSL, it has mainly been manipulated to keep the level less than 1 m aMSL. This is achieved by managing the height of the rubble weir between 0.4 and 0.6m aMSL which is the lowest it can be and still satisfy the recreational user requirements. Since about 2000 the mouth has been regularly opened and closed to try and maintain a balance between keeping enough water in the estuary to allow recreational use, while still trying to allow for the system to function more naturally. In summer months the mouth has been opened for a number of days each month, often coinciding with spring tides to allow for greater influx of seawater and to facilitate fish recruitment into the system. In addition the mouth is left often for the majority of the winter months in order to manage flood risk unless there has been insufficient rainfall. Refer to section 2.5 “Management History” for more information on this process.

These changes to the natural processes working in the estuary have led to a number of changes to biophysical characteristics of the system. While there has been some monitoring of water parameters in Zandvlei estuary by the City of Cape Town since the 1970s, some of these stations have been discontinued, making tracking long-term trends difficult. However currently there are nine monitoring stations located within the main estuary area and marina canals where a comprehensive range of chemical, microbiological, algal and physical analyses are undertaken once per month by the City’s accredited laboratory.

Salinity within the estuary remained relatively constant during the 1970s. There was a gradual decline in salinity seen from 1980 to the early 1990s from a mean of 10 ppt to 5 ppt, which is attributable to the increase in the weir height during that period (CEC 2010). Between 2002-2010 the salinity recovered to a more natural higher level of between 9-11 ppt, again linked to alteration of the weir (this time a reduction in height). In addition to monthly sampling undertaken by the City, salinity levels are regularly monitored by a community citizen science group. The data obtained through this programme indicates that salinity levels in the north of the estuary fluctuate between 5 and 15 ppt, 5 and 20 ppt in the mid-region and 5 and 32 ppt near the mouth. Temperature and pH both seem fairly uniform and consistent across the estuary and within acceptable ranges (CEC 2010). Surface dissolved oxygen levels within the estuary were found to be acceptable in all data from monitoring during the 1970s as well as the 2000s. There is very limited data on bottom water dissolved oxygen concentration, however the little data there are show very low levels of dissolved oxygen. Low dissolved oxygen levels can lead to death of certain aquatic organisms and result in fish kills.

Monitoring of the main nutrient constituents (Nitrogen and Phosphorus) between 1973-1978 as well as 2000-2009 indicate that the estuary is in a eutrophic state (CEC 2010). Eutrophic conditions generally lead to highly productive systems that can often have problem with overgrowth of pest species, and generally have quite low overall species diversity. Both total Nitrogen and Phosphorous concentrations showed some improvement (reduction) between 2000-2009, less often indicating

eutrophic, and more often indicating a healthier mesotrophic condition. Observable consequences of the nutrient levels include the proliferation of pond weed (*Potamogeton pectinatus*) which tolerates brackish conditions and associated epiphytic algae (*Cladophora / Enteromorpha* sp.). The phytoplankton community in the main body of water excluding the Marina canals tends to comprise mostly Bacillariophyceae (diatoms), Chlorophyceae and various other minor groups (e.g. Cryptophyceae, Euglenophyceae). Blue-green algae (Cyanophyceae) are seldom recorded in the system. Chlorophyll levels associated with the phytoplankton community follows a seasonal pattern and has reduced since 2011 (Table 1).

Table 1. Median annual Chlorophyll concentrations within Zandvlei estuary (Source: Haskins 2016).

Year	2011	2012	2013	2014	2015
Median annual chlorophyll concentration (µg/)	27	32	17	14	13

An extensive survey of the sediments in Zandvlei and the Marina da Gama canals conducted in 2013 by the CSIR revealed that, contrary to popular belief, metal contamination was minimal (CSIR 2015). Cadmium levels were somewhat elevated but it was postulated that this was not due to an anthropogenic source because cadmium concentration in sediment can increase through a natural process linked to the productivity of single-celled plants (phytoplankton).

2.4 Biodiversity

The biodiversity of the Zandvlei estuary has been greatly impacted on by the changes to flow regimes as well as the development of much of its catchment and banks. As a consequence the biodiversity of the system is now vastly different from what it would have been, and is in a degraded state. The situation assessment for the Zandvlei Estuary Management Plan (CEC 2010 and CEC 2013) and the Morant and Grindley (1982) CSIR report contain comprehensive biodiversity information for the Zandvlei estuary. The Zandvlei Estuary Nature Reserve (ZENR) keeps species lists online at www.biodiversity.co.za and the Zandvlei Trust also records a wealth of information on the Trust website (www.zandvleitrust.org.za). A comprehensive description of all aspects of the ZENR can also be found in the Integrated Reserve Management Plan (Gibbs, Thompson and Sheasby 2011).

While the system is rather degraded, it still provides a range of different habitats for species, including salt marsh, reed beds, sand banks as well as open water. The Zandvlei Estuary Nature Reserve has two primary vegetation types, namely Cape Flats Dune Strandveld on the lowland areas, and Cape Peninsula Granite Fynbos on the higher Boyes Drive area. In the extreme north of the reserve and Westlake wetlands area, the vegetation type is in a transition area to Cape Flats Sand Fynbos (Gibbs, Thompson and Sheasby 2011).

While there are a number of early studies that have identified an abundance of microalgae, diatoms, and zooplankton and aquatic invertebrates in the estuary (described in Morant and Grindley 1982), with the exception of regular phytoplankton monitoring and occasional fish and sand prawn surveys, there has been little detailed work on these biotic components since. A few recent studies have found lower abundances of polychaetes and sand prawns than earlier studies (Southern Waters 2001, Fowler 2000 in CEC 2010) Surveys over the last three years have shown that prawn densities

are highly variable annually. For example, densities greater than the maximum found in previous studies occurred just after the 2012 golden algae bloom, but declined again in 2014 (ZENR pers. comm.).
Eighteen species of reptiles and amphibians have been recorded in and around the Zandvlei area. The only listed species on the IUCN Red List is the Endangered Western Leopard Toad that is known to breed in the upper estuary and surrounding wetlands.

A total of 40 species of fish have been found in the Zandvlei estuary (CEC 2010 updated with GZENR fish list). The species found in Zandvlei include a number of different groups with varying levels of dependence on estuaries: 1) species that are dependent on estuaries for their entire life cycle; 2) species dependent on estuaries as juveniles (this includes the endangered white steenbrass (IUCN Red List 2016); 3) species where juveniles are mainly occurring in estuaries, but are also at found at sea; 4) species where juveniles are mainly found at sea, but also in estuaries; and 5) purely freshwater species. The longsnout pipefish that is found in Zandvlei is now known as *Syngnathus temminckii*. It is common and widespread in estuarine and coastal habitats from Walvis Bay to Durban. The rarer *S. watermeyerii* does not however occur in Zandvlei. There are also a number of introduced fish species such as carp *Cyprinus carpio* and tilapia (*Oreochromis mossambicus* and *Tilapia sparrmanii)* that are found in the estuary.

A relatively diverse avifauna utilizes Zandvlei estuary. Coordinated waterbird counts (CWAC) have been compiled by the Animal Demography Unit of the University of Cape Town in different parts of the estuary since 2001. During this time at least 88 species of waterbird have been counted, most of them in the Westlake wetlands and in the lower estuary. In general there has been an increase in the number of birds counted since the start of the CWAC data collection. Earlier records indicate higher numbers of species counted (Begg 1975 in Morant and Grindley 1982), however these counts included non-waterbird species and so do not necessarily indicate a decline in the number of species using the estuary. Complete bird lists from the ZENR list 173 species of bird recorded within the Reserve, including six red data species (ZENR 2016).

There are 21 mammal species recorded in the ZENR. Of the semi-aquatic mammals the Cape Clawless Otter is one of the larger species most dependant on the estuary. The surrounding areas would have supported a more diverse range of mammal species prior to the development of the land. The ZENR likely provides refuge for the remaining mammal species occurring in the Zandvlei area.

The aquatic habitats have been affected by the influx of aquatic vegetation including alien species *Eichornia crassipes* (water hyacinth), *Ceratophyllum demersum* (hornwort), *Azolla filliculoides* (Red waterfern) and *Myriophyllum aquaticum* (Parrot's feather), whilst indigenous pondweed *Potamogeton pectinatus* has become dense throughout the estuary and is periodically removed. Invasive and alien-species management within the ZENR is applied in accordance with the City of Cape Town's invasive alien species strategy and in coordination with various government-funded initiatives, including Working for Water and Working for Wetlands.

Most of the terrestrial habitats have been converted into residential or recreational areas. The remaining natural vegetation surrounding the estuary is also threatened by invasion of alien trees, grasses and weeds. The City's Environmental Resource Management Department (Biodiversity

Management Branch) have however, embarked on projects to rehabilitate and re-vegetate certain marginal shoreline areas with appropriate indigenous species.

A weir was installed in the central salt pans of the system in 1999- 2000 the aim of the weir to was to allow the CCT to manipulate the water levels of the central pans to simulate natural conditions. The weir has been out of operation since approximately 2004 when the concrete base was damaged.

2.5 Management history

Zandvlei Estuary has a long history of interventions by man. Some of the earliest modifications of Zandvlei date back to 1866 when, during a drought, the mouth to the estuary was blocked off and the estuary was drained with the idea to use it as agricultural land. While the land was never converted to farming due to the re-flooding of the estuary during the winter rains, agriculture in the catchment expanded. In the 1930's the first construction of weirs across the inflowing rivers occurred. These weirs separated the inflowing freshwater from the saline water in the estuary, allowing the former to be used for irrigation purposes.

In 1882 the railway line from Cape Town to Simons Town was built which cut off sections of the western part of the wetland from the rest of the estuary. The population of the area and developments increased shortly after this rail link. The estuary began being utilized as a recreational area. There was a break in recreational use between 1947 and 1961 as a result of siltation and aquatic weed infestation. During this time extensive dredging and weed removal occurred. To support continued recreation use and developments surrounding the estuary, the outlet channel was canalized in the 1950s and eventually a rubble weir was constructed near the mouth which maintained water levels within the estuary.

Between 1969 and 1973, Marina da Gama was built along the eastern shore of the estuary. In order to create the marina, a large quantity of material was dredged. This material was then used to create the two islands which lie between the marina and the main estuary water body. Urbanisation continued and eventually surrounded the entire estuary.

While the Zandvlei estuary is substantially modified, it is a highly utilised recreational area which still boasts some natural habitat and conservation value.

In 1977 the Zandvlei Nature Reserve in the north of the estuary was first recognized, which was later to become the Greater Zandvlei Estuary Nature Reserve (GZENR). The current land use within the catchment is mainly recreational, residential and light industrial.

A comprehensive Estuary Management Plan (CEC 2011 updated in 2013) has been developed for the Zandvlei estuary following the Estuary Management Plan Protocol (DEA 2013) that includes compiling a Situation Assessment Report (CEC 2010) and a Management Plan with extensive stakeholder input, and formation of an Estuary Management Forum comprising local stakeholders and management agency representatives. The Reserve is currently managed in terms of both the Integrated Reserve Management Plan (Gibbs, Thompson and Sheasby, 2011), and the Estuary Management Plan (CEC 2013) by the City of Cape Town with guidance and input from the Zandvlei Estuary Management Forum which has been reconvened more recently as the Zandvlei Estuary

Nature Reserve Protected Area Advisory Committee. There is also an established "urban catchment forum" (Zandvlei Catchment Forum) which meets on a quarterly basis and addresses a range of topics and challenges related to the entire catchment area (all inflowing rivers, Zandvlei and other small water bodies in the catchment).

Apart from undertaking management of general biodiversity and recreational activities within the GZENR, the City also manages the mouth of the estuary (management of a weir and open and closure of a sand bar which controls water levels in the estuary and Marina da Gama area) for different objectives, including protecting sewage infrastructure, allowing recreational activities to occur in the estuary as well as protecting lower lying buildings from potential flood damage. These largely human requirements are also balanced with the need to ensure the system maintains estuarine characteristics which requires ingress of sea water and allows for the movement of estuarine and marine species into and out of the system.

The above mentioned management of the mouth has for many years been undertaken in terms of the Zandvlei Estuary Mouth Management Plan protocol (City of Cape Town 2014, as amended) which was submitted to, and approved by, DEA&DP in 2011 (Reference E12/2/4/7-A5/328-CJ2142/11). The protocol was subsequently updated by the City and again approved by DEA&DP in 2014 (Reference No. 16/3/1/6/A6/46/2105/14). The updated protocol made provision for both the periodic opening and closure of the mouth and gradual removal of marine derived sediments deposited in a sandbar upstream of the mouth.

As the above approval of the Mouth Management Plan has lapsed, instead of merely applying for renewal of the plan, the City has opted to incorporate the mouth management requirements which remain the same into this overall Basic Assessment amendment application for approval of the broader range of stormwater and related maintenance activities within the Zandvlei estuary.

2.6 Current ecosystem health & sensitivity

In 2012 the estuaries of South Africa were assessed during a desktop health assessment to try and identify gaps in knowledge and shortcomings of previous assessments and provide a comprehensive consistent assessment of estuaries in South Africa. The assessment targeted a number of different areas, examining both the pressures and threats to each estuary as well as the current condition for a number of bio-physical parameters. The National Biodiversity Assessment (van Niekerk and Turpie 2012) rated Zandvlei as having a "Fair" overall Estuary Health State and a resulting Ecological Category of D (Table 2).

The threats and pressures to the system are mainly related to pollution, loss of habitat (marina and other developments) and changes in flow largely caused dredging for developments, mouth canalization and manipulation. The biotic components are all rated as "fair" indicating they have a good potential basis for recovery if the main threats are dealt with. The components with the lowest rankings were all physical parameters, and many are directly related to the changes in flow and breaching of the estuary mouth. The assessment report recommended that Zandvlei estuary be restored to a more functional status, mainly through how the water level and breaching is regulated, which would allow it to fulfil its role in contributing to biodiversity of the country (van Niekerk and

Turpie 2012). The estuary is however, highly altered and realistically can never be fully restored to its previous functional state as this would involve many residential developments becoming flooded during high water periods.

2.7 Conservation importance

Several IUCN red listed species are found within the Zandvlei estuary and surrounds. The Western Leopard Toad completes its entire lifecycle in and around the estuary itself. The estuary does provide some areas of mostly intact habitat, although large portions of the margins are completely converted and of little conservation value, however rehabilitation may be possible for some of these areas. The estuary is also listed as an important estuary in terms of providing a nursery habitat for estuarine dependent fish. The endangered white steenbras has been regularly recorded in Zandvlei in recent surveys, but evidence of a higher abundance in the past exists. If the health of the system improves it could become a more critical habitat for this and other important line fish species which depend upon estuaries in their lifecycle (e.g. dusky kob, leervis and elf). These marine fish are serial batch spawners (release gametes many times over an extended spawning season) that breed along the east coast with peaks in spawning activity during late winter and spring. After an egg and larval phase lasting several weeks, the peak in recruitment of juveniles to estuaries along the Western Cape coast takes place during spring and early summer (September - December).

Table 2. Results of the National Biodiversity Assessment for Zandvlei estuary (van Niekerk and Turpie 2012).

Indicator		Rating
Pressures	Change in Flow	Medium
	Pollution	High
	Habitat Loss	Medium
	Mining	No
	Artificial Breaching	Yes
	Fishing Effort	Medium
	Fishing Effort (catches in tonnes)	0.1
	Bait collection	No
Health Condition	Hydrology	Fair
	Hydrodynamics	Poor
	Water Quality	Poor
	Physical habitat	Poor
	Habitat State	Fair

	Microalgae	Poor
	Macrophytes	Fair
	Invertebrates	Fair
	Fish	Fair
	Birds	Fair
	Biological State	Fair
	Estuary Health State (Mean)	Fair
	Ecological Category	D

3 REQUIRED MAINTENANCE ACTIVITIES

Nine different management/maintenance measures were identified as necessary to ensure safe functioning of the CCT stormwater system and to enhance and support environmental process within wetlands, rivers and estuaries in the greater CCT area (Table 3) (Gibb 2015). Seven of these maintenance measures are required in the Zandvlei estuary and surrounds (Table 3). These measures are divided into more detailed sub-types and a brief description and location is provided in Table 3 and Figure 2 and Figure 3. Detailed method statements for these maintenance activities as undertaken by the CCT are provided in Appendix C of the Technical Assessment Report (Gibb 2014).

Table 3. Maintenance measures required for the Zandvlei Estuary.

MAINTENANCE/MANAGEMENT MEASURE	INTERVENTION SUB-TYPE	REQUIRED IN ZANDVLEI	DESCRIPTION AND LOCATION
1. Vegetation management 1.1. Aquatic (submerged and floating) vegetation management	1.1.1 Manual removal	Yes	Removal of invasive aquatic species across the estuary including the lower reaches of rivers entering the Zandvlei estuary. Pondweed is managed in designated areas using a floating mechanical harvester in terms of the Zandvlei Estuary Management Plan.
	1.1.2 Mechanical removal	Yes	
	1.1.3 Biocontrol	Yes	Biocontrol agents may be released to control listed alien aquatic species such as water hyacinth under the guidance of the City's Invasive Species Unit if required
	1.1.4 Chemical control	No	
	1.1.5 Manipulation of water levels	No	Not applicable in this system for vegetation management
1.2. Reedbed and indigenous emergent vegetation management	1.2.1 Manual removal	Yes	Clearing reeds and sedges from a diversion canal near the entrance of the Sand River. Clearing vegetation from areas in front of stormwater pipe openings throughout estuary.
	1.2.2 Mechanical removal	Yes	Clearing reeds and sedges from a diversion canal near the entrance of the Sand River. Clearing vegetation from areas in front of stormwater pipe openings throughout estuary.
	1.2.3. Chemical control	No	
	1.2.4 Burning	Yes	Prescribed burning of e.g. senescent reed beds is occasionally undertaken by the Biodiversity Management Branch in terms of the Zandvlei Integrated Reserve Management Plan (Fire Management Plan).
	1.2.5 Manipulation of water levels	No	Not applicable in this system for vegetation management

MAINTENANCE/MANAGEMENT MEASURE	INTERVENTION SUB-TYPE	REQUIRED IN ZANDVLEI	DESCRIPTION AND LOCATION
1.3.Riparian / marginal vegetation management	1.3.1 Manual removal	Yes	Associated with proposed bank re-profiling and rehabilitation between the yacht club and the estuary mouth (refer to 2.1 below). Removal of alien vegetation occurs throughout the system.
	1.3.2 Mechanical removal.	Yes	Associated with proposed bank re-profiling and rehabilitation between the yacht club and the estuary mouth (refer to2.1 below). Will also be required to create access for long boom excavator to be used for approved dredging of marine sediments in lower estuary.
	1.3.3 Biocontrol.	No	
	1.3.4 Chemical control.	Yes	Herbicides and foliar sprays used when appropriate in conjunction with manual clearing of alien vegetation.
	1.3.5 Burning.	Yes	Prescribed ecological burns and burning of cut brush material generated from alien clearing, rehabilitation efforts. All burning is undertaken by the Biodiversity Management Branch in terms of the Zandvlei Integrated Reserve Management Plan (Fire Management Plan).
2. Erosion control	2.1 Estuary bank profile enhancement.	Yes	Cutting back and profiling banks approximately 10m wide on the lower reaches of estuary, between the yacht club and the mouth. Followed by rehabilitation including the planting of indigenous sedges and reeds.
	2.2 Construction, maintenance and expansion of erosion control structures.	Yes	Maintenance of concrete canal walls and walkway at mouth. Maintenance of revetments e.g. wooden pole, gunite and cement block banks Maintenance of gabion works around bridge structures e.g. the pedestrian bridge at Albertyn Rd. Erosion control measures required to protect road in municipal caravan park
3. Sediment Management	3.1 Construction, maintenance and expansion of sediment traps.	No	
	3.2 Manual/mechanical sediment removal from sediment traps/retention	Yes	Removal of marine sediment sandbar in lower reaches of Zandvlei As described in amended Mouth Management Plan (DEADP

MAINTENANCE/MANAGEMENT MEASURE	INTERVENTION SUB-TYPE	REQUIRED IN ZANDVLEI	DESCRIPTION AND LOCATION
	areas.		reference number (16/3/1/6/A6/46/2105/14). Removal of silt from all three inflowing rivers/canals and from the depositional area in the upper region of the estuary.
	3.3 Manual/mechanical sediment removal from canals, channels and waterbodies.	Yes	Removal of sediment from numerous stormwater outlets if blocked. Sediment removal from the existing diversion channel near the inflow of the Sand River. Removal of organic sediments from artificial Marina da Gama canals if required.
4. Channel Enclosure	4.1 Conversion of an open channel to an enclosed pipe / culvert system.	No	
5. Litter and debris management	5.1 Litter and debris removal using either mechanical or manual methods.	Yes	Removal of illegally dumped material as and when required.
	5.2 Removal of structures to reduce water obstruction.	No	
	5.3 Construction, maintenance and expansion of litter management infrastructure	Yes	Installation of new litter traps at stormwater outlets and/or inflowing rivers/ canals. Repair of existing litter traps at Sand River inflow and elsewhere as required.
6. Construction, maintenance and expansion of minor stormwater infrastructure	6.1 Stormwater outlets, dam scour valves, headwalls and culverts	Yes	Construction and repair of outlets, headwalls and culverts throughout the system as needed.
7. Maintenance of attenuation infrastructure	7.1 Weirs	Yes	Repairs to and possible replacement of the centre salt pan weir. Rubble weir below Royal Road bridge is lowered/ raised as required to manipulate water levels. As described in amended Mouth Management Plan (DEADP reference number (16/3/1/6/A6/46/2105/14).
	7.2 Retention / detention ponds and dams registered in terms of the National Water Act as dams with a Safety Risk	No	
	7.3 Flood protection embankments / berms	No	
	7.4 SUDS facilities	No	

MAINTENANCE/MANAGEMENT MEASURE	INTERVENTION SUB-TYPE	REQUIRED IN ZANDVLEI	DESCRIPTION AND LOCATION
	7.5 Other dams / ponds	No	
8. Recreational access	8.1 Construction, maintenance and expansion of footbridges, boardwalks or bird hides	Yes	Installation of footpaths on estuary banks in lower reaches of system. Boardwalks and bird hides throughout the system as part of the continuing development and maintenance of the Greater Zandvlei Nature Reserve.
9. Management of river / estuary mouth	9.1 Breaching: removal of sand bars deposited in mouth	Yes	Water levels are actively managed through artificial breaching and closure of the mouth (removal and re-instatement of sandbar) to prevent flooding and to ensure water levels are sufficient for recreational activities. The process also ensures regular inflows of sea water which assists with faunal movement and water quality management. As described in amended Mouth Management Plan (DEADP reference number (16/3/1/6/A6/46/2105/14).
	9.2 Straightening: redirecting meandering mouth across the shortest route directly towards the sea	No	Not applicable as the outlet is contained within existing concrete walls.

Figure 2. Location of required maintenance measures within the northern section of the Zandvlei estuary.

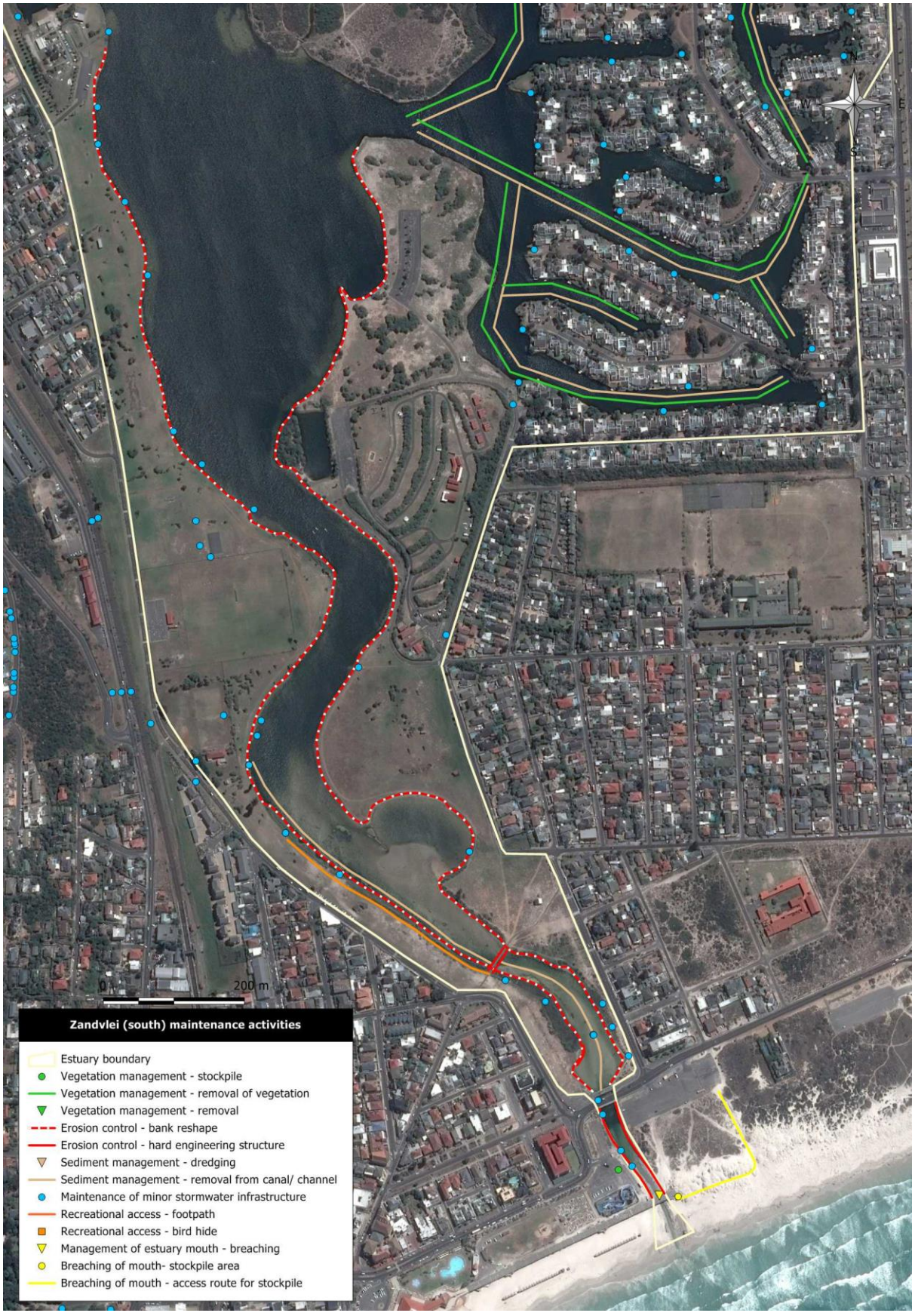

Figure 3. Location of required maintenance measures within the southern section of the Zandvlei estuary.

4 POTENTIAL IMPACTS OF THE PROPOSED MAINTENANCE ACTIVITIES

A range of potential impacts associated with each of the proposed maintenance activities on the Zandvlei estuarine environment and broader marine environment are identified. These along with appropriate mitigation measures are addressed separately in the tables below. Detailed assessment of the positive impacts associated with the proposed maintenance activities are provided in the Technical Assessment Report (Gibb 2014). Positive impacts of maintenance activities are expected to be the same in estuarine systems and are reiterated in the text below, but assessments of these positive impacts are not repeated here. Potential negative impacts are assessed taking cognisance of the estuary attributes, health status and conservation importance.

Best practice mitigation measures

Standard "best practice" mitigation measures that are broadly applicable to maintenance works undertaken in the vicinity of all watercourses including estuaries are described under "General Specifications" in the Environmental Management Programme (EMPr) (Appendix H of the Basic Assessment Report) (Gibb 2014). These include specifications on: Environmental Awareness, Vegetation Impacts, Biodiversity Impacts, Topsoil, Construction Plant and Material Management, Solid Waste Management, Washing and Wastewater Management, Sanitation, Fuels, Oil, other Hazardous Substances and Spills, Stormwater Management and Erosion, Air Quality, Noise Control, Concrete Batching, Trenching and Excavations, Access Roads, Road Reserves, Working Times, Health and Safety, Fire Prevention and Control, Works and Site Decommissioning, Rehabilitation, Monitoring and Compliance, Heritage and Archaeology. Mitigation measures included in these General Specifications are not repeated here, but they are fully applicable to maintenance work in estuarine environments and this impact assessment report must be read in conjunction with the EMPr.

4.1 Vegetation management

4.1.1 Aquatic (Submerged and floating) vegetation management

Aquatic submerged and floating vegetation management is required in the Zandvlei estuary. Thirteen problem aquatic weeds species have been recorded in the Zandvlei estuary and its catchment (Freshwater Consulting Group and Wetland Solutions, 2011).

Aquatic vegetation such as pondweed and associated epiphytic algae is currently managed from defined areas within the Marina da Gama canals and main waterbody area using a floating motorised pond weed harvester in terms of a pond weed management plan under the supervision of the reserve manager. Other aquatic plants such as hyacinth, parrots feather, Kariba weed etc are managed when these invasive species become problematic through a combination of manual removal, mechanical removal and biocontrol. These species tend to occur mainly in the inflowing

rivers since the salinity of the main vlei restricts their expansion into the lower estuary. Biocontrol is also used within the Westlake wetland area.

Negative impacts associated with these methods include possible damage to riparian vegetation through stockpiling material on the estuary banks and disturbance to estuary sediments if large teams operate in the water body.. Stockpiling of vegetation impacts can be mitigated by minimising the number of stockpiles, situating them appropriately at a sufficient distance back from the bank; and removing them promptly after dewatering to minimise damage to riparian vegetation. Aquatic vegetation removed from Zandvlei is typically stockpiled on grassed areas and lawns along he Marina da Gamma channels. These areas are used to avoid damage to riparian vegetation. Disturbance of sediments can be mitigated by using smaller teams and only walking in the channel where required. The impacts associated with aquatic vegetation removal are local and short term and are rated LOW with mitigation (Table 4). It should be noted that large teams are rarely required for aquatic vegetation removal in Zandvlei.

Table 4. Assessment of negative impacts associated with removal of submerged and floating aquatic vegetation .

	Extent	Magnitude	Duration	Probability	Status	Significance
With mitigation	Local	Medium	Short-term	Probable	Negative	Low
Recommended mitigation measures: • Use manual removal with small teams where safe and feasible. • Where mechanical removal is required, use a long boom excavator with water bucket to avoid damage to the estuary banks and intertidal zone. • The floating weed harvester which is used to manage pondweed should follow guidelines in the Zandvlei Estuary Management / Reserve Management Plan/s and be supervised by reserve management. • For mechanical removal, access routes should be as direct as possible, at right angles to the channel or area to be cleared. • Stockpile excavated/ cut material at least 10m from the HWM/ water edge for no longer than two weeks. • Unless urgently required, do not clear aquatic vegetation over the period August - December. (This period includes Western Leopard Toad breeding and emergence, the peak bird breeding period and peak period of juvenile marine fish recruitment to estuaries.) • A reserve population of *Potamogeton pectinatus* should be retained as this species provides a valuable habitat and food source for organisms. • Conduct follow up operations timeously to prevent re-infestation.						

4.1.2 Reedbed and indigenous emergent vegetation management

Management of reeds in wetlands improves floral biodiversity and wetland structure in instances where it allows for re-establishment of a more diverse habitat and flora. Another positive impact of optimal reed management is water quality improvement of stormwater passing through filtration reedbeds (*Typha capensis* and *Phragmites australis*). Management of reeds that clog channels can also reduce erosion.

Negative impacts associated with manual removal of reedbeds and other emergent vegetation are generally considerably less than those associated with mechanical removal where the establishment of temporary access points for machinery and the use of machinery in the estuarine functional zone has additional negative impacts. For this reason, manual removal is recommended as a mitigation

measure, it is however, acknowledged that scale of work required, or the depth of water in estuaries, will frequently require the use of machinery.

When clearing emergent vegetation and accessing the site, habitat may be damaged or removed, mobile biota such as birds and fish may be disturbed and biota with limited mobility (juvenile birds, amphibians, reptiles and invertebrates) may suffer mortalities. Negative impacts of burning include the loss of reedbed invertebrates and reduced bird breeding habitat, but this has not been shown to be worse than cutting if the burn is carefully controlled. Burning reed is also known to increase early shoot emergence and density and has been shown to increase plant diversity. Stacking of cleared vegetation on the estuary banks for dewatering prior to removal also may have impacts on the marginal vegetation. Removal of reeds at river and stormwater outlets can result in a short to medium term loss of buffering/natural filtration and lead to decreases in estuary water quality. Disturbance of the sediments associated with mechanical removal of vegetation and with burning releases nutrients into the water column, thereby promoting re-growth of the vegetation. For these reasons indiscriminate and frequent clearing or burning should be avoided, and temporary machine access points and stockpile areas should be kept to the minimum required number and footprint.

The extent of vegetation to be removed when clearing out an existing canal, or in front of stormwater outlets, is however, an extremely small proportion of the habitat type that is dominant along much of the upper estuary wetlands. The impact is also short term and is reversible. With effective mitigation that includes recommendations on appropriate areas where emergent vegetation may be removed, the methods used and seasonal timing of the vegetation clearing, this impact is rated as LOW with mitigation (Table 5).

Table 5. Assessment of negative impacts associated with removal of emergent vegetation (reed beds).

	Extent	Magnitude	Duration	Probability	Status	Significance
With mitigation	Local	Med	Short-term	Probable	Negative	Low

Recommended mitigation measures:

- Only clear emergent vegetation in channels and at stormwater outlets to improve conveyance capacity, do not clear for aesthetic reasons in unchannelled estuary flood plains.
- Where mechanical removal is required, use a long boom excavator with water bucket to avoid damage to the estuary banks and intertidal zone.
- For mechanical removal, access routes should be as direct as possible, at right angles to the channel or area to be cleared..
- Stormwater outlets may be cleared as frequently as required, but larger scale removal of reeds (e.g. channel clearing) should only take place once every two years to allow recovery.
- Stockpile excavated/ cut material at least 10m from the HWM/ water edge for no longer than two weeks.
- Use manual removal where safe and feasible, cut reeds close to ground at end of dry season.
- Unless urgently required, do not clear or burn emergent vegetation over the period August - December. (This period includes Western Leopard Toad breeding and emergence, the peak bird breeding period and peak period of juvenile marine fish recruitment to estuaries.)

4.1.3 Riparian / marginal vegetation management

Riparian or marginal vegetation management within the Zandvlei estuary is largely the manual / mechanical removal of alien trees, grasses and weeds, and rehabilitation with appropriate indigenous species that is undertaken by the City's Environmental Resource Management Department. The positive impacts of these activities include improved biodiversity value and improvement in moisture levels in wetlands invaded by terrestrial species because of the high water use by alien woody species. Biocontrol agents can be very effective in reducing alien vegetation

density and guidelines for their use are provided in the EMPr (Gibb 2014). Potential negative impacts associated with manual / mechanical removal include disturbance as a result of access roads or paths and camps; loss of estuarine habitat if felled material is stockpiled on site, bank erosion and resultant short-term deterioration in water quality due to increases in sediment load. The use of chemical sprays in conjunction with manual / mechanical methods is often required to prevent coppicing or re-infestation by seedlings, but these should be used with caution near estuaries where non-target plant and animal species may be harmed should active chemical agents enter the estuarine water body. Guidelines for the chemical control of vegetation are provided in the EMPr (Gibb 2014). Burning of riparian vegetation can result in mortalities of biota and burning stockpiled vegetation, can cause heat scars that re-vegetate slowly and are prone to erosion. Potential negative impacts of marginal vegetation management are rated as LOW with mitigation.

Table 6. Assessment of negative impacts associated with riparian vegetation management.

	Extent	Magnitude	Duration	Probability	Status	Significance
With mitigation	Site specific	Med	Short-term	Possible	Negative	Low

Recommended mitigation measures:

- Heavily mechanised methods to remove alien vegetation e.g. bulldozers are not acceptable within the estuarine functional zone, manual methods or the use of chainsaws is appropriate.
- Limit workforce size when removing vegetation on banks or in muddy areas to reduce habitat degradation by trampling.
- Access routes should be as direct as possible, at right angles to the channel or area to be cleared.
- Stockpile cut material at least 10m from the HWM/ water edge for no longer than two weeks.
- Implement erosion control measures if bank stability is compromised by removal of marginal vegetation.
- Conduct follow up operations timeously to prevent re-infestation.
- Strictly follow EMPr guidelines for chemical control of vegetation in the estuarine functional zone.
- The replanting of cleared areas with appropriate indigenous vegetation should be considered if little indigenous vegetation remains.

4.2 Erosion control

4.2.1 Estuary bank profile enhancement

The proposed bank profile enhancement and rehabilitation of Zandvlei estuary banks in suitable candidate areas such as along the western banks between the yacht club and the estuary mouth is intended to improve the biodiversity value and increase the intertidal habitat area. The banks along of the estuary (specifically in this stretch) are currently a largely modified habitat consisting of steep, grass topped earth banks which in some cases have existing revetments that are prone to undercutting and offer little marginal habitat for estuarine biota. Bank profile enhancement and rehabilitation within the estuary will take place where erosion and artificial conditions necessitate the action and if there is sufficient area to undertake the re-profiling of the banks. The impacts associated with bank re-profiling are temporary disturbance or mortality of biota and possible short-term increases in lateral erosion of the banks and hence suspended sediments in the estuary water (increased turbidity). The loss of existing marginal vegetation (largely kikuyu grass) is not considered significant as it is of little biodiversity importance. Positive impacts from bank re-profiling and successful replanting of appropriate marginal vegetation are anticipated, including improved biodiversity value and reduced erosion of estuary banks. The negative impacts of bank profile enhancement are assessed as LOW with appropriate mitigation (Table 7).

Table 7. Assessment of negative impacts associated with bank profile enhancement.

	Extent	Magnitude	Duration	Probability	Status	Significance
With mitigation	Local	Med	Temporary	Definite	Negative	Low

Recommended mitigation measures:

- Replant modified bank with suitable, indigenous vegetation as soon as possible.
- Implement temporary erosion control measures in areas where tidal or flood water may erode banks prior to establishment of planted vegetation.
- Use manual methods to re-profile banks where possible.
- Do not undertake bank profile enhancement over the period August - December. (This period includes western leopard toad breeding and emergence, the peak bird breeding period and peak period of juvenile marine fish recruitment to estuaries.)

4.2.2 Construction, maintenance and expansion of erosion control structures

The repairs/maintenance of existing erosion control structures in the lower Zandvlei estuary are include the section between the pedestrian bridge and the mouth where the concrete canalized walls at the outlet and gabions under the bridge require periodic attention. There are also revetments located along extensive stretches of the banks of the system in both the Marina canals and the main vlei body. Maintenance of these existing structures is required to ensure that the shoreline areas, which are largely used for recreation, do not collapse into the water. These structures are already in place and constitute an artificial habitat that has little biodiversity value itself (the hard structures do provide the little available habitat for reef associated marine fish species that are not tolerant of lower salinities higher up in the estuary, but this is not a natural situation). If possible the existing revetments should be replaced with the alternative erosion control measure (bank profile enhancement) which is described in the preceding section. This approach will not be feasible in the case of the canal wall structures at the outlet through which the estuary's connection with the marine environment is maintained and through which all biota must pass when entering or leaving the system. The impacts associated with this work are limited to the maintenance phase only and include potential water quality deterioration associated with cement works, risks of pollution associated with the use of vehicles and equipment within the estuary functional zone, disturbance of biota, and increased sediment mobilization and turbidity. It is important that these repairs do not take place during the peak fish recruitment (September-December) when the estuary mouth is open i.e. Spring Tides. The negative impacts are site specific, temporary and with effective mitigation measures the assessed impact is rated as LOW (Table 8).

Table 8. Assessment of negative impacts associated with maintenance of erosion control structures in the Zandvlei estuary.

	Extent	Magnitude	Duration	Probability	Status	Significance
With mitigation	Site specific	Medium	Temporary	Definite	Negative	Low

Recommended mitigation measures:

- Do not undertake repairs during peak estuarine fish recruitment period (September- December).
- Educate construction contractors and workers as to the sensitivity of the estuary mouth region and ensure that no dumping of construction wastes into the estuary takes place.
- Maintain or reduce footprint of existing hard structures in the estuary, do no create additional barriers to the movement of biota.
- Limit construction activity to closed mouth phase where possible

4.3 Sediment management

Removal of marine sediment sandbar in lower reaches of Zandvlei As described in amended Mouth Management Plan (DEADP reference number (16/3/1/6/A6/46/2105/14).

Removal of silt from all three inflowing rivers/canals and from the depositional area in the upper region of the estuary

There are various sediment management requirements within Zandvlei. It is necessary to remove accumulated sediments deposited at the three river inflows in the north of the system and from stormwater outlets located around the system to maintain conveyance capacity. The frequency of removal is determined by the rate of deposition which could be influenced by the preceding year/s run-off and catchment activities. The latter is important since farming activities in the upper catchment are known to contribute large quantities of silt via the rivers flowing into Zandvlei from the west (i.e. Westlake and Keysers River). The sandy nature of the lower catchment area to the east means that the river flowing from the eastern side (Sand canal) potentially also contributes large amounts of sand to Zandvlei. Removal of sediment from the river inflow depositional area will be relatively infrequent (e.g. once every 10 - 15 years), and may be more frequent at the stormwater outlets (e.g. once every 2 to 5 years, but is also dependant on the preceding seasons depositional rates) The large volume of sediments to be removed from the river inflow depositional area would in most cases require mechanical removal (long arm excavator with water bucket), although the environmental impacts of manual removal are less, this is only really practical in small areas. Accumulated sediments typically have a high organic content (and potentially other more persistent inorganic contaminants such as trace metals, hydrocarbons, PCBs) and emergent vegetation (usually reeds) will have become established in these sediments. As mentioned above, the establishment of reeds and other emergent vegetation at stormwater outlets provides a valuable water filtering role and has positive impacts on estuarine water quality. Reeds and other emergent vegetation also provide valuable habitat. Removal of sediment to restore flow capacity may also require removal of the emergent vegetation “roots and all”.

In addition to removal of sediment from the above areas, it is also necessary to manage the sandbar upstream of the outlet. During periods that the mouth is open, marine sands are washed into the estuary and settle out. If the system were not already heavily altered, this sand would probably also be washed out to sea when conditions were conducive for scouring and entrainment of the settled sand. The presence of the rubble weir however results in these marine sands being trapped and thus forms a plug within the lower reaches of the estuary. It is estimated that 40 000 m^3 of sediment has accumulated since 2002 (Killick 2012). Annual accumulation is in the order of 3 000 m^3.

The practice of mouth management (i.e. removal and re-instatement of the sandbar – see section 4.9.1 “Breaching”) does not result in scouring or mobilization of these sediments and despite numerous discussions regarding mechanisms to encourage scouring no practical solutions have been found to exist. Consequently there has been a significant build-up of marine sediment and the sand plume has advanced some distance upstream (approximately 230 m over a 9 year period). This has resulted in significantly reduced water depth in the area affected by sedimentation which affects fish movement and also impacts on recreational activities. This also has a potential to increase flood risks in the surrounding residential areas. The unconsolidated nature of the sand further poses a safety risk as people may become trapped in the sand. The need for management of this sand plume was

discussed by the Zandvlei Estuary Management Forum in 2013, and accordingly the existing approved Mouth Management Plan (DEA&DP approval Ref E12/2/4/7 – A5/328 – CJ2142/11), which originally only described breaching, was amended (City of Cape Town 2014) to include management of the sand plume upstream of the outlet and resubmitted and approved by DEA&DP (DEA&DP Ref 16/3/1/6/A6/46/2105/14). The City commenced with management of the plume in 2015 as described in the amended Mouth Management Plan but, due to budget constraints, only approximately 5% of the extent of the plume has been removed. The original approval was granted for a 5 year period which has lapsed. The City would like to receive renewal of the approval in order to continue with management of the sand plume and has opted to address this as part of the current overall Basic Assessment amendment application.

The impacts associated with sediment removal from depositional areas include temporary loss of habitat and biota (associated with sediment and emergent vegetation removal as well as access to the site), and mobilization of silt, organic matter and other contaminants that can contribute to eutrophication or pollution of the estuary water body. The negative impacts associated with emergent vegetation removal which may take place as a consequence of sediment management have already been assessed in Table 5.

These impacts are local, but of high intensity and are rated as MEDIUM without and LOW with effective mitigation that includes defining a "designated sediment removal area" and depth of sediment removal at river entrances to the estuary (Table 9). Removal of the sand plume located upstream of the outlet should be undertaken in terms of the methodology described in the amended Zandvlei Mouth Management Plan (2014).

Table 9.Assessment of negative impacts associated with sediment removal at river inlets and stormwater outlets to the Zandvlei estuary.

	Extent	Magnitude	Duration	Probability	Status	Significance
With mitigation	Site specific	Medium	Short term	Definite	Negative	Low

Recommended mitigation measures:

- Spatially define limits of sediment removal area, as a guideline removal of sediment within a radius of 20m of storm water outlets is appropriate, but at river inlets to the estuary, the "designated sediment removal area" should be defined, mapped and approved by the CCT environmental team.
- To avoid over-excavation and creation of artificial channels, install permanent, marked stakes to indicate the appropriate depth to which sediments should be removed.
- Access routes for machinery to be constructed at right angles to the water body. Access routes that will be used repeatedly should be permanent and maintained.
- Designate temporary sediment storage areas for dewatering of sediments at least 5m from the estuary water edge. Truck access roads should only extend to temporary storage areas.
- Remove stockpiled sediment within two weeks of completion of the operation.
- If contamination is suspected (e.g. trace metals, hydrocarbons), test dredged sediments to inform appropriate disposal, if testing is not possible, assume contamination and dispose of in an appropriate licensed waste landfill site.
- To minimise the duration and extent of disturbance to the estuary water body, start upstream and work downstream, preferably during the dry period when the mouth is closed and tidal currents are not present.
- Avoid sediment removal during peak fish recruitment period (September-December).
- Rehabilitate access routes prior to winter.
- Cover trucks transporting sediment form the site.
- Minimise frequency of sediment removal (bi-annual or longer if possible) to allow recovery of emergent vegetation that has positive effects on water quality.

4.4 Channel enclosure

This maintenance measure is not required in Zandvlei estuary.

4.5 Litter and debris management

4.5.1 Litter and debris removal using either mechanical or manual methods.

Impacts associated with litter and debris removal is intentionally positive. Due to the generally dispersed nature of litter items, most litter clean-up is manual and has negligible negative environmental impacts. Damage to estuary banks and marginal vegetation can, however occur where litter is removed and stockpiled, whilst the process of clearing storm water pipes or litter traps and transporting litter away from the collection point can mobilize trapped litter that then enters the estuary water body and is further dispersed by flow, tidal currents or wind. Litter, particularly plastic, released into an estuary can be widely distributed in the marine environment (regional scale impact) where it poses a serious threat to marine life that mistakenly ingests such material leading to fatalities. The estuary is the "last stop" en route to the broader marine environment and special care must be taken to effectively collect and dispose of litter. These potential negative impacts can be effectively mitigated and the negative impacts of litter and debris management is rated as VERY LOW without, and INSIGNIFICANT with mitigation.

Table 10. Assessment of impacts associated with litter and debris removal in the Zandvlei estuary.

	Extent	Magnitude	Duration	Probability	Status	Significance
With mitigation	Site specific	Medium	Temporary	Definite	Negative	Low
Recommended mitigation measures: • Clear in a downstream direction. • Install temporary nets below litter traps and across pipes or outlets when cleaning to catch any dislodged litter or debris. • Avoid temporary stockpiling of litter, if necessary locate above tidal inundation area, cover to avoid redistribution and remove with 2 says of completion of the cleaning operation. • Cover trucks used to transport litter or rubble to disposal facility.						

4.5.2 Construction, maintenance and expansion of litter management infrastructure

Construction of new litter management infrastructure will have long-term positive impacts in reducing the solid waste pollution load on the estuary and the broader marine environment. Installation of infrastructure can have temporary, negative water quality and sediment impacts. Within Zandvlei estuary, the CCT intends to repair the existing litter trap at the Sand River inflow and install new litter traps on stormwater outlets and or inflowing rivers as required. These repairs and new installations will require the use of concrete and the General Specifications in the EMPr must be adhered to, with emphasis on the section detailing best management practice for concrete batching. The negative impacts associated with construction and maintenance of litter infrastructure are assessed as LOW significance with effective mitigation.

Table 11 Assessment of negative impacts associated with the construction and maintenance of litter traps.

	Extent	Magnitude	Duration	Probability	Status	Significance
With mitigation	Site specific	Low	Temporary	Definite	Negative	Low

Recommended mitigation measures:

- Adhere to General Specifications as described in EMPr (particularly concrete batching).
- In the upper estuary (above yacht club), do not undertake construction during Western Leopard Toad breeding period (August - September), and in the lower estuary (below yacht club) avoid peak estuarine fish recruitment period (September-December).
- Limit construction activity to closed mouth phase where possible.
- Consider rehabilitation of areas impacted by construction activities.

4.6 Construction, maintenance and expansion of minor stormwater infrastructure

A properly functioning stormwater system reduces erosion and deposition in natural waterbodies downstream. Negative impacts on the estuarine environment associated with the repair and maintenance of minor stormwater infrastructure are largely confined to the construction phase when the use of machinery and cement can have negative sediment and water quality impacts and temporary, localised disturbance of estuarine biota may occur. Localised losses of marginal habitat will happen with the construction of new stormwater infrastructure and ongoing negative impacts on estuary water and sediment quality could occur especially if the new stormwater outlets drain polluted areas. Negative impacts associated with maintenance and repair of existing stormwater infrastructure are assessed as VERY LOW with mitigation that is applicable to all use of machinery or construction activities within the estuarine functional zone (Table 12). Potential negative impacts due to the installation of new storm water infrastructure are permanent and are assessed as LOW significance with mitigation (Table 13). The use of Sustainable Drainage Systems (SuDS) measures to ensure that stormwater quality and quantity are managed in a manner that minimises the potential impact on the receiving estuarine environment is recommended.

Table 12. Assessment of impacts associated with the maintenance and repair of minor stormwater infrastructure in the Zandvlei estuary.

	Extent	Magnitude	Duration	Probability	Status	Significance
With mitigation	Site specific	Low	Short term	Definite	Negative	Very Low

Recommended mitigation measures:

- Adhere to General Specifications as described in EMPr (particularly concrete batching).
- In the upper estuary (above yacht club), do not undertake construction during Western Leopard Toad breeding period (August - September), and in the lower estuary (below yacht club) avoid peak estuarine fish recruitment period (September-December).
- Limit construction activity to closed mouth phase where possible.
- Consider rehabilitation of areas impacted by construction activities.

Table 13. Assessment of impacts associated with construction of new minor stormwater infrastructure in the Zandvlei estuary.

	Extent	Magnitude	Duration	Probability	Status	Significance
With mitigation	Site specific	Low	Short term	Definite	Negative	Very Low

Recommended mitigation measures:

- Adhere to General Specifications as described in EMPr (particularly concrete batching).
- Do not undertake construction during Western Leopard Toad breeding period (August - December), this will also avoid the peak estuarine fish recruitment period (September- December).
- Limit construction activity to closed mouth phase where possible.
- Consider rehabilitation of areas impacted by construction activities.
- Avoid creating hard structures in the estuary channel; do no create additional barriers to the movement of biota.

4.7 Maintenance of attenuation infrastructure:

Flood attenuation infrastructure such as weirs, retention / detention ponds and dams, floor protection, embankments/ berms, and other dams/ ponds are not presently required in Zandvlei estuary.

4.8 Recreational access: construction, maintenance and expansion of footbridges, boardwalks or bird hides

The construction of recreational access infrastructure has a positive impact of directing pedestrian and light traffic to formalised crossings, controlling damage to estuary bed and banks. Construction of this infrastructure also however, causes a localised loss of habitat within the development footprint, whilst potential construction phase impacts are the same as for other construction activities within the estuarine functional zone (i.e. temporary disturbance and possible pollution from construction materials and use of machinery). Access infrastructure around estuaries should as far as possible not take place within the intertidal area (bird hides and access boardwalks may be the exception) and should be set back at least 5m from the high water mark to allow a natural vegetation buffer between the estuary water body and the structure. Negative impacts of recreational access infrastructure construction and maintenance are assessed as LOW significance without, and VERY LOW significance with mitigation.

Table 14. Assessment of impacts associated with the construction and maintenance of recreational access infrastructure in the Zandvlei estuary.

	Extent	Magnitude	Duration	Probability	Status	Significance
With mitigation	Local	Low	Temporary	Definite	Negative	Very Low

Recommended mitigation measures:

- Do not construct infrastructure below the High Water Mark and allow a setback of at least 5m from the estuary water edge.
- Avoid peak bird and Western Leopard Toad breeding periods (August – December).
- Where possible, use manual methods to carry materials onto site using existing access routes/paths.

4.9 Management of river / estuary mouth

4.9.1 Breaching

Artificial breaching of the Zandvlei estuary which involves both the periodic opening and closure of the mouth by removing or re-instating a sand bar across the mouth is required as the estuary and its catchment have been altered by anthropogenic activities. The construction of a rubble weir in the 1950's has altered the hydrological functioning of the Zandvlei estuary. The rubble weir inhibits the natural breaching of the estuary and has contributed to the formation of a sand bar in the estuary mouth. The porous rubble weir which is located downstream of Royal Road bridge cannot be completely removed as it serves as protection (from scour damage that could occur when the mouth is open) of the gravity sewer line which crosses the outlet just upstream of the bridge.

Managing the mouth of the Zandvlei estuary is undertaken as a routine maintenance and management measure in order to meet and balance different objectives, including protecting a sewage pipeline which traverses the base of the estuary near the mouth, allowing recreational activities to occur in the estuary as well as protecting lower lying buildings from potential flood damage. These largely human requirements are also balanced with the need to ensure the system maintains estuarine characteristics such as saline influence and facilitating the movement of estuarine species into and out of the system. This is the only estuary in Cape Town where such breaching takes place on a regular basis, and hence a substantial body of knowledge in support of this process has built up over the years.

Management of the Zandvlei mouth is informed by the existing protocols described in the City's Zandvlei Estuary Mouth Management Plan (City of Cape Town as amended, 2014). The provincial Department of Environmental Affairs and Development Planning (DEA&DP) approved the protocol for a period of 5 years which as now lapsed. As the need for management of the mouth in the described manner has not changed, and the established operational methodology will continue to be utilised, the City must request renewal of the existing protocol but has opted to incorporate the activity within this overall amendment application for authorisation of all the applicable maintenance activities within the estuary.

The methodology used for breaching the estuary mouth extracted from the existing protocol and impacts of thereof are summarised below.

At the beginning of winter before the onset of winter rains the mouth is artificially breached (sand bar removed), it usually remains open thereafter throughout winter unless it is an exceptionally dry winter. If the mouth closes again during the winter period due to a sand bar developing through wind/wave action it must be removed in order to avoid flooding.

During the summer the sand bar in the river mouth is opened approximately five days before a spring tide and closed after the spring high tide or approximately 1 day later. Breaching during a spring high tide of 1.7m allows a strong saline inflow. The mouth is breached 5-6 times during the summer and occasionally during winter in response to unseasonal storms or planned water sporting events. The mouth management regime of the Zandvlei was revised in 2001 to its current form. One of the drivers for the revised management measures for Zandvlei were concerns over a decrease in salinity in the estuary.

The rubble weir will remain at 0.4 mASL which is the level it was lowered to in 2014, unless raising it on a temporary basis to 0.6 mASL is specifically requested for sailing events. The porous rubble weir which is located downstream of Royal Road bridge cannot be completely removed as it serves as protection (from scour damage that could occur when the mouth is open) of the gravity sewer line which crosses the outlet just upstream of the bridge.

The approach balances the often conflicting environmental and social (flooding and recreation) issues and represents the best attainable scenario under these constraints.

A number of positive social and ecological impacts are associated with the breaching (periodic opening and closure) of the Zandvlei estuary in terms of the established methodology described in the existing Zandvlei Mouth Management Plan (City of Cape Town 2014). For example the installation of the rubble weir has limited the ingress of sea water into the estuary which has resulted in halotolerant vegetation species being replaced by freshwater species. Breaching of the estuary and maintaining the rubble weir at 0.4 mASL (when undertaken in line with the mitigation measures listed below) can result in improved salinity in the estuary and also facilitate fish recruitment into the estuary. An assessment of the risks, threats and opportunities associated with management of the mouth of Zandvlei is included in section 3 of the City's existing Mouth Management Plan.

The impacts associated with artificial breaching of the Zandvlei estuary mouth are rated overall as having a positive LOW significance.

Table 15. Assessment of impacts associated with breaching of the Zandvlei River mouth.

	Extent	Magnitude	Duration	Probability	Status	Significance
With mitigation	Local	Medium	Long term	Definite	Positive	Low

Recommended mitigation measures:

- The breaching process which involves opening and closure of the mouth of Zandvlei by removing and re-instatement of the sandbar should follow the established methodology in the City's existing Mouth Management Plan (2014), summarised briefly below:
- Maintain the rubble weir at 0.4 mASL unless raising it on a temporary basis to 0.6 mASL is specifically requested for sailing events.
- Breaching should be timed so that the estuary is open for as long as possible (usually 7- 14 days per month) during August/ September to November. This is to allow fish migration during fish recruitment periods.
- During summer breaching should occur during spring tides that are preferably over 1.7 m. This will maximise saline inflows.
- Breaching of the mouth outside spring high tides should only be permitted when water levels are too high (in excess of 1.0 aMSL for long periods) which can result in flooding and damage to infrastructure.
- Minimise the use of earth moving equipment above the high tide level, use the most direct route to the intertidal and avoid dunes and vegetation.
- Use the existing access route described in the Mouth Management Plan and minimise the impact footprint on the intertidal.

4.9.2 Straightening of estuary mouth

Not required as the mouth of the Zandvlei is contained by concrete walls.

4.10 CONCLUSION

The maintenance measures required for Zandvlei estuary all seek to improve the functioning of the City's stormwater system and to minimise any negative impacts on the environment (most

interventions are intended to have positive impacts). Effective mitigation is available for all proposed maintenance activities and all negative impacts are assessed as being at most of LOW significance.

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