# 6. SUMMARY AND CONCLUSIONS

The Liesbeek River and its tributaries flowing through the Kirstenbosch NBG are considered to be of moderate to high ecological importance and sensitivity due to the presence of sensitive aquatic invertebrate taxa, unique fish species and its location within the Table Mountain National Park. The PES of the potentially affected section of river ranges from largely natural to largely modified, mainly due to the impacts of existing infrastructure (road culverts, landscaping, upstream parking areas).

The proposed upgrade of existing infrastructure at the Kirstenbosch NBG is not considered to pose any highly significant additional risks to adjacent aquatic ecosystems, aside from those already present. The existing infrastructure, including culverts, gardens and landscaping have degraded the river, and contributed to channel erosion and incision along the potentially affected river reach. It is not expected that the upgrades will contribute to further significant degradation of the river ecosystem. Indeed, it is anticipated that the proposed installation of gabions to stabilise the eroding section of river bank adjacent to the site will result in a positive impact on the ecological integrity of the river reach. Care should, however, be taken with regards to environmental considerations during the construction phase and attention should be paid to the maintenance of the proposed permeable paving in the parking area and the proposed gabions along river bank during the operational phase. The recommended mitigation measures presented in the current report for the construction and operational phases should be written into the Environmental Management Programme (EMP) for the proposed upgrading project.

It is recommended that the relevant official(s) from the Western Cape Regional Office of DWS be contacted to establish which application forms must be filled in and what information must be provided to the Department for the “water use” authorisations that are required for the proposed activities in terms of Sections 21(c) and (i) of the NWA.

# 7. REFERENCES


Chakona A, Swartz ER, Gouws G, Bloomer P. 2013. A freshwater fish defies ancient mountain ranges and drainage divides: extrinsic and intrinsic influences on the evolutionary history of a recently identified galaxiid. *Journal of Biogeography* 40**:** 1399-1412.

City of Cape Town. 2009. Management of Urban Stormwater Impacts Policy, Version 1.1, May 2009. Roads & Stormwater Department: Catchment, Stormwater and River Management Branch.

Dallas HF. 2007. River Health Programme: South African Scoring System (SASS) data intepretation guidelines. Freshwater Consulting Group/Freshwater Research Unit. University of Cape Town. Prepared for: Institute of Natural Resources and Department of Water Affairs and Forestry.

Dickens CWS, Graham PM. 2002. The South African Scoring System (SASS) Version 5 rapid bioassessment method for rivers. *African Journal of Aquatic Science* 27: 1–10.

DWAF. 1999. Resource Directed Measures for Protection of Water Resources. Volume 3: River Ecosystems. Department of Water Affairs and Forestry, Pretoria.

Kleynhans CJ. 1999. Assessment of Ecological Importance and Sensitivity. Appendix R7 in: DWAF; Resource Directed Measures for Protection of Water Resources; Volume 3: River Ecosystems. Department of Water Affairs and Forestry, Pretoria. 9 pp.

OWSA [Orrie, Welby-Solomon & Asscociates CC]. 2014. Stormwater Management Plan. SANBI Kirstenbosch. New Administration Building, Parking Facility and Refurbishment of Fynbos Lodge. Prepared for South African National Biodiversity Institute (SANBI).

Waters JM, Cambray JA. 1997. Intraspecific phylogeography of the Cape galaxias from South Africa: evidence from mitochondrial DNA sequences. *Journal of Fish Biology* 50**:** 1329-1338.

Wishart M, Hughes J, Stewart B, Impson D. 2006. Extreme levels of intra-specific divergence among Cape Peninsula populations of the Cape galaxias, *Galaxias zebratus* Castelnau 1861, reveals a possible species complex. *African Journal of Aquatic Science* 31**:** 99-106.

**Appendix A:**

Present Ecological State (PES) assessment method for riverine habitat integrity

## Present Ecological State (PES) assessment method for riverine habitat integrity

The DWAF (1999) Habitat Integrity assessment method for determining the Present Ecological State (PES) of a riverine ecosystem, also known as the Index of Habitat Integrity (IHI, after Kleynhans 1996), aims to assess the number and severity of anthropogenic perturbations on a river and the damage they potentially inflict on the habitat integrity of the system. These disturbances include abiotic factors (such as water abstraction, weirs, dams, pollution and dumping of rubble) and biotic factors (such as the presence of alien plants and aquatic animals which modify habitat). The assessment method is a largely field-based site assessment, supplemented with information gleaned from other sources including relevant reports, strategic plans, maps, aerial photographs, land cover databases, together with local knowledge.

Aspects considered in the assessment comprise those instream and riparian zone perturbations regarded by the developers of the method as the primary causes of the degradation of river ecosystems. The severity of each impact is assessed, using a score between zero and 25 as a measure of impact (Table A1).

**Table A1:** Description of the Impact Classes used in the River PES assessment and the range of scores for each Class

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

The assessor must assign a confidence level (high, medium or low) to each criterion based on his/her knowledge of the site and catchment. High confidence would be based on the assessor having a thorough knowledge and understanding of the site and surrounding area. Low confidence would be based on the assessor having knowledge based on the site visit only and some supplementary information (e.g. land cover). Whilst it is near-impossible to remove all subjectivity involved in making PES assessments, descriptions of each criterion are provided to assist with the assessment (Table A2).

**Table A2:** Descriptions of criteria used in the IHI assessment (after Kleynhans 1996)

| Criterion | Description |
|---|---|
| Water abstraction | Direct abstraction from within the specified river/river reach as well as upstream (including tributaries) must be considered (excludes indirect abstraction by for example exotic vegetation). The presence of any of the following can be used as an indication of abstraction: cultivated lands, water pumps, canals, pipelines, cities, towns, settlements, mines, impoundments, weirs, industries. Water abstraction has a direct impact on habitat type, abundance and size; is implicated in flow, bed, channel and water quality characteristics; and riparian vegetation may be influenced by a decrease in water quantity. |
| Extent of inundation | Destruction of instream habitat (e.g. riffle, rapid) and riparian zone habitat through submerging with water by, for example, construction of an in-channel impoundment such as a dam or weir. Leads to a reduction in habitat available to aquatic fauna and may obstruct movement of aquatic fauna; influences water quality and sediment transport. |
| Water quality | The following aspects should be considered; untreated sewage, urban and industrial runoff, agricultural runoff, mining effluent, effects of impoundments. Ranking may be based on direct measurements or indirectly via observation of agricultural activities, human settlements and industrial activities in the area. Water quality is aggravated by a decrease in the volume of water during low or no flow conditions. |
| Flow modification | This relates to the consequence of abstraction or regulation by impoundments. Changes in temporal and spatial characteristics of flow such as an increase in duration of low flow season can have an impact on habitat attributes, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season. |
| Bed modification | This is regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment. The effect is a reduction in the quality of habitat for biota. Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation is also included. Extensive algal growth is also considered to be bed medication. |
| Channel modification | This may be the result of a change in flow which alters channel characteristics causing a change in instream and riparian habitat. Purposeful channel modification to improve drainage is also included. |
| Presence of exotic aquatic fauna | The disturbance of the stream bottom during exotic fish feeding may influence, for example, the water quality and lead to increased turbidity. This leads to a change in habitat quality. |
| Presence of exotic macrophytes | Exotic macrophytes may alter habitat by obstruction of flow and may influence water quality. Consider the extent of infestation over instream area by exotic macrophytes, the species involved and its invasive abilities. |
| Solid waste disposal | The amount and type of waste present in and on the banks of a river (e.g. litter, building rubble) is an obvious indicator of external influences on stream and a general indication of the misuse and mismanagement of the river. |
| Decrease of indigenous vegetation from the riparian zone | This refers to physical removal of indigenous vegetation for farming, firewood and overgrazing. Impairment of the riparian buffer zone may lead to movement of sediment and other catchment runoff products (e.g. nutrients) into the river. |
| Exotic vegetation encroachment | This excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Encroachment of exotic vegetation leads to changes in the quality and proportion of natural allochthonous organic matter input and diversity of the riparian zone habitat is reduced. |
| Bank erosion | A decrease in bank stability will cause sedimentation and possible collapse of the river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or encroachment of exotic vegetation. |

**Weightings and calculation of instream and riparian status**

Once a score has been allocated to an impact, it is moderated by a weighting system (devised by Kleynhans (1996). Assignment of weights is based on the perceived relative threat of the impact to the habitat integrity of a riverine ecosystem. The total score for each impact is equal to the assigned score multiplied by the weight of that impact (Table A3).

**Table A3:** Instream and riparian criteria used to derive IHI scores, with their respective weightings (after Kleynhans 1996)

| Instream Criteria | Wgt | Riparian Zone Criteria | Wgt |
|---|---|---|---|
| Water abstraction | 14 | Water abstraction | 13 |
| Extent of inundation | 10 | Extent of inundation | 11 |
| Water quality | 14 | Water quality | 13 |
| Flow modification | 7 | Flow modification | 7 |
| Bed modification | 13 | | |
| Channel modification | 13 | Channel modification | 12 |
| Presence of exotic macrophytes | 9 | | |
| Presence of exotic fauna | 8 | | |
| Solid waste disposal | 6 | | |
| | | Decrease of indigenous vegetation from the riparian zone | 13 |
| | | Exotic vegetation encroachment | 12 |
| | | Bank erosion | 14 |

Based on the relative weights of the criteria, the impacts of each criterion are estimated as follows:
Rating for the criterion /maximum value (25) x the weight (percent).

The impact scores for all criteria calculated in this way are summed, expressed as a percentage and subtracted from 100 to arrive at a PES score for the instream and riparian components, respectively. The PES or IHI scores (%) for the instream and riparian zone components are then used to place these two components into a specific Habitat Integrity or PES Class (Table A4), also known as an Ecological Category.

**Table A4:** Habitat Integrity classes (from DWAF 1999)

| Class | Description | Score (% Of Total) |
|---|---|---|
| A | Unmodified, natural. | 90 - 100 |
| B | Largely natural with few modifications. A small change in natural habitats and biota may have taken place, but the assumption is that ecosystem functioning is essentially unchanged. | 80 - 89 |
| C | Moderately modified. A loss or change in natural habitat and biota has occurred, but basic ecosystem functioning appears predominately unchanged. | 60 - 79 |
| D | Largely modified. A loss of natural habitat and biota and a reduction in basic ecosystem functioning is assumed to have occurred. | 40 - 59 |
| E | Seriously modified. The loss of natural habitat, biota and ecosystem functioning is extensive. | 20 - 39 |
| F | Modifications have reached a critical level and there has been an almost complete loss of natural habitat and biota. In the worst cases, the basic ecosystem functioning has been destroyed. | 0 - 19 |

**Appendix B:**

South African Scoring System Version 5 (SASS5) aquatic invertebrate assessment method

**South African Scoring System Version 5 (SASS5) aquatic invertebrate assessment method**

The SASS5 macroinvertebrate-based assessment method (see Dickens & Graham 2002) is specifically designed for the assessment of the ecological integrity of perennial river systems. It involves kick- and sweep-sampling of aquatic macroinvertebrates from three “biotope groups”, using a hand-held 950 µm-mesh net. The three biotope groups are Stones (including stones in and out of current), Vegetation (including marginal and aquatic vegetation, both in and out of current), and Gravel, Sand and Mud (GSM). The sample from each of the three biotope groups is placed in a basin and all the taxa identified, at the level of invertebrate family. Each invertebrate taxon has a pre-assigned SASS5 “sensitivity score” based on its general susceptibility to or tolerance of pollution, on a scale of 1 to 15, with sensitive taxa being assigned higher scores. Interpretation of the sample results is based on two values: the SASS5 Score, which is the summed sensitivity scores of all taxa present, and the average score per taxon (ASPT), which is the SASS5 Score divided by the number of taxa.

Data were analysed using the SASS5 interpretation guidelines developed by Dallas (2007), which assign an Ecological Category (ranging from A to E/F) to a site on the basis of the SASS5 Score and ASPT. The SASS5 data interpretation guidelines provide Ecoregion-specific ranges of SASS5 Scores and ASPT values for deriving an Ecological Category, with different ranges given for upper-river and lower-river zones for those Ecoregions in which sufficient data were available to generate separate guidelines.

**Appendix C:**

Ecological Importance & Sensitivity (EIS) assessment method for river ecosystems

**Ecological Importance and Sensitivity Assessment Method for River Ecosystems**

(taken from Appendix R.7 of DWAF 1999)

The ecological importance of an aquatic ecosystem is an expression of its importance to the maintenance of ecological diversity and functioning, while ecological sensitivity refers to the ability of a river and its biota to resist disturbance and its capability to recover from disturbance once it has occurred (resilience). The Ecological Importance and Sensitivity (EIS) assessment method of DWAF (1999) for river ecosystems takes into account both biotic and abiotic components of a river reach.

Biotic components included in the assessment are:
(1) the presence of rare and endangered biota;
(2) the uniqueness of the biota;
(3) species/taxon richness; and
(4) the presence of biota with an intolerance to flow and/or water quality changes (i.e. sensitive biota).

Abiotic (habitat) components included in the assessment are:
(1) the diversity of aquatic habitat types or features;
(2) the refuge value of habitat types;
(3) sensitivity of available habitat to flow changes;
(4) sensitivity to flow-related water quality changes;
(5) importance as a migration route/corridor for instream and riparian biota; and
(6) proximity to national parks, wilderness areas, nature reserves, natural heritage sites or natural areas.

A score of 0 or 1 (low rating) to 4 (very high rating) is assigned to each of the biotic and abiotic criteria listed above, together with confidence ratings, and the median score is calculated to derive the overall EIS category for the two components. A description of the EIS scoring categories is provided in Table C1 (below), together with an indication of the range of median EIS scores for each category.

**Table C1:** Ecological Importance and Sensitivity (EIS) categories

| EIS Categories (and ranges of median EIS scores) | General Description |
|---|---|
| Very high (>3 but ≤4) | Quaternaries/delineations that are considered to be unique on a national or even international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use. |
| High (>2 but ≤3) | Quaternaries/delineations that are considered to be unique on a national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases, may have a substantial capacity for use. |
| Moderate (>1 but ≤2) | Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use. |
| Low/marginal (>0 but ≤1) | Quaternaries/delineations that are not unique at any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity for use. |

**Appendix D:**

Impact significance rating method

## Impact significance rating method

The evaluation method is adapted from Hacking, AATS – Envirolink, 1998: An innovative approach to structuring environmental impact assessment reports. In: IAIA SA 1998 Conference Papers and Notes.

### Definitions of or criteria for environmental impact parameters

The significance of environmental impacts is a function of the environmental aspects that are present and to be impacted on, the probability of an impact occurring and the consequence of such an impact occurring before and after implementation of proposed mitigation measures.

***(a) Extent (spatial scale)***

| L | M | H |
|---|---|---|
| Impact is localized within site boundary | Widespread impact beyond site boundary; Local | Impact widespread far beyond site boundary; Regional/national |

Take into consideration:

- Access to resources; amenity
- Threats to lifestyles, traditions and values
- Cumulative impacts, including possible changes to land uses at and around the site

***(b) Duration***

| L | M | H |
|---|---|---|
| Quickly reversible, less than project life, short term (0-5 yrs) | Reversible over time; medium term to life of project (5-15 yrs) | Long term; beyond closure; permanent |

Take into consideration:

- Cost – benefit economically and socially (e.g. long or short term costs/benefits)

***(c) Intensity (severity)***

| Type of Criteria | Negative | | |
|---|---|---|---|
| | H- | M- | L- |
| Qualitative | Substantial deterioration, death, illness or injury, loss of habitat/diversity or resource, severe alteration or disturbance of important processes. | Moderate deterioration, discomfort, Partial loss of habitat/biodiversity/resource or slight or alteration | Minor deterioration, nuisance or irritation, minor change in species/habitat/diversity or resource, no or very little quality deterioration. |
| Quantitative | Measurable deterioration Recommended level will often be violated (e.g. pollution) | Measurable deterioration Recommended level will occasionally be violated | No measurable change; Recommended level will never be violated |
| Community response | Vigorous | Widespread complaints | Sporadic complaints |

| Type of Criteria | Positive | | |
|---|---|---|---|
| | L+ | M+ | H+ |
| Qualitative | Minor improvement, restoration, improved management | Moderate improvement, restoration, improved management, substitution | Substantial improvement, substitution |
| Quantitative | No measurable change; Within or better than recommended level. | Measurable improvement | Measurable improvement |
| Community response | No observed reaction | Some support | Favourable publicity |

Take into consideration:

- Cost – benefit economically and socially (e.g. high nett cost = substantial deterioration)
- Impacts on human-induced climate change
- Impacts on future management (e.g. easy/practical to manage with change or recommendation)

***(d) Probability of occurrence***

| L | M | H |
|---|---|---|
| Unlikely; low likelihood; Seldom | Possible, distinct possibility, frequent | Definite (regardless of prevention measures), highly likely, continuous |

The specialist study must attempt to quantify the magnitude of impacts and outline the rationale used. Where appropriate, international standards are to be used as a measure of the level of impact.

***(e) Status of the impact***

Describe whether the impact is positive, negative or neutral for each parameter. The ranking criteria are described in negative terms. Where positive impacts are identified, use the opposite, positive descriptions for criteria.

**Determination of impact significance**

Based on a synthesis of the information contained in (a) to (e) above, the specialist will be required to assess the significance of potential impacts in terms of the following criteria:

***Significance: (Duration X Extent X Intensity)***

| | | | | |
|---|---|---|---|---|
| Intensity = L | | | | |
| Duration | H | Medium | Medium | Medium |
| | M | Low | Low | Medium |
| | L | Low | Low | Medium |
| Intensity = M | | | | |
| Duration | H | Medium | High | High |
| | M | Medium | Medium | High |
| | L | Low | Medium | High |
| Intensity = H | | | | |
| Duration | H | High | High | High |
| | M | Medium | Medium | High |
| | L | Medium | Medium | High |
| | | L | M | H |
| | | Extent | | |

Positive impacts would be ranked in the same way as negative impacts, but result in high, medium or low positive consequence.

**Degree of confidence in predictions:**

State the degree of confidence in the predictions, based on the availability of information and specialist knowledge.

# STORMWATER MANAGEMENT PLAN

# SANBI KIRSTENBOSCH

# NEW ADMINISTRATION BUILDING,

# PARKING FACILITY AND REFURBISHMENT OF FYNBOS LODGE


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## NOVEMBER 2014

# Contents

# 1 Introduction

This report is the stormwater management plan for the proposed new administration building, provision of parking facilities and the refurbishment of the existing Fynbos Lodge for SANBI in Kirstenbosch.

The work falls under *Contract SANBI: G174/2013 for the provision of professional services for the design of a new administration building for the South African National Biodiversity Institute in Kirstenbosch.*

## 1.1 Existing Stormwater Services

There are 6 buildings with a total floor area of 1003m$^2$ located on the site earmarked for the construction of the new Administration building. The area is serviced with an existing access road with shaded and unshaded parking areas. The buildings are accessed by walkways.

The access road has a half round channel along the south eastern edge which terminates at a catchpit. The catchpit is drained with a 300mm∅ concrete pipe which in turn discharges onto the apron garden area located north east of the catchpit. A second Stormwater system is located along the north western side of the rest of the access road which in turn terminates at a catchpit.

**Figure 1: Typical Example of existing stormwater infrastructure.**

The catchpit is connected to a stormwater system which in turn discharges into a stormwater pipe system on Rhodes Drive.

The Stormwater from the roads of the buildings is managed by a system of open surface channels which discharge directly into the Liesbeek River located west of the development.

The existing system appears to function satisfactorily with no visual evidence of scouring or erosion at the discharge points. Signs of scouring of the existing river bed was observed.

# 2 Background

## 2.1 Stormwater Policy Requirements

The City of Cape Town Catchment Management Policy (2009) indicates the recurrence and duration of design storm event for a site, according to the following criteria:

- Size of the catchment.
- Nature of the site with respect to it being a greenfield (new development) or brownfield (existing development) project.

The new SANBI Administrative Building complex in Kirstenbosch will be considered as a greenfield development with a land area of approximately 1.0 hectares (ha). Therefore, in accordance with the City of Cape Town Catchment Management Policy (2009), the following requirements need to be complied with for the **control of quantity and rate of runoff:**

- The protection of stability in downstream channels requires a 24 hour extended detention of stormwater runoff for a 1 year recurrence interval, 24hr storm event.
- The protection of downstream properties from fairly frequent nuisance floods requires the reduction of a 10 year recurrence interval post-development peak flow to a pre-development peak flow level.
- The protection of floodplain developments and floodplains from adverse impacts of extreme floods requires the reduction of a 50 year recurrence interval post-development peak flow to existing pre- development peak flow levels and the evaluation of the effects of the 100 year recurrence interval storm event on the stormwater management system, adjacent properties and downstream facilities and downstream properties. The impacts need to be managed through detention controls and or flood plain management.

In terms of **water quality**, the City of Cape Town Catchment Management Policy (2009) has criteria for achieving sustainable urban drainage system objectives in various development scenarios.

The water quality target for the SANBI Administrative Building complex, being a greenfield site, is the removal of **80% of Suspended Solids (SS) and 45% of Total Phosphates (TP)** produced on site as a result of post development stormwater runoff or to reduce to undeveloped catchment levels whichever requires a higher level or treatment. In addition all litter, grease and oil need to be trapped at the source.

## 2.2 The Site

The ± 1.0 ha site is located in the existing Kirstenbosch Botanical Gardens. (Co-ordinates

Access to the botanical gardens is off M63 - Rhodes Drive along the south eastern boundary. A secondary access is located off the M63 - Rhodes Drive in the north western corner of the botanical gardens. Access to the construction site is via the main entrance.

The following figure illustrates the locality of the site.


**Figure 2: Site Locality**

## 2.3 Existing Stormwater Services

The area is serviced with an existing ± 6m wide access road ± 200m long, starting at the main gate and terminating at the entrance to the nursery.

There are 4 buildings with a total floor area of ± 580 $m^2$ located on the south eastern side of the access road and 2 buildings with a total floor area of ± 720 $m^2$ on the north western side of the access road on the site, earmarked for the construction of the new Administration Building. There are 22 shaded and 15 unshaded off street parking bays. The buildings are accessed by walkways.

The access road has a half round channel along the south eastern edge which terminates at a catchpit. The catchpit is drained with a 300 mm ∅ concrete pipe which in turn discharges onto the open garden area located north east of the catchpit. A second Stormwater system is located along the north western side of the rest of the access road winch in turn terminates at a catchpit at the end of the road. The catchpit is connected to a stormwater system which in turn discharges into a stormwater pipe system located on Rhodes Drive.

The Stormwater from the roofs of the buildings, on the south eastern side of the access road, is managed by a system of open surface channels which terminates at a headwall. The headwall discharges directly into the Liesbeek River, located west of the development, via a 300 mm Ø pipe.

The existing system appears to function satisfactorily with no visual evidence of scouring or erosion at the discharge points.

Signs of scouring of the existing river bed was observed.

## 2.4 Geohydrology

The geology underlining the site for the proposed new SANBI building at Kirstenbosch Botanical Gardens is expected to comprise Quaternary age scree gravels and coarse sands of colluvial origin and variable thickness at ground surface, underlain by coarse porphyritic granites of the Cape Granite Suite, together with their associated residual granite soils. Variable weathering can be expected in the granites, ranging from relatively deep residual granite soils to granite bedrock and core-stones exposed across the area.

A perched water table can develop seasonally in the coarse colluvials screes and gravels. The permanent water table lies at depth in the fractures granite rock aquifer.

## 2.5 Climate

Kirstenbosch receives around 951 mm of rain per year and receives most of its rainfall during the winter months (SA Explorer, 2014). Figure 6 shows the average rainfall values for Kirstenbosch per month. It receives the lowest rainfall (19 mm) in February and the highest (166 mm) in June. (Note: for the simulated Rainfall Grid the MAP is estimated as 1200mm)

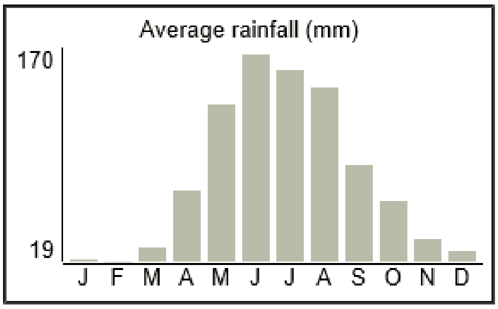



**Figure 2.5.1: Average Rainfall (mm) for Kirstenbosch (SA Explorer, 2014)**

The monthly distribution of average daily maximum temperatures (Figure 7) shows that the average midday temperatures for Kirstenbosch ranges from 15.4°C in July to 23.7°C in February. The region is the coldest during July when the mercury drops to 7.3°C; on average during the night (SA Explorer, 2014).

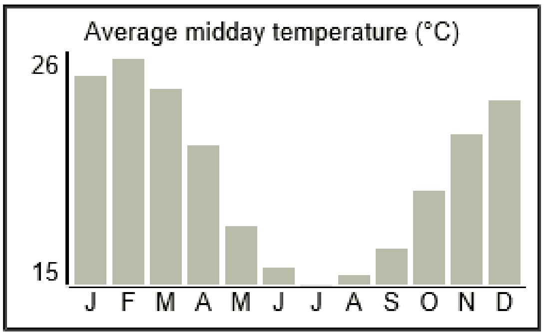



**Figure 2.5.2: Average Midday Temperature (˚C) for Kirstenbosch (SA Explorer, 2014)**

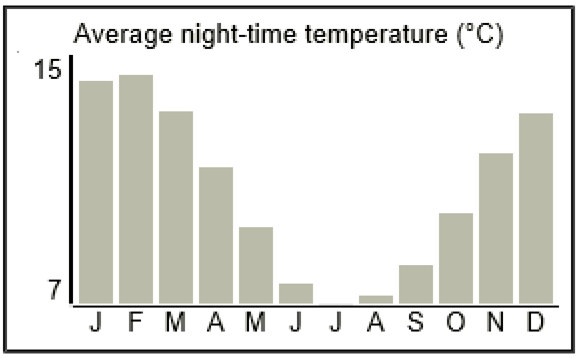



**Figure 2.5.3: Average Night-Time Temperature (˚C) for Kirstenbosch (SA Explorer, 2014)**

# 3 Methodology

## 3.1 Flood Calculation Design Methodology

The stormwater runoff for the storm events as prescribed in the City of Cape Town Catchment Management Policy (2009) were calculated using the Rational Method, Standard Design Flood Method, Hydrograph Method and the Empirical Flood Estimation Method as set out in the *Introduction to Flood Hydrology* by Haarhoff and Cassa, 2007. In additional computer based stormwater discharges simulations based on the Modified Chicago Method were run.

## 3.2 Rational Method

The Rational Method is one of the methods recommended for small catchments by the Stormwater Management Plan Guidelines for New Developments (2009). The method is based on the assumption that the discharge is the product of a runoff coefficient, storm intensity and area of the catchment.

$$Q = \frac{ciA}{3.6}$$

Where:

| | |
|---|---|
| Q | Discharge in $m^3/s$ |
| c | Runoff coefficient a factor dependent on surface roughness and permeability ranging from 0 to 1 |
| i | Storm or rainfall Intensity in mm/hr |
| A | Area of the catchment in $km^2$ |

The rainfall intensity is independent of the development on the site whilst the area and runoff coefficient are dependent on site ground characteristics such as vegetation, sub-catchment delineations etc. It is for this reason that the intensity is discussed here whilst the area and runoff coefficients are discussed in section 3.2.2.

### 3.2.1 Intensity

The data for intensity of rainfall and rainfall volumes can be obtained from weather station data. The nearest weather station to the Kirstenbosch Botanical Garden is Cecelia ,
Longitude18 w c . 7 km south east of the site.

Using the City of Cape Town 2010 Rainfall Grid the nearest data point (X-50 821.85; Y-3 761 949.08) is located 450 m from the site.

**Map 3.1: Proximity of weather station to Kirstenbosch Botanical Garden site**

Storm rainfall depths for the 24 hour storm duration and different recurrence intervals (RI) were obtained from the City of Cape Town 2010 Rainfall Grid.

**Table 3.1: Rainfall depths for different storm recurrence intervals at nearest Data Point**

| Recurrence Interval (yrs) | 2 | 5 | 10 | 20 | 50 | 100 | 200 |
|---|---|---|---|---|---|---|---|
| Rainfall Depth (mm) | 81.5 | 107.2 | 124.1 | 140.2 | 161 | 176.5 | 191.9 |

Source: City of Cape Town 2010 Rainfall Grid

The 1 year RI storm needs to be retained for a further 24 hours after the storm i.e. 48 hours after the commencement of the storm event.

The 10 year and 50 year RI storm event storm duration must be determined as the storm duration which requires the greatest pond storage volume. The 100 year RI storm duration is the storm duration that creates the largest peak flow.

Long storm durations such as 24 hour storm events have greater rainfall depths than a storm event of 45 minutes (0.75 hour) duration but have a lower intensity and therefore requires greater detention volumes whilst shorter duration events like a 0.75 hour storm event have greater intensity and hence greater peak flows. Therefore the 1, 10 and 50 year RI will be calculated for 24 hour storm duration. The 100 year flood will be calculated for the shortest possible storm duration which is assumed to be 0.75 hour because shorter duration storms produce greater intensity rainfalls and thus greater peak flows.

The rainfall intensity can be calculated as the depth of rainfall falling over the time of concentration. The 24 hour storm can be assumed to have a triangular distribution with the peak rainfall intensity occurring at 12 hours.

### 3.2.2 Site Catchment Areas and Runoff Coefficient

3.2.2.1 Pre-development Area

The topography of the site slopes down from the south west towards the north east. The stormwater draining through the site is therefore both a combination of onsite stormwater runoff and stormwater from the mountain to the north west of the site. The area under concern for this study is going to be limited to the area to be developed. (i.e. 1.0 ha)

**Table 3.2.1: Pre-development catchment characteristics**

| Sub-catchment | Area ($m^2$) | Runoff Length (m) | %Urban | Slope | Description | Runoff Coefficient |
|---|---|---|---|---|---|---|
| 1 | 10 000 | 200 | 0 | 4.2 | Mild slope, thick bush and grass, impermeable sand | 0.65 |

The area of the site is approximately 1.0 ha.

3.2.2.2 Post-development

The sub-catchments remain the same as pre-development with the exception of the percentage of impervious area which has increased to 70%. The post-development site consists of roads, office buildings, parking and open-spaces. A general slope of 4.2% was assumed across the site.

**Table 3.2.2: Post development sub-catchment characteristics**

| Sub-catchment | Area (m2) | Runoff Length (m) | %Urban | Slope | Description | Runoff Coefficient |
|---|---|---|---|---|---|---|
| 1 | 10 000 | 200 | 0 | 4.2 | Buildings, roads, parking areas and open spaces with ild slope, thick bush and grass, impermeable sand | 0.95 |

# 4 Findings and Discussion

## 4.1 Peak Runoff

The following peak flows were determined and are tabulated as follows.

**Table 4.1: Pre and Post-development Runoff Comparison**

| RI | Pre-Development Runoff ($m^3/s$) | Post Development Runoff ($m^3/s$) | Difference ($m^3/s$) |
|---|---|---|---|
| 2 | 0.56 | 0.82 | 0.26 |
| 5 | 0.90 | 1.31 | 0.41 |
| 10 | 1.13 | 1.65 | 0.52 |
| 20 | 1.40 | 2.05 | 0.65 |
| 50 | 1.78 | 2.60 | 0.82 |
| 100 | 2.15 | 3.14 | 0.99 |

The post development runoff is 46% more than the pre-development runoff for the 1 in 10 year recurrence interval storm.

## 4.2 Storage Requirements

An initial analysis was performed to determine the storage requirements. The storage requirements were calculated using a triangular distribution for the 24 hour storm for a 1 in 10 year recurrence interval (which was determined to be a design objective in section 2.1).

The difference between the Pre and Post development volume is calculated as $50m^3$. This volume can be retained within the Permeable paving structure detailed in Figure 4.4.

## 4.3 Water Quality

In terms of **water quality**, the City of Cape Town Catchment Management Policy (2009) has criteria for achieving sustainable urban drainage system objectives in various development scenarios.

The water quality target for the SANBI Administrative Building complex, being a greenfield site, is the removal of **80% of Suspended Solids (SS) and 45% of Total Phosphates (TP)** produced on site as a result of post development stormwater runoff or to reduce to undeveloped catchment levels; whichever requires a higher level or treatment. In addition all litter, grease and oil need to be trapped at the source.

Because of the existing topography and unavailability of any suitable open space the water quality will be controlled using permeable paving only.

## 4.4 Permeable Paving

Permeable paving serves both structural and stormwater management functions by being able to handle heavy loads from vehicles and by reducing stormwater runoff. Permeable paving has a very high initial infiltration rate of 4500 mm/hr and can treat and store stormwater (EPA, 2014b) Permeable paving consists of a paver usually 80mm thick, a geotextile and layers of finer stone to increase infiltration and treatment of the stormwater (Figure 4.4.2). The stormwater is then released via a 110 mm diameter underdrain into a stormwater network. Permeable paving can reduce TSS between 71% and 99% and total phosphorus between 42% and 65% (EPA, 2014b).

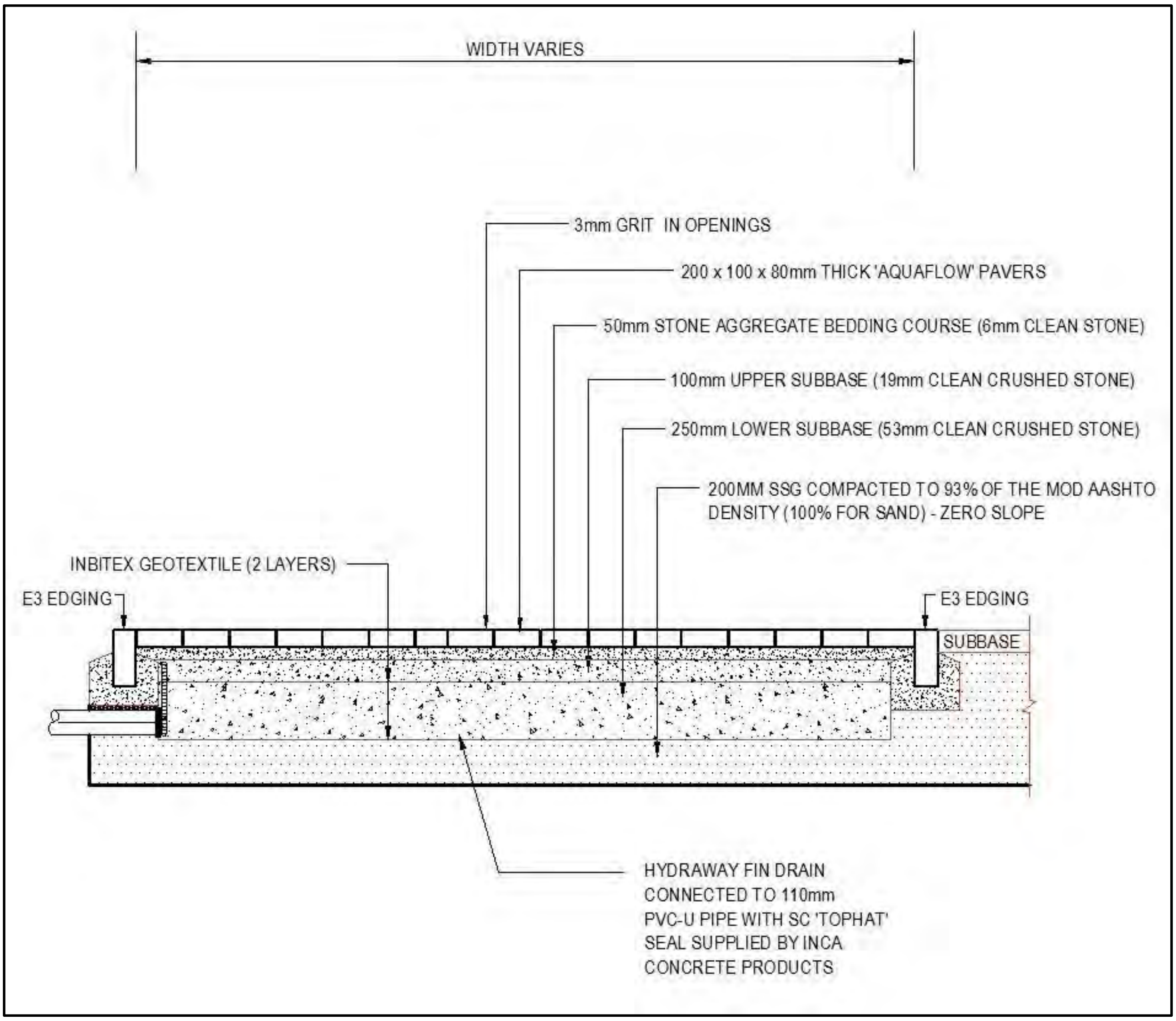



**Figure 4.4.2: Detail of Proposed Permeable Paving Layer Works**

Permeable paving is most effective in a parking lot when situated at the lowest drainage point of the site or in roads when stormwater is drained along the length of the road. Since the natural drainage path is towards the north-east, the proposed layout can accommodate the detention requirements.

The parking and road is approximately 2400$m^2$ and therefore has the potential to treat and retain 850$m^3$ (which is adequate for the storage of a 1 in 10 year storm event). The area required for the treatment of water for a RI 10yr 24 hour storm is 1200$m^2$; the 2400$m^2$ of Permeable Paving which is proposed for this development is adequate. Therefore the treatment of the stormwater on site will be adequately met using permeable paving only.

# 5. Stabilisation of the River Bank

## 5.1 Location

Figure 5.1 indicates the position of the river and its proximity to the existing buildings.


**Figure 5.1: River Proximity to Existing Buildings**

## 5.2 Catchment

Figure 5.2 indicates the catchment area of the River under study.

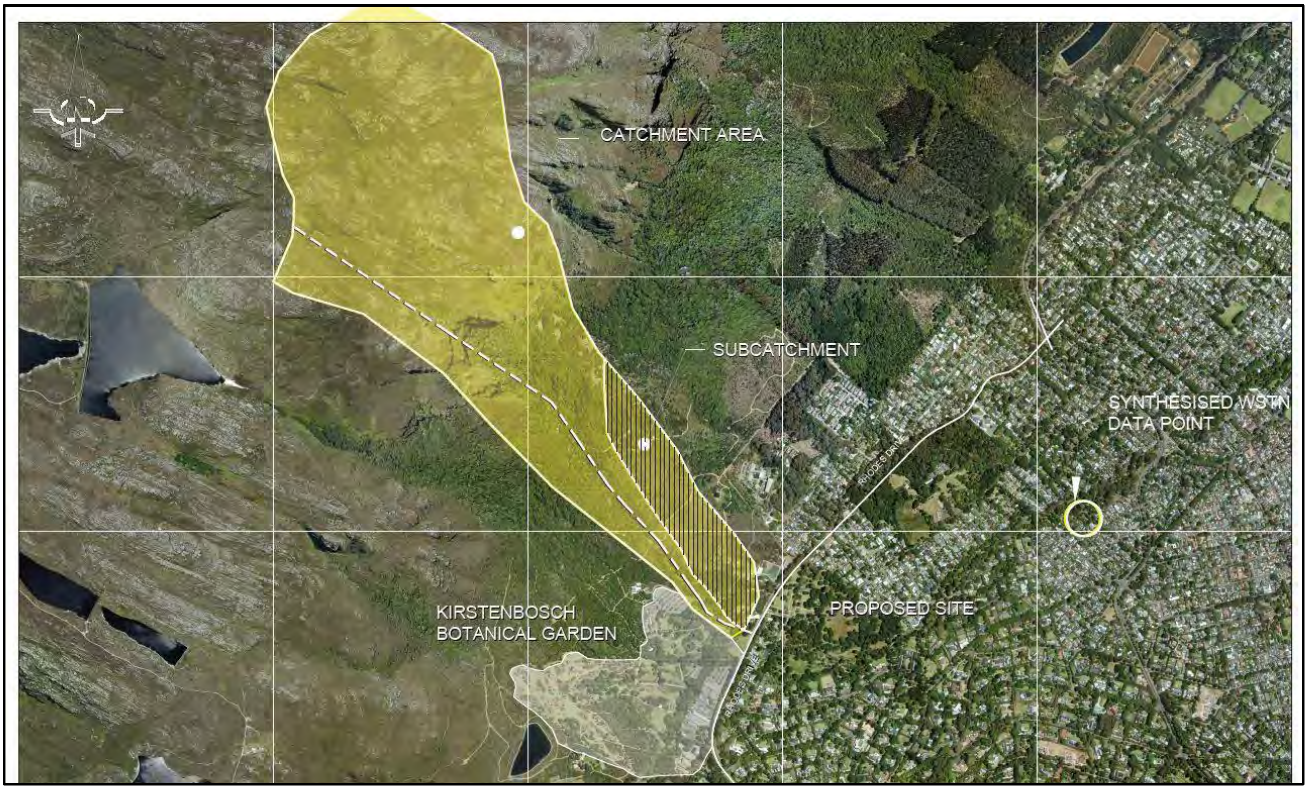



**Figure 5.2: Study Area Catchment**

<u>The following catchment characteristics were assumed.</u>

- Area: 1.76km$^2$
- Length of Longest Water Course: 2.7km
- Maximum Catchment Elevation: 1070m
- Minimum Catchment Elevation: 120m
- Slope (85/10 Method): 34%
- Catchment Centroid: X: -53195.9794 Y: -3761011.8185

## 5.3 Determination of Peak Flows

The peak flows for the different Recurrence Intervals are tabled in Table 5.3

**Table 5.3: Peak Flows for Recurrence Intervals**

| RI | PEAK FLOW ($m^3/s$) | MANUAL CALCULATIONS | | | | PC SWMM |
|---|---|---|---|---|---|---|
| | | Rational Rural | SDF Method | Hydrograph Method | Empirical Flood Estimation | Modified Chicago Method |
| 2 | $Q_n$ | 8.94 | 4.47 | 26.08 | 8.30 | 9.82 |
| 5 | $Q_n$ | 12.53 | 10.25 | 35.52 | 19.27 | 14.18 |
| 10 | $Q_n$ | 15.42 | 15.27 | 44.95 | 27.57 | 15.83 |
| 20 | $Q_n$ | 18.47 | 20.74 | 55.49 | 41.24 | 18.66 |
| 50 | $Q_n$ | 22.40 | 28.65 | 72.14 | 59.30 | 22.40 |
| 100 | $Q_n$ | 25.86 | 35.13 | 88.79 | 72.97 | 27.77 |

## 5.4 Depth of Flow

Figure 5.4.1, Figure 5.4.2 and Figure 5.4.3, indicate the depth of flow for the 1 in 50 year recurrence interval for the three cross-sections 1, 2 and 3 as indicated in Figure 5.1.

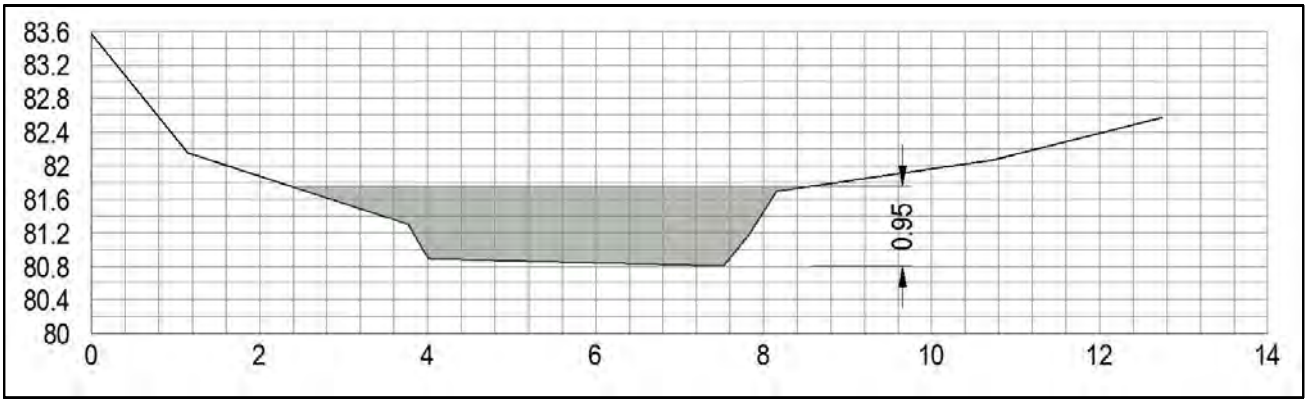



**Figure 5.4.1: Section 1-1 RI 50yr Peak Flow Water Depth**

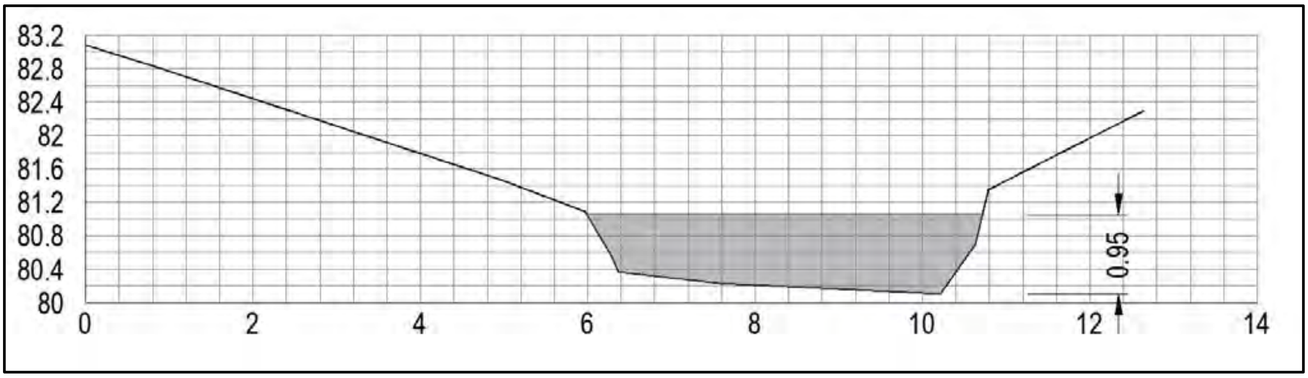



**Figure 5.4.2: Section 2-2 RI 50yr Peak Flow Water Depth**

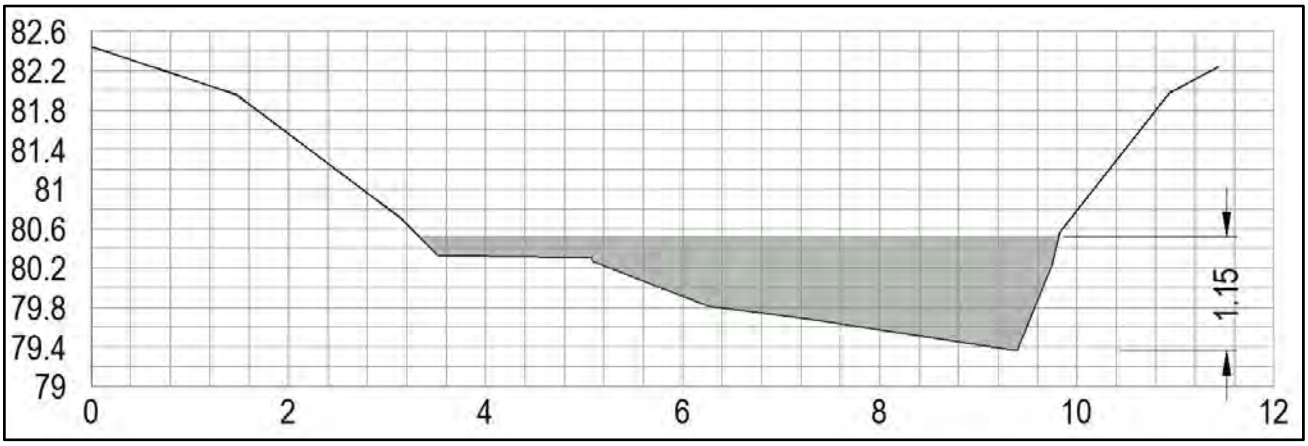



**Figure 5.4.3: Section 3-3 RI 50yr Peak Flow Water Depth**

Table 5.4.3 tabulates the calculated heights for the different recurrence intervals.

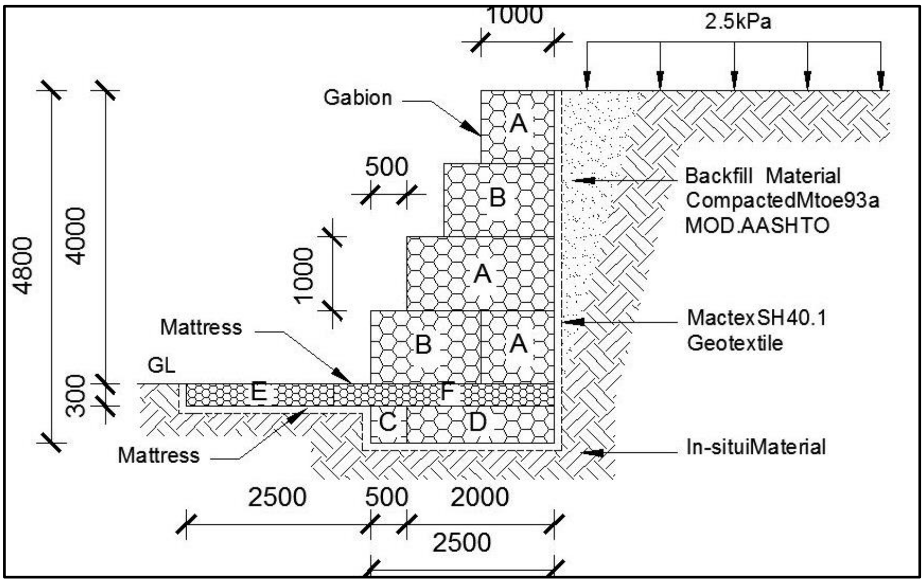
**Table 5.4.3 : Peak Flows for Recurrence Intervals**

| d (m) | A ($m^2$) | P (m) | R (m) | s | n | Q ($m^3$/s) |
|---|---|---|---|---|---|---|
| 0.50 | 1.74 | 4.61 | 0.38 | 0.07 | 0.03 | 8.24 |
| 0.60 | 2.17 | 5.06 | 0.43 | 0.07 | 0.03 | 11.21 |
| 0.70 | 2.65 | 5.51 | 0.48 | 0.07 | 0.03 | 14.73 |
| 0.80 | 3.16 | 5.96 | 0.53 | 0.07 | 0.03 | 18.75 |
| 0.90 | 3.69 | 6.47 | 0.57 | 0.07 | 0.03 | 23.03 |
| 1.00 | 4.33 | 7.50 | 0.58 | 0.07 | 0.03 | 27.19 |
| 1.10 | 5.05 | 8.52 | 0.59 | 0.07 | 0.03 | 32.28 |

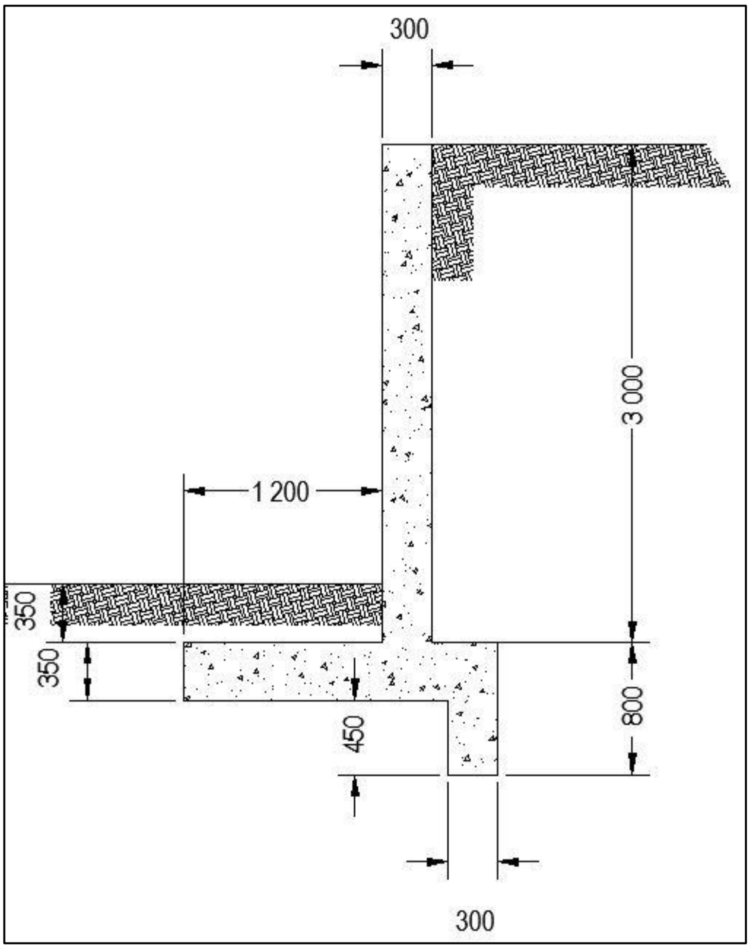
## 5.5 Stabilisation Options

Two **(2)** options to stabilise the existing embankment were investigated viz.

Option 1: Stabilisation using Gabions



Option 2: Stabilisation using Concrete Retaining Walls.




## 5.6 Discussion

The stabilisation of the embankment utilising gabions is considered to be less evasive than the construction of a concrete retaining structure. The construction of gabions will not necessarily require any excavation for trimming of the existing riverbed. The construction of the gabion will not pose a pollution problem. It is therefore recommended that the gabions be used in lieu of the concrete structure.

# 6. Conclusion

The site is part of the sub-catchment which originates 950m north west of the site. The stormwater discharge is currently managed by a system of natural watercourses and sheetflow discharges augmented with surface channels, catchpits and a pipe system for the existing development. The attenuation of a 10 year RI 24 hour storm (± 50$m^3$) will be accommodated in the permeable paving of the roads and parking area.

The proposed development has a negligible increase in the 1 in 100 year RI peak discharge and is therefore assumed to be managed downstream.

The stormwater quality treatment targets, as set by the City of Cape Town Catchment Managment Policy (2009), can be achieved using the permeable paving only.

Calculations indicate that the 1 in a 100 year RI peak discharge of the Liesbeek River tributory is contained within the existing watercourse, however, the embankment of the river is to be protected against erosion; for the section of embankment in close proximity to the existing building.

The utilisation of gabions is recommended to be used for the stabilisation of the embankment.

# 7. Recommendations

The following recommendations are made for the adequate stormwater management for the development of SANBI Kirstenbosch Administrative Building Complex:-

1. The stromwater discharge volume up to a 1 in 10 year RI to be detained in the permeable paving of the roads and parking area.

2. The permeable paving will serve as the stormwater quality treatment of the runoff.

3. Gabions to be used to stabilise the existing embankment of the river; for the section in close proximity to the existing building.