GARDEN ROUTE BOTANICAL GARDEN - DAM MAINTENANCE MANAGEMENT PLAN

Rehabilitation of flood damage to the George Botanical Garden dam wall: Aquatic specialist inputs & Environmental Control

Prepared for SMEC (Project C1945) and the George

Municipality by

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DECLARATION OF SPECIALIST INDEPENDANCE

I consider myself bound to the rules and ethics of the South African Council for Natural Scientific Professions (SACNASP);

• At the time of conducting the study and compiling this report I did not have any interest, hidden or otherwise, in the proposed development that this study has reference to, except for financial compensation for work done in a professional capacity;

• Work performed for this study was done in an objective manner. Even if this study results in views and findings that are not favourable to the client/applicant, I will not be affected in any manner by the outcome of any environmental process of which this report may form a part, other than being members of the general public;

• I declare that there are no circumstances that may compromise my objectivity in performing this specialist investigation. I do not necessarily object to or endorse any proposed developments, but aim to present facts, findings and recommendations based on relevant professional experience and scientific data;

• I do not have any influence over decisions made by the governing authorities;

• I undertake to disclose all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by a competent authority to such a relevant authority and the applicant;

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• All the particulars furnished by me in this document are true and correct.

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Expertise: > 10 years' experience working on aquatic ecosystems across South Africa, with a focus on the Southern Cape in the last 3 years. Includes research and consulting expertise, having published > 10 water-related research articles and compiled > 80 aquatic specialist reports. Research and consulting have been in a range of sectors including agriculture, urban developments, linear structures, renewable energy, conservation, and mining.

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1. INTRODUCTION

Confluent Environmental (Pty) Ltd assisted by CapeEAPrac to provide aquatic specialist inputs to the rehabilitation of the Botanical Gardens Dam Wall. The dam is one of two original dams that provided drinking water for the town of George via a furrow system. The Botanical Gardens is managed by the Garden Route Botanical Garden Private Trust (GRBG Trust) under an MoU with the George Local Municipality's Parks and Recreation Department.

The dam is one of the largest features of the Botanical Gardens and a walkway circumnavigates the open water on the crest of the dam wall which allows visitors spectacular scenic views. The area is surrounded by a diverse variety of indigenous plants from the area. A smaller dam which functions more as a wetland is located to the north-west of the dam (Figure 1).

Over time the dam wall has weakened due to wave action and plant growth along the wall, and the situation was exacerbated during a major rainfall event in November 2021 which caused widespread flooding throughout George.

The aquatic assessment relied on method statements and design details provided by the contracted engineer in the report "Rehabilitation of Dam Wall in the Garden Route Botanical Gardens, George" (SMEC, 2023).

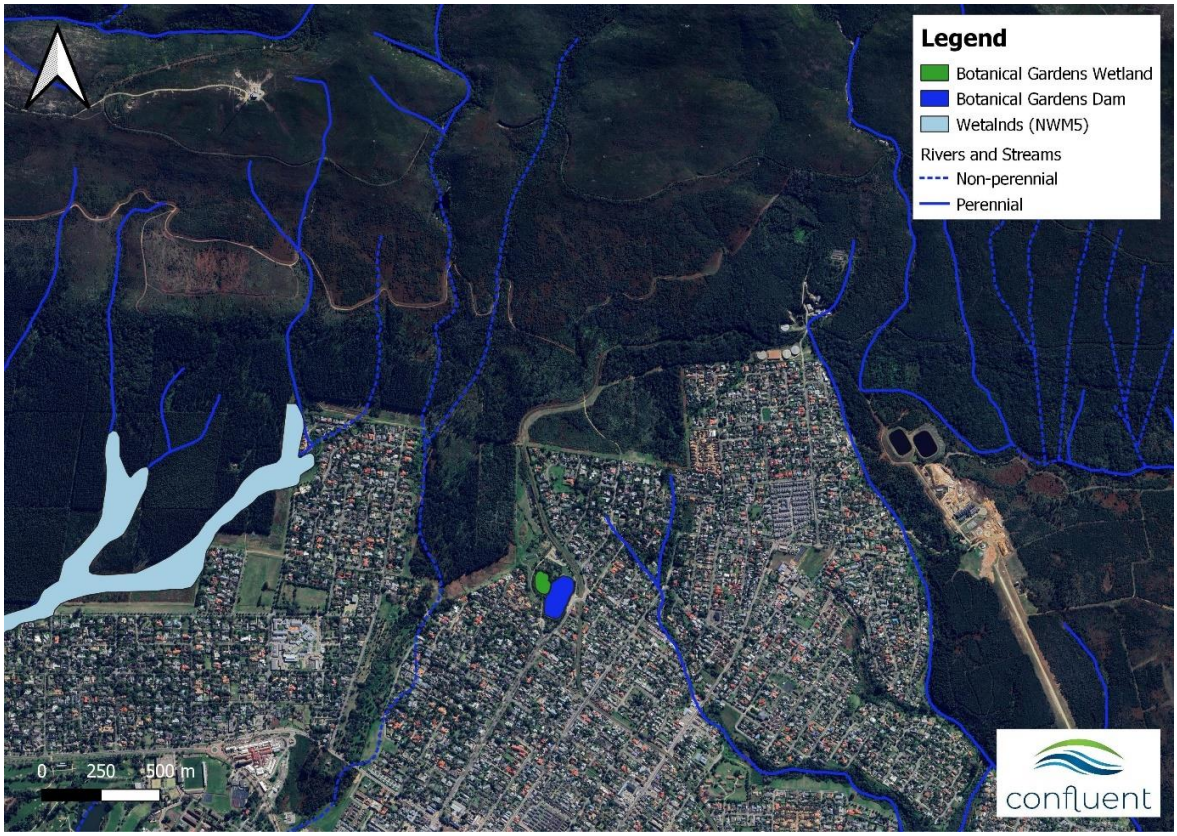


Figure 1. Location of the Botanical Gardens Dam and Wetland in relation to mapped watercourses. Both the dam and wetland are artificial, having been excavated to provide George with water over a century ago.

1.1 Problem Statement

The upstream slope of the wall has eroded on the eastern, western, and southern embankments over time. Large and medium trees and vegetation have been allowed to grow into the dam wall, which have undermined its stability (SMEC, 2023; Figure 2). The overflow has been non-operational leading to higher water levels than the safe operating level, increasing the risk of further erosion. A section of walkway was recently closed due to erosion encroachments and undermining. Rehabilitation and maintenance of the dam is therefore urgently required to prevent a total collapse of the dam wall which could cause extensive damage in parts of the suburb of Camphersdrift.

Figure 2. Image of eroding dam wall along the walkway (SMEC, 2023).

1.2 Proposed Dam Maintenance

The SMEC report provides detailed design and methods for rehabilitation and maintenance of the dam (SMEC, 2023). A cross section of the proposed rehabilitation of the upstream embankments is provided in Figure 3 which depicts a relatively flat slope of 1:3.5. The aim of is to improve stability, reduce erosion, increase safety during maintenance work, and reduce the risk of foundation conditions that are difficult to detect. The proposed rehabilitation measures would result in the Full Supply Capacity of the dam reducing from 27 818 m^3 to 20 412 m^3.

The maintenance work comprises the following:

- Remove trees from the embankment. Relevant permits for the removal of trees will be obtained where protected trees such as yellowwoods are present.
- Dewater the entire dam to gain access to the inner dam wall for slope rehabilitation. A portion of the wall excavations may be stored inside the dam basin for reuse in a temporary coffer dam (pond).
- Clear and grub the remainder of the trees and vegetation inside the work area.

- Construct a temporary coffer dam inside the existing basin during the construction phase. This can be used to house any sensitive vegetation, amphibians or fish displaced during the construction works.
- Remove silt and unsuitable fill material to a location provided by the GRBG Trust. A portion may be retained to create an artificial island in the dam. Dependent on budget.
- Construct new dam wall embankment on upstream slope. Infill of the eroded sections with suitable material obtained from an approved material source. Reconstruction of the upstream slope embankment to a 1:3.5 slope.
- Installing erosion protection using a range of different grass / vegetation mixes on the upstream slope which will also form part of a study to determine the best vegetation characteristics for erosion protection on earth fill dam embankments.
- Construction of new spillway at the location of existing overflow pipes which discharge into an existing open channel connecting to the stormwater system in Caledon Street (Figure 4).
- Assess existing bottom pipe outlet and make recommendations on suitable rehabilitation options to permanently decommission the bottom outlets.
- Conduct repairs on the existing walkway surface.

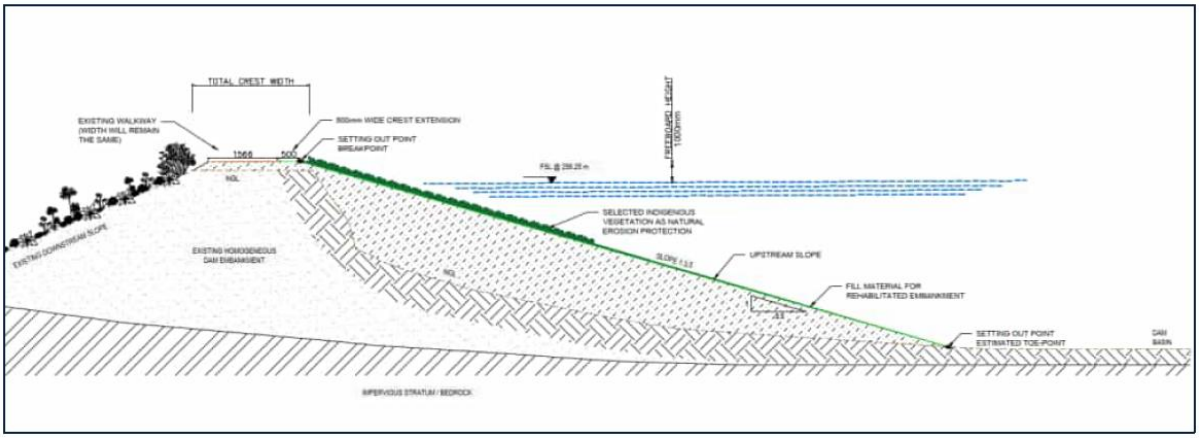


Figure 3. Cross section of the new proposed upstream embankment (SMEC, 2023).

The maintenance work that is required on the dam requires prior Environmental Authorisation (EA) for the following 'listed activities' under the National Environmenta Management Act (NEMA): **Listing 1, Activity 19** for work that is to be undertaken within a watercourse or within 32m from the edge of a watercourse and **Listing Notice 3, Activity 12** for the removal of more than 300 square metres of indigenous vegetation. The exception is for maintenance activities that are undertaken in terms of an adopted Environmental Maintenance Management Plan (EMMP).

Figure 4. Surveyed layout of the dam relative to surrounding area indicating location of the existing spillway to be upgraded (SMEC, 2023).

1.3 Scope of Work

The proposed works are to be undertaken in a Protected Area in terms of the National Environmental Management Protected Areas Act (NEMPAA), in terms of the National Environmental Management Act (NEMA) for an offstream dam which is not defined as a watercourse in terms of the National Water Act (NWA; Act No. 36 of 1998) as no natural inflow or outflow occurs. The dam is however, located adjacent the artificial but functional wetland where a population of *Afrixalus knysnae* (Knysna leaf-folding frogs) are known to occur. As this species is Red Listed as Endangered, it is necessary that care be taken to ensure the wetland habitat and frog population is protected during the construction and operational phases of the dam repair. The regulated area of a wetland is defined as 500 m from the edge, and therefore the proposed rehabilitation works will be undertaken in the regulated area. The proposed work constitutes a water use in terms of Section 21 defined as:

S21 c) Impeding or diverting the flow of water in a watercourse; and

S21 i) Altering the bed, banks, course or characteristics of a watercourse.

According to GN509 a Risk Matrix to determine the risk of conducting the work in its mitigated state must be compiled by a SACNASP-registered aquatic scientist. Mitigation measures will be provided to reduce the impacts to water quality and aquatic biota, as well as for rehabilitation of the aquatic environment post-construction.

This will include interrogation of available desktop resources including:

- DWS spatial layers (1:50 000 rivers)
- National Wetland Map 5 and Confidence Map (CSIR, 2018)

- Engineering plans and designs
- Proposed construction method statement
- Western Cape Biodiversity Spatial Plan (WCBSP, 2017)

A site visit was conducted to determine:

- Sensitivity of the dam to proposed construction works
- Determine furrow route and key diversion / control points diverting water from natural watercourses into dams at the botanical gardens
- Conduct a survey of the dominant fish species present in the dam

A report compiled to:

- Incorporate findings of the desktop and site assessment in a Maintenance Management Plan including a Risk Matrix with control measures aimed at minimising disturbance and impacts to the aquatic environment.

1.4 Exclusions and Limitations

- Two site assessments were undertaken in February and March which is late summer. This season is considered acceptable to determine the dominant aquatic plant species and biota present and potentially impacted by dam repair works.
- The level of risk assigned to this assessment assumes that plans and method statements are implemented as indicated in various reports, and that all mitigation measures described in this report are fully implemented.
- The fishing methods used limited collection to smaller species and juvenile fish in the shallower, littoral (side) portion of the dam to a depth of approximately 1.5 m. Larger fish are definitely in the deeper part of the dam as they are often at the water surface. The aim of monitoring however was to determine if any fish species indigenous to the area were present in the dam, and the methods used are suitable for this purpose.

2. DESKTOP SURVEY

2.1 Site description

The dam is located on the catchment divide between quaternary catchment K30B to the west and K30C to the east. Mean annual rainfall averages 787mm which is relatively high for South Africa, and the rainfall intensity is mapped as ‘Very High’. The dam is an artificial off-channel impoundment with a furrow as the water source. The outlet flows into an earthen channel which connects to a stormwater drain.

The dam is an earth-fill dam that was constructed with a cut-to-fill method. The smaller dam located to the north-west functions more as a wetland with extensive macrophytes and wetland vegetation covering most of the water surface. Known as the O-dam, this feature is rich in bird and amphibian life and has a population of Knysna Leaf-folding Frogs (*Afrixalus knysnae;* Red List = Endangered). The water source for this dam is the same furrow as the main dam.

Table 1. Summary of relevant catchment features for the proposed development area.

Feature	Description
Quaternary catchment	K30B and K30C
Mean Annual Runoff	300 mm
Mean Annual Precipitation	787 mm
Inherent erosion potential of soils (K-factor)	0.74, Very High
Rainfall intensity	Very High
Ecoregion Level II	22.02, Southern coastal belt
Mapped Vegetation Type	FFh9: Garden Route Shale Fynbos (Critically Endangered)
Conservation	Garden Route Biosphere Reserve Van Kervel Nature Reserve

2.2 Historical Assessment

The furrow system was established in the 1800s, and the dam and wetland are clearly visible on an aerial photo from 1936 (Figure 5). At that time land use in the surrounding area was largely agricultural fields. It is not known whether any historical maintenance has been necessary on the dam before the present work proposed.

Figure 5. Historical aerial photo of the dam and wetland in 1936.

3. SITE VISIT

The site was visited twice in February and March 2023. The first site visit included a walk around of the dam wall with the consulting engineer to better understand the proposed maintenance. The second site was undertaken to survey fish in the dam and identify key points along the furrow and how the furrow is operated.

3.1 Environmental Conditions

While no formal method exists to determine the Present Ecological State of a dam, basic descriptors of the water quality, biota and habitat are presented in this section and that on fish.

3.1.1 Vegetation

Water levels in the dam have presently been drawn down substantially and no inflow from the furrow has been directed into the dam for many months. This is to reduce the risk of further erosion and collapse of the wall. The drawn down area has resulted in the expansion of an existing area of littoral vegetation dominated by hydrophilic plant species typically associated with seasonal and temporary wetland areas. This area occurs to the north of the dam where no embankment is present and a gentle gradient leads into the dam (Figure 4 and Figure 6).

Figure 6. Northern shoreline showing extensive cover with hydrophilic vegetation.

These species are indicated in Table 2 which includes information on the species suitability for use in revegetating exposed soil on the instream embankment at conclusion of the works. Water levels in a dam fluctuate, influencing the degree to which soil is saturated, which in turn dictates the plants species suitable for revegetation. They must either be adapted to permanent saturation, periodic saturation, or dry conditions. In the context of the dam this can be classified as the low, mid, and high water zones. The high-water zone would be above the dam's full supply level (FSL) and would only ever be saturated briefly up to the freeboard level (1m) and to a minimal extent as water levels reduce via the spillway. Icons used by van Ginkel and Cilliers (2020) to categorise plants based on soil saturation preferences can be used as a guide for replanting and bank stabilisation in different soil saturation zones around the dam (Figure 7).

Suitability for planting on the dam embankment for stabilisation is indicated in Table 2. Only five of the species are not recommended for the dam wall as they can grow up to 3m, but these could be planted in the northern area of the dam which has no embankment.

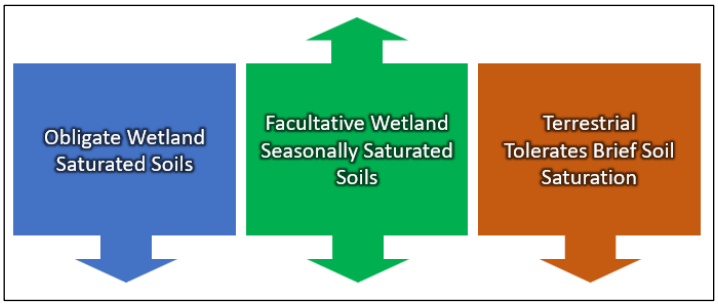
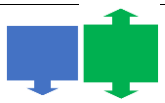
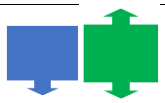
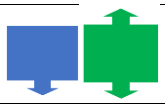


Figure 7. Icons indicating soil saturation categories for different plants.

Table 2. Indigenous plant species in the littoral zone of the dam that can be rescued, cultivated or introduced for revegetation post-construction.

Species	Common name	Suitable for use in rehabilitation	Soil saturation	Suitable for Dam Wall
Persicaria decipiens	Slender knotweed	Yes. Replant in a species mix.		✓
Axonopus fissifolius	Carpet grass	Yes. Plant in a species mix.		✓
Cliffortia odorata	Wild vine	Yes. Replant in a species mix.		X
Prionium serratum	Palmiet	Yes. Excellent bank stabilisation in clumps.		X
Wachendorfia thyrsiflora	Blood root	Yes. Plant in clumps.		✓
Typha capensis	Bulrushes	Yes. Plan in a few isolated clumps as can take over.		✓
Falkia repens	n/a	Yes. Mat-forming. Plant in species mix.		✓
Helichyrsum cymosum	Fume everlasting	Yes. Spreads well. Plant in species mix.		✓
Elegia capensis	Horsetail restio	Yes. Plant in a clump or in a species mix.		X
Psoralea affinis	Fountain bush	Yes. Plant in species mix.		X
Juncus lomatophyllus	Creeping rush	Yes. Plant in clumps around water's edge.		✓
Laurembergia repens	n/a	Yes. Plant in a species mix.		✓
Cliffortia strobilifera	n/a	Yes. Plant in a mix or in clumps.		X

Isolepis prolifera	n/a	Yes. Plant in a mix or in clumps.		✓
				✓
Juncus oxycarpus	n/a	Yes. Plant in clumps.		✓
Eleocharis dregeana	Finger sedge	Yes. Plant in clumps or in a mix.		✓
Aquatic macrophytes				
Nymphaea nouchali	Blue waterlily	Yes. Plant in open water in clumps.		n/a
Aponogeton distachyos	Waterblommetjie	Yes. Plant in open water in clumps		n/a
Nymphoides thunbergiana	Yellow floating heart	Yes. Plant in open water in clumps		n/a

Basic physico-chemical parameters were measured *in situ* using a handheld multiparameter water quality meter. These results are as follows:

Table 3. Basic physico-chemistry of water measured in the dam.

pH	Temperature	Dissolved O2	Electrical Conductivity	Total Dissolved Salts	Clarity
6.5	20.1 °C	6.09 mg/L	143 µS/cm	72 mg/L	14 cm

Water quality in the dam is of a high standard as it comes from a mountain stream with minimal land use impacts. This is reflected in the low Electrical Conductivity reading (Table 3). However, turbidity of the water is very high as indicated by the low clarity reading of 14 cm. Unimpacted waters are usually in the range of 40 – 60 cm even in tannin-stained waters. The high turbidity is likely due to the presence of large carp (*Cyprinius carpio*) and koi (ornamental) carp in the dam which are known to forage aggressively in bottom sediments resulting in their continual resuspension, as well as uprooting aquatic plants limiting their establishment.

Figure 8. Photo of the dam clearly showing the high level of turbidity (suspended sediment leading to low clarity result).

3.2 Furrow Layout and Operation

The furrow is a historical water transfer system that used to supply the town of George as early as 1812. Water diverted from an unnamed stream supplies the dam, wetland and coffer dam and flows from the southern slopes of the Outeniqua Mountains upslope from the botanical gardens. An open piped diversion transfers water from the stream to the earth furrow. The pipe is unscreened and located on the side of the stream where it abstracts approximately 20% of the stream flow when open. Most flow bypasses the furrow and remains in the natural watercourse. The offtake point is operated by opening and closing a valve located on the pipe on the inside of the botanical gardens. Water is only abstracted from the stream (at a low rate) when required to fill the coffer dam or filling the dam or wetland area. Closer to the dam the water can be diverted to either the dam or the wetland. Water from the coffer dam is used to irrigate the gardens, nursery and propagation yard. The furrow system provides a mechanism of transferring aquatic biota from the natural stream into aquatic features in the botanical gardens (Figure 9).

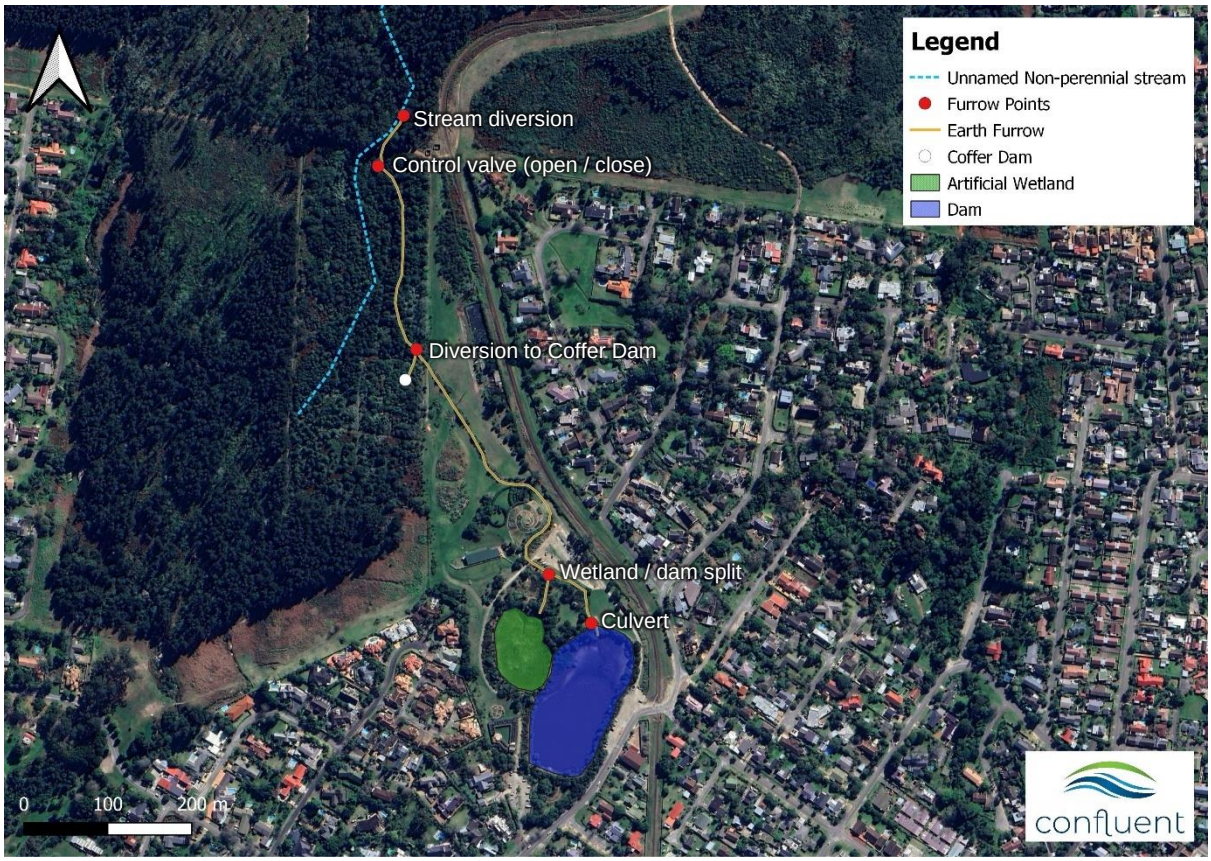


Figure 9. Layout of the furrow which diverts water from a non-perennial stream into the dam, wetland and a small coffer dam used for irrigation in the botanical gardens. Points along the furrow are labelled.

Figure 10. Photos of key operational points and features along the furrow supplying water to the botanical gardens dam mapped in Figure 9.

3.3 Fish Survey

Fish in the dam were surveyed on 27 March 2023. A combination of electrofishing and seine netting were used to collect fish. The dam still had an expanse of open, deeper water, allowing larger fish to retreat to this part of the dam. Therefore, fish identification was mainly from small to medium fish as no large fish were caught during the survey.

3.3.1 Methods

Electro Fishing

A SAMUS 725M electro shocking device was used to sample littoral margins of the dam and, where possible up to 1.5 m depth into the dam basin. An electro-shocker passes an electric current between two electrodes placed in the water, and stunned fish are caught with a scoop net. Fish are kept in a bucket of water until sampling is completed. The fish were then identified and released back into the dam.

Seine Netting

Seine nets trap fish by enclosing or encircling them. The bottom or 'lead line' of the net has lead weights strung into it to weigh the net down. The top or 'float line' includes cork, polystyrene or plastic floats to keep the top of the net on the surface. As the net is pulled through the water, fish are herded towards the centre and into a bag. Seine netting is an effective method of collecting small-sized fish; but its use is limited to areas where there are no submerged snags and flow is slow.

3.3.2 Results

The most abundant fish in the dam were *Gambusia affinis* (Mosquito fish) and *Lepomis macrochirus* (Bluegill sunfish). Both species have been introduced to South Africa from North America and are listed as Category 1b by NEMBA (Table 4 and Table 5). Activities for these fish species are restricted as indicated in Table 5. A person may not facilitate or encourage the species to multiply, they may not be translocated, sold, traded or donated. Two fish species indigenous to South Africa, but not to the Western Cape were recorded in the dam. These were *Tilapia sparrmanii* and *Oreochromis mossambicus*. Both species have been translocated to river systems beyond their native range, and *O. mossambicus* is listed as Vulnerable due to hybridisation with introduced *Oreochromis niloticus* (not observed in the dam) in their native river systems. Both species are listed as Category 3 which carries similar restrictions to Category 1b.

Figure 11. Fish species collected during electrofishing and seine netting surveys.

While carp were not collected using the fishing methods in this survey, at least 10 observations of large *Cyprinus carpio* have been made by users of the iNaturalist platform. They were also observed swimming at the surface in the deepest part of the dam during surveys for this assessment. Common carp as well as koi-carp are present.

Table 4. Fish species sampled in the botanical gardens dam in order of abundance.

Scientific Name	Common Name	IUCN Red List Status	Indigenous / Alien	NEMBA Category *
Gambusia affinis (Baird & Girard, 1853)	Mosquitofish	Least Concern	**Alien** Origin: North America	Category **1b** in reserves declared in terms of the Protected Areas Act
Lepomis macrochirus (Rafinesque, 1819)	Bluegill sunfish	Least Concern	**Alien** Origin: North America	Category **1b** in reserves declared in terms of the Protected Areas Act
Tilapia sparmannii (Smith, 1840)	Banded tilapia	Least Concern	**Indigenous** to Orange River and KZN rivers. **Translocated to WC**.	Category **3**
Oreochromis mossambicus (Peters, 1852)	Mozambique tilapia	Vulnerable (decreasing due to hybridisation with Nile tilapia)	**Indigenous** SA occurring southwards to the Bushmans River in EC, and north into KZN and the Limpopo system. **Translocated to WC.**	Hybrids of *O. mossambicus* considered as listed tilapia species (Category **3**)
Cyprinus carpio (Linnaeus, 1758)	Eurasian carp	Vulnerable in native range (Europe).	**Alien.** Origin: England, introduced in the 18th century	Category **1b** in reserves declared in terms of the Protected Areas Act

* NEMBA refers to the National Environmental Management: Biodiversity Act, 2004. Alien and invasive species lists, 2020. Read in conjunction with 5.

Table 5. Restricted activities associated with categories assigned to Invasive species (NEMBA, 2020)

Restricted Activities as defined in the Act	Category 1a	Category 1b	Category 2	Category 3
a. Importing into the Republic, including introducing from the sea, any specimen of a listed invasive species.	Prohibited	Prohibited	Permit Required	Prohibited
b. Having in possession or exercising physical control over any specimen of a listed invasive species.	Exempted	Exempted	Permit Required	Exempted
c. Growing, breeding or in any other way propagating any specimen of a listed invasive species, or causing it to multiply.	Prohibited	Prohibited	Permit Required	Prohibited
d. Conveying, moving or otherwise translocating any specimen of a listed invasive species.	Prohibited	Prohibited	Permit Required	Prohibited
e. Selling or otherwise trading in, buying, receiving, giving, donating or accepting as a gift, or in any way acquiring or disposing of any specimen of a listed invasive species.	Prohibited	Prohibited	Permit Required	Prohibited
Restricted Activities as defined in Regulation 6				
f. Spreading or allowing the spread of any specimen of a listed invasive species.	Prohibited	Prohibited	Permit Required	Prohibited
g. Releasing any specimen of a listed invasive species.	Prohibited	Prohibited	Permit Required	Prohibited
h. The transfer or release of a specimen of a listed invasive fresh-water species from one discrete catchment system in which it occurs, to another discrete catchment system in which it does not occur; or, from within a part of a discrete catchment system where it does occur to another part where it does not occur as a result of a natural or artificial barrier.	Prohibited	Prohibited	Permit Required	Prohibited
i. Discharging of or disposing into any waterway or the ocean, water from an aquarium, tank or other receptacle that has been used to keep a specimen of an alien or a listed invasive species.	Prohibited	Prohibited	Permit Required	Prohibited
j. Catch and release of a specimen of a listed invasive fresh-water fish or listed invasive fresh-water invertebrate species.	Prohibited	See Notice 3	See Notice 3	See Notice 3
k. The introduction of a specimen of an alien or a listed invasive species to off-shore islands.	Prohibited	Prohibited	Prohibited	Prohibited
l. The release of a specimen of a listed invasive fresh-water fish species, or of a listed invasive fresh-water invertebrate species, into a discrete catchment system in which it already occurs.	See Notice 3	See Notice 3	See Notice 3	See Notice 3

3.3.3 Fate of Fish

Given that all the species identified in the dam are listed as invasive for various reasons in the NEMBA, it will not be possible to relocate them to alternative dams without the necessary permits. As introduced and invasive species to the area, this would also not be an ecologically well-informed decision and would set a poor example of how to manage alien fish, especially from the botanical gardens. It is therefore recommended that the fish be humanely euthanised and distributed to poor communities for food if possible. This has been achieved with carp caught from Groenvlei lake through the Gift of the Givers charitable programme. It may also be possible to enlist the services of the Invasive Fish Species Management (IFSM) group who are working with Cape Nature to remove the carp from Groenvlei. Smaller fish species that cannot be used as food for people must be humanely euthenised using a lethal dose of clove oil.

3.4 Terrapins

Whilst not collected during the fish survey, it is well known that there are numerous terrapins living in the dam, and they were observed at the water surface during site surveys. Over 100 observations of Cape Terrapin / South African Helmeted Terrapin (*Pelomedusa galeata*) have been made by iNaturalist users in both the dam and in the adjacent wetland. The species is listed by the IUCN Red List as Least Concern as it is a resilient species adaptable to harsh environmental conditions which is not currently under any significant threats. The species is widespread and found in all South African provinces.

During colder months of the year, terrapins are known to aestivate during winter, when they are known to move away from waterbodies and bury themselves under vegetation. Their diet is primarily carnivorous, but they also eat waterweeds and their roots. Mating occurs in spring, and nests are excavated close to the water with egg clutches of approximately 30.

The terrapins are within their natural distribution range and can therefore be reintroduced to the dam once the repair work has finished. They will need to be accommodated in the coffer dam during construction works. They should not be moved to the wetland. While there are definitely terrapins in the wetland, the further introduction of high numbers of large terrapins may place the amphibian population under high pressure due to predation.

4. PROPOSED MAINTENANCE AND RECOMMENDATIONS

Maintenance actions are required in the short term to repair the dam embankment (wall) will involve careful and informed decision making about consequences for wildlife in the dam. Maintenance is also required on the furrow system to maintain the efficient flow of water when required, but to ensure the system is not wasteful or impacts on instream resources negatively. The dam and furrow maintenance have been separately considered as two distinct sections.

4.1 Dam

The methods proposed by SMEC (2023) for rehabilitation and maintenance of the dam embankment have been summarised in Section 1.2 of this report. It is assumed that the method statement provided by SMEC (2023) will be fully implemented without any major deviations. The focus is therefore on ensuring that the construction and operational phase of dam's rehabilitation are managed in a manner that does not detrimentally impact on the adjacent wetland or cause unnecessary or long-term impacts to the dam as an aquatic ecosystem. Reference is made to the annotated site layout in Figure 12. No-Go areas are indicated in orange and include a distance of 5 m either side of the furrow system. Some work will be required on the furrow, but this is dealt with separately. For the purpose of repairing the dam, the furrow constitutes a No-Go area.

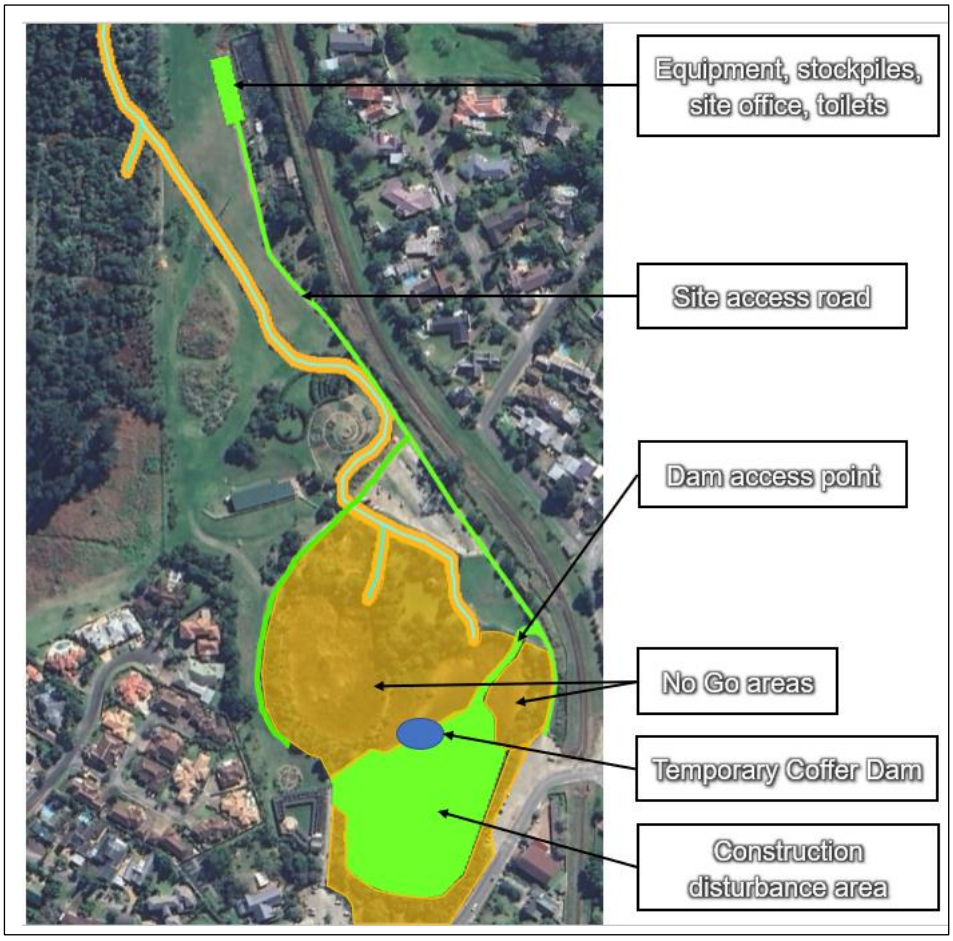


Figure 12. Annotated photo of the site showing access point, temporary coffer dam, site office locations, and no-go zones during the construction phase. Orange colour indicates 'No-go' areas while green indicates areas of disturbance expected during construction.

Drawing down of the dam's water level will be a pre-requisite for work being undertaken in the dam basin. The only aquatic species identified in the dam that is not on the NEMBA invasive species list is the terrapin (*Pelomedusa galeata*). Control measures are recommended in a step-by-step order which should be followed.

Control Measures

4.1.1 Pre-construction

- Appoint and aquatic specialist and environmental control officer (ECO) to oversee works.
- As far as possible, work should be scheduled to avoid Spring months (September to October) when breeding and dispersal of species is at its peak.
- It is very important that at no point must any water, animal or plant be transferred from the dam to the wetland as this could create an unintended impact and the wetland is a No-Go area for the duration of this project. (aquatic specialist to be consulted).
- Delineate No-Go areas using net (shade-cloth) fencing (ECO to oversee). Ensure all workers and staff (both casual and permanent) are aware of No-go areas and are informed of fines payable for encroachment into these areas.
- Attempts must be made to rescue and replant any indigenous hydrophilic vegetation in the access route to the dam basin. Digging out plants with as much soil as possible will improve their chances of surviving transplanting elsewhere or into pots for replanting later. It is not necessary to rescue *Juncus effusus*. Any cleared vegetation

can be loosely piled in the footprint of disturbance for a few days, allowing any mobile inhabitants (ie. Small frogs hiding in leaf bases) time to move on.

- Construct the coffer dam in line with the inflow from the furrow, between the construction area and No-Go area indicated in Figure 12. The dam should have a 'low' side with a gentle slope where terrapins can climb out, bask in the sun and move over land inside the No-Go area if they wish. Water lilies and other aquatic plants can be placed in the coffer dam to provide shelter and food.
- High numbers of terrapins may create excessive waste in the water with the result that it becomes unhealthy for them to inhabit for the duration of the construction phase. In this case, it will need to be replenished periodically with clean water from the furrow system which is why it is recommended that the coffer dam be constructed in line with the furrow. If it is possible to supply clean water from the botanical garden's coffer dam via irrigation pipes that would also be acceptable as this is the same water source and may be easier to control the flow.
- Terrapins may carry Salmonella bacteria and therefore anyone handling them must wear gloves and must wash their hands thoroughly with antibacterial soap after handling.
- The temporary coffer dam must be completely fenced off from the construction area using shade cloth, preferably held in place with sandbags at the base, *or* dug into the substrate to prevent terrapins from climbing out of the dam and walking back into the dam basin under the shadecloth.
- Ensure the pipe inside the dam leading to the outflow has a screen over it to prevent small fish from being transferred out of the dam. It is not desirable to release a lot of alien fish fry and small fish into the stormwater drains because they will ultimately lead to a watercourse nearby, increasing the spread of these fish.
- As the dam level is drawn down, small fish can be netted and humanely euthenised in plastic baths containing a lethal dose of clove oil. Larger carp species can be fished on rods, using bows (as per IFSM), gill nets, or catch nets as water levels drop. All fish must be humanely euthenised preferably with immersion in a lethal dose of clove oil. Terrapins must be removed and transferred to the coffer dam. Large fish must be distributed to poor communities if possible. Lethal dosage values must be obtained from a wildlife vet (Dr.David Huchzermeyer) and the communication regarding this process must be ongoing between project consultants and Cape Nature (Martine Jordaan).
- Small fish that die due to drawdown of the dam along the shoreline are expected to be numerous and some of these can be fed to the terrapins.
- An Environmental Control Officer (ECO) and aquatic specialist must inspect the site on a weekly basis for the duration of the construction phase to ensure the health and wellbeing of terrapins and to ensure the full implementation of all control measures. Management of the GRBG must inspect the site on a daily basis to ensure the health and wellbeing of animals.
- Point of entrance into the dam basin (for heavy machinery) must be demarcated by the appointed ECO to ensure that the protected yellowwood trees in proximity are not harmed.
- The necessary Forestry License must be obtained from the Department of Forestry for the relocation of young yellowwood saplings found on the inside of the dam wall. These rescued saplings must be replanted within the Botanical Gardens.

4.1.2 During construction

- As terrapins lay their eggs in clutches in muddy banks it is possible that clutches of eggs could be disturbed, broken, and immature terrapins injured in the process. If this occurs, it is necessary to immediately stop work in the area of the nest until the remaining eggs can be moved and any injured terrapins rescued. In this event, it is

recommended to make contact with a vet regarding the correct procedure to follow as it may be possible to rescue and rehabilitate immature terrapins depending on their level of development.

- In the event of heavy rainfall, work must cease on the dam until rainfall has stopped. Any water in the dam must once again be released before work goes on.
- The ECO must compile monthly monitoring reports to ensure compliance with the EMMP.

4.1.3 Post-construction

- Manually clear all alien vegetation from disturbed areas with an emphasis on the following species: *Acacia mearnsii* (Black wattle); *Acacia melanoxylon* (Black wood); *Erigeron bonariensis (*Horseweed) and *Paspalum* sp. While *Juncus effusus* (Soft rush) is widely distributed in wetlands and almost considered naturalised in South Africa, it is thought to be an introduced species. While it is not necessary to actively remove plants, no new planting is encouraged. Hand-pulling of plants should be undertaken, and no herbicide must be used.
- Revegetation of bare, disturbed areas must utilise species listed in Table 2. Very light interseeding in patches of *Cynodon dactylon* and *Stenotaphrum secundatum* can be used, but this must be kept to a minimum as these grasses can provide dense cover outcompeting other species.
- If budget permitted the construction of an island, then this must be revegetated as per above point. An island would create basking habitat for the terrapins, habitat for birds, and an interesting feature for visitors to the gardens, but it is not a requirement.
- Refilling of the dam must use water from the furrow system. Refilling must take place slowly so as not to encourage suspension of disturbed sediments. Terrapins must be released from the coffer dam, and all fencing removed from No-Go areas once the dam starts to refill.

4.1.4 Operation and Maintenance

- The dam embankment must be kept free of trees and large shrubs. As a botanical garden it is likely that new seedlings of this nature will continually begin growing along the dam wall. Ongoing awareness and maintenance of the vegetation on the wall must be practiced.
- The public need to be informed of the impact of introducing alien fish (especially carp) into the dam. Without carp, the dam could have a completely different appearance with clear water more typical of the source from which it comes, and abundant rooted macrophytes. Education boards are recommended to educate visitors about fish endemic to the southern Cape and how they are threatened with extinction by alien fish.
- A second phase following repair of the dam could be an attempt to introduce indigenous fish such as *Galaxias zebratus* to the dam. However, it is recommended that the dam be monitored for suitability of this exercise 12 months following completion of repairs. Water quality and the presence of predators such as the terrapins and other fish species will be key factors influencing this decision which must be made in conjunction with Cape Nature.

4.2 Furrow

A few points along the furrow require periodic maintenance. The only actual watercourse as defined by the National Water Act is the stream from which water is diverted into the furrow. Therefore, any actions required for the maintenance and upkeep of the furrow system beyond the stream do not require authorisation. However, as the furrow has been operational for over a century, it has developed features of a non-perennial stream including the presence of amphibians and hydrophilic plants. Knysna leaf-folding frogs are known to occur at the inflow to the dam. Recommendations are therefore made with the intention of protecting aquatic systems whether natural or artificial.

Control Measures

- The stream diversion point (Figure 10) must be kept clear of instream debris such as branches and large stones which can divert flow and cause jams. These can result in water displacement and erosion of banks. The diversion should be inspected following any rainfall event, and at least once a month.
- A stainless steel screen should be fitted over the diversion inflow to reduce the number of frogs and tadpoles from ending up in the furrow. The screen should also be checked for blockages.
- A stainless steel screen should be fitted over the pipeline diverting water from the furrow to the irrigation coffer dam in the gardens. Several frogs and tadpoles were observed in the coffer dam, which is not linked to any aquatic ecosystem and difficult to escape. All screens must be regularly monitored for blinding and blockage.
- The piped culvert under a small pedestrian bridge at the inflowing furrow to the dam is blocked by sediment and vegetation and must be unblocked. For this to be successful however, it will be necessary to excavate a channel from the culvert into the dam, as the silt and vegetation build up extend along the length of the furrow. This work should be undertaken in winter to avoid peak breeding season, and any plants removed should be replanted on the sides of the bank, or in the dam area to preserve eggs or hiding frogs.
- Weekly weather predictions must be consulted when considering the level of the dam and operation of the furrow. The furrow should not be left open during periods of rainfall.

5. CONCLUSIONS

The proposed repairs and rehabilitation of the Botanical Gardens Dam are necessary to ensure the safe and ongoing storage of water. While not classified as a natural watercourse, the adjacent artificial wetland with its resident population of Knysna leaf-folding frogs is a sensitive feature that requires careful consideration for the duration of works.

Drawdown of the dam represents an opportunity to eliminate alien fish from the dam, creating the possibility that indigenous fish suitable to the environment could potentially be introduced in the future. It is also an opportunity to educate visitors to the garden about our endemic fish and the dangers posed to them by alien fish. At the very least, water quality in the repaired dam should be much clearer and more representative of the source without the presence of large carp.

Detailed recommendations have been provided for the protection of aquatic biota and water quality for both the dam repair work as well as the maintenance of the furrow system. Provided these measures are fully implemented the risk to aquatic ecosystems is considered Low, it is recommended that the work required be approved in terms of the General Authorisation according to GN509 of the National Water Act as well the NEMA in terms of adopting this Maintenance Management Plan. The Risk Matrix is provided in Appendix 1 of this report.

This document is available for public review and comment for a period of 30-day, extending from 8 September 2023 to 9 October 2023. All comments received from stakeholders during this period will be considered by the professional team and specialists and responded to where necessary. The final submission to the Competent Authority, Department of Fisheries, Forestry & Environmental Affairs (DFFE), will be inclusive of all submissions received to ensure informed decision-making.

6. APPENDIX: RISK MATRIX

RISK MATRIX for Botanical Gardens Dam
Risk Matrix completed by Jackie Dabrowski SACNASP registration number 115166.
Impacts assume full implementation of mitigation measures.

					Severity															
No.	Phases	Activity	Aspect	Impact	Flow Regime	Water Quality	Habitat	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures
1	Dam Construction Phase	Establishment of work area in the dam basin	Clearing access path and drawdown of the water level	Disturbance to aquatic vegetation and aquatic biota (fish, frots, terrapins)	0	1	1	2	2	1	2	5	1	2	1	2	6	30	Low	80	• Work should be scheduled to avoid Spring (September to October) during peak breeding and dispersal of species. • No water, animal or plant be transferred from the dam to the wetland during construction. the wetland is a No-Go area.. • Delineate No-Go areas using net (shade-cloth) fencing and educate all staff to this effect. • Try to escue and replant any indigenous hydrophilic vegetation in the access route to the dam basin. • Construct the coffer dam in line with the inflow from the furrow, between the construction area and No-Go area indicated in Figure 12. The dam should have a 'low' side where terrapins can climb out and bask in the sun. Aquatic plants can be placed in the coffer dam to provide shelter and food. • High numbers of terrapins may foul the coffer dam water making it an unhalthy environment for them. In this case, it will need to be replenished periodically with clean water from the furrow system which is why it is recommended that the coffer dam be constructed in line with the furrow. If it is possible to supply clean water from the botanical garden's coffer dam via irrigation pipes that would also be acceptable. • Terrapins may carry Salmonella bacteria and therefore anyone handling them should wear gloves and should was their hands thoroughly with antibacterial soap • The temporary coffer dam should be completely fenced off from the construction area using shade cloth, preferably held in place with sandbags at the base, or dug into the substrate to prevent terrapins from climbing out of the dam and walking back into the dam basin under the shadecloth. • Ensure the pipe inside the dam leading to the outflow has a screen over it to prevent small fish from being transferred out of the dam during drawdown. It is not desirable to release a lot of alien fish fry and small fish into the stormwater drains. • As the dam level is drawn down, small fish can be netted and humanely euthenised in plastic baths containing a lethal dose of clove oil. Larger fish can be fished on rods, using bows (as per IFSM), gill nets, or catch nets as water levels drop. All fish must be humanely euthenised preferably with immersion in a lethal dose of clove oil. Terrapins must be removed and transferred to the coffer dam. Large fish must be distributed to poor communities if possible. Lethal dosage values must be obtained from a wildlife vet (Dr.David Huchzermeyer) and the communication regarding this process must be ongoing between project consultants and Cape Nature (Martine Jordaan). • Small fish found dead along the shoreline can be fed to the terrapins. • An Environmental Control Officer (ECO) must be appointed to inspect the site on a daily basis for the duration of the construction phase to ensure the health and wellbeing of terrapins and to ensure the full implementation of all control measures.

2		Excavations along the dam embankment	Heavy machinery disturbing soil	Injury or disturbance to terrapin nests	1	1	2	2	1,5	1	1	3,5	1	2	5	3	11	38,5	Low	90	• Clutches of eggs could be disturbed or broken during excavations. If this occurs work must immediately be stopped in the area and a vet must be contacted for advice.
1		Post Construction	Restoration of aquatic plants and biota	Revegetation of exposed soil and release of biota	1	1	1	2	1,25	1	1	3,25	1	2	1	2	6	19,5	Low	80	• Manually clear alien species: Acacia mearnsii (Black wattle); Acacia melanoxylon (Black wood); Erigeron bonariensis (Horseweed) and Paspalum sp. While Juncus effusus (Soft rush) is widely distributed in wetlands and almost considered naturalised in South Africa, it is thought to be an introduced species. While it is not necessary to actively remove plants, no new planting is encouraged. Hand-pulling of plants should be undertaken, and no herbicide must be used. • Revegetation of bare, disturbed areas should utilise species listed in Table 2. Very light interseeding in patches of Cynodon dactylon and Stenotaphrum secundatum can be used.. • If budget permitted the construction of an island, then this should be revegetated as per above point. An island would create basking habitat for the terrapins, habitat for birds, and an interesting feature for visitors to the gardens. • Refilling of the dam should use water from the furrow system. Refilling should take place slowly so as not to encourage suspension of disturbed sediments. Terrapins should be released from the coffer dam, and all fencing removed from No-Go areas once the dam starts to refill.
2	Dam Operation Phase	Dam maintenance and awareness	Vegetation management and education	Limit tree growth on embankmenta nd prevent reintroduction of alien fish	1	1	1	2	1,25	1	3	5,25	1	1	1	3	6	31,5	Low	70	• The dam embankment must be kept free of trees and large shrubs. • The public must be informed of the impact of introducing alien fish (especially carp) into the dam. Without carp, the dam could have a completely different appearance with clear water more typical of the source from which it comes, and abundant rooted macrophytes. Education boards are recommended. • A second phase following repair of the dam could be an attempt to introduce indigenous fish such as Galaxias zebratus to the dam. However, it is recommended that the dam be monitored for suitability of this exercise 12 months following completion of repairs. Water quality and the presence of predators such as the terrapins and other fish species will be key factors influencing this decision which must be made in conjunction with Cape Nature.
3	Furrow Operational Phase	Furrow Maintenance	Preventionof of erosion and biota impacts at diversion point.	Erosion or habitat loss if not undertaken	0	0	0	1	0,25	1	1	2,25	1	1	5	1	8	18	Low	70	• The stream diversion point (Figure 10) must be kept clear of instream debris such as branches and large stones which can divert flow and cause jams. These can result in water displacement and erosion of banks. The diversion should be inspected following any rainfall event, and at least once a month. • A stainless steel screen should be fitted over the diversion inflow to reduce the number of frogs and tadpoles from ending up in the furrow. The screen should also be checked for blockages. • A stainless steel screen should be fitted over the pipeline diverting water from the furrow to the irrigation coffer dam in the gardens. Several frogs and tadpoles were observed in the coffer dam, which is not linked to any aquatic ecosystem and difficult to escape. • The piped culvert under a small pedestrian bridge at the inflowing furrow to the dam is blocked by sediment and vegetation and must be unblocked. For this to be successful, it is necessary to excavate a channel from the culvert into the dam, as the silt and vegetation build up extend along the length of the furrow. This work should be undertaken in winter to avoid peak breeding season, and any plants removed should be replanted on the sides of the bank, or in the dam area to preserve eggs or hiding frogs. • Weekly weather predictions must be consulted when considering the level of the dam and operation of the furrow. The furrow should not be left open during periods of rainfall.

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