Liesbeek River Bank

TU Delft

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A design proposal for the Liesbeek River bank, to maintain, restore and improve the water quality, water quantity, ecology and amenity

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Contents

1 Introduction

There are two main freshwater features within the Two Rivers Urban Park (TRUP), namely the Liesbeek and the Black River. Biologically sensitive wetland areas and areas of high faunal sensitivity status comprising remnant and artificial floodplains form an important ecological system, that is worth being maintained to protect endangered species [3]. The LLPT (Liesbeek Leisure Properties Trust) is proposing to redevelop the River Club property which is situated in TRUP area and portions of adjacent properties, including among others, portions of the original course of the Liesbeek River and Liesbeek Canal for commercial, retail, residential, institutional and associated uses. SRK Consultancy ®(South Africa) assessed the impact of the proposed redevelopment on among others, the potential Surface Water Hydrology for both the Liesbeek and the Black River and surrounding areas [11, 12, 10]. These floodplains are deemed crucial for flood prevention and for Cape Town to become a water sensitive city. This report focuses on the development of the original Liesbeek River run. Currently, the Old Liesbeek section offers relatively poor habitat support because it is not being managed effectively and is not being replenished by freshwater from the Liesbeek. However, the original Liesbeek River channel falls under the definition of a water body according to the National Water Act No. 36 from 1998 [26]) and therefore governmental water protection regulations apply. By law it is prohibited to build within 30 meters proximity to a water body. Therefore, the consulting company SRK proposes a Corridor Alternative where it is intended to fill in the original Liesbeek River channel. This report outlines an alternative position to the one that is offered by the SRK consultants and advises that the island concept on which the River Club property stands should by maintained and that the old Liesbeek River channel should be reestablished as a flowing water body. Filling up the original Liesbeek River channel would have negative impacts on seasonal flooding, ecology and the water quality.

The River Club developers argue that by removing the channel would have only little negative impact but failed to examine the positive impact that this water body once it was reestablished and maintained. Currently, the original Liesbeek River channel might appear unattractive to the untrained public, but it has potential to improve the aquatic and ecological status, mitigate flood risks and add to the amenity of the Two River Urban Park and to the River Club's developing plan respectively. This report seeks to address how reestablishing the original Liesbeek River channel and form, and transforming it into a liveable urban wetland that adds to the city's objectives of creating Cape Town into a water sensitive city by 2040. Even though the existing wetlands such as the lower Liesbeek River and the Valkenberg wetland are artificially modified, they provide important services which are in line with creating a more water sensitive city. Their positive impact particularly lies in flood attenuation, storm water mitigation, water quality amelioration and providing habitat for endangered floral and faunal species in an increasingly urbanised environment [3].

Figure 1.1: Water bodies within the limits of the Two River Urban Park [3]

2
Analysis

2.0. Water quality

The independent consultancy company Blue Science ® assessed the aquatic and the water quality of the Liesbeek River in a specialist report [3]. This section summarises their findings and suggestions and implements them for a new design of the original Liesbeek River channel.

Belcher and Grobler [3] explain in the report that the water quality in the Liesbeek River has a strong seasonal variability due to stormwater entering the river system during the rainy season bringing litter, high number of suspended solids and Coliform bacteria with it.

According to Belcher and Grobler (2016) the mitigation of stormwater runoff from the surrounding developed urban areas is necessary to improve the aquatic and water quality of the two river system. This comprises pre-cleaning of stormwater by sand and litter traps. Stormwater can then be partially treated by means of a wetland. Even though the existing wetlands are artificially modified they play an important role in water quality amelioration such as sediment trapping, phosphate trapping, nitrate removal and toxicant removal. The original Liesbeek River channel is not only important to preserve green and ecologically valuable spaces in the cities but it has potential to be transformed in an attractive wetland and recreational open water body. This would also be beneficial for the development plans of the River Club since it increases the amenity of this urban space. To increase the positive impact of the original Liesbeek River channel. Belcher and Grobler advise to preserve the status quo meaning that the original Liesbeek River channel as well as the canalised Liesbeck River both should be maintained. To improve the heavily degraded condition of the original Liesbeek River channel following measures can be undertaken:

1. Replenishing the original Liesbeek River with the lower flows from the Liesbeek River
2. Improve storm water quality that enters the original River channel with silt and litter traps
3. Enhancing the functionality of the aquatic ecosystem by reshaping of the channel and re-vegetating with suitable aquatic vegetation (wetland) can positively impact the water quality

The latter point also applies to the canalised section of the Liesbeek River to the East of the Riverclub.

Elevated levels of phosphorus result from wastewater discharges and from urban and agricultural runoff [3]. This goes hand in hand with stormwater since in case of heavy rainfalls the sewers and WWTW are overloaded and cannot treat the entire municipal wastewater stream. Aquatic systems react very sensitively to elevated phosphorus levels which can lead to eutrophication (algae bloom) [3]. This will lead to development of odor and create nuisance. The depletion of oxygen in a water body endangers fish and other faunal species and can even destroy entire aquatic systems. Even low concentrations of phosphorus (0.025 to 0.25 mg/l) result in eutrophic conditions [3]. Reestablishing the original Liesbeek River channel and using a series of wetlands is likely to be beneficial for the aquatic system. However, removing this water body can lead to a decrease in ecological status of the entire river system and its wetlands (see section 2.2).

2.1. Water quantity

The assessment of SRK Consultancy is based on the Surface Water Hydrology Impact Assessment undertaken by Aurecon ®[1]. This section summarises their findings in light of the water quantity aspects, and compare

the outcomes to the Water Sensitive Legislation and implements them for the new proposed design for the original Liesbeek River channel. The project description as provided by SRK from which activities affecting the water quantity are listed below.

- Infilling of portions of the site in the floodplain, and rehabilitation of river banks and the installation of service infrastructure;
- Widening of the Liesbeek Parkway into the original course of the Liesbeek River, between Station Road all the way up to Malta Road. Thus infilling the original course of the Liesbeek River (the Western Liesbeek River Course)
- Storm water infrastructure: vegetated stormwater swales (at the location of the original course of the Liesbeek River) underlain by a piped drainage network.

The proposed development triggers the following NWA (National Water Act) water use activities that impact water quantity.

- Impeding or diverting the flow of water in a watercourse. In case of the proposed development filling up the original Liesbeek River course.
- Altering the bed, banks, course or characteristics of a water course. In case of the proposed development the Liesbeek canal and part of the Black River.

Currently there are no functional wetlands on the site of the River Club, although several wetlands are located in the vicinity of the site. The site was infilled in the past with waste and rubble and used for recreational activities. Even though the site was elevated, most of the site is below the 1:100 year floodplain as reported by SRK. Figure 2.1 shows that even most of the site is below the 20 year floodplain. Potential impacts associated with the project were assessed according to SRK's standard Impact Assessment methodology. The impacts on water quantity are summarized here as they are presented in the SRK executive summary [11]. Per item it is stated if the impact is negative or positive and to which degree, according to SRK standard Impact Assessment.

- Loss of riverine wetlands along the Black River margin, Low negative impact
- Change in flood hazard, Very low negative impact
- The Liesbeek Canal, High positive impact
- The Liesbeek River, Low negative impact

Looking more specifically into the impact on the Surface Water Hydrology for both the Liesbeek and the Black River and surrounding areas assessed by Aurecon ®[1] the following can be summarized. Flooding currently occurs (i.e. regardless of the redevelopment of the River Club) in the adjacent urban area for storms more frequent than 1:5 to 1:10 year return interval flood events from local overland flows only (that occur when the local stormwater runoff exceeds the capacity of the stormwater system). Added to the document a Figure, 2.1, showing the Flood planes of the site.

According to Aurecon ®, the combined development of the River Club along the TRUP (Two River Urban Park), the PRASA (Passenger Rail Agency of South Africa) and the NRF (National Research Foundation), is likely to have a negative impact on the flood levels. This is in the order of 0.01 meter up to 0.15 meter, this is depending on the storm recurrence interval and location. The biggest differences in flood levels occur in the vicinity of the South African Astronomical Observatory (SAAO). During a 1:5 year return interval flood event, three buildings at the south-west west of the SAAO are flooded, this is under current conditions. However, floodwater elevations would increase by approximately 12 cm following development of the River Club, TRUP and PRASA in the catchment. Would the River Club be developed in isolation of TRUP, NRF and PRASA the impact on flood levels would be of a similar magnitude for all recurrence intervals, the negative impact on the flood levels is likely to be 0.00 meter to 0.03 meter in this case.

The anticipated increase in peak flow at the Black River at the site is from stormwater currently directed over the site from the Liesbeek River, down the original course of the Liesbeek which will be directed into the rehabilitated Liesbeek Canal after the site is infilled. The increase in flow is significant, will take place over a few hours, and will increase flood levels locally along the (rehabilitated) Liesbeek Canal. The development of the River Club (as well as the TRUP and the PRASA upgrades) may increase the extent of inundation from overland flow at the following locations:

- South African Astronomical Observatory
- Valkenberg Wetland
- Malta Sports Fields

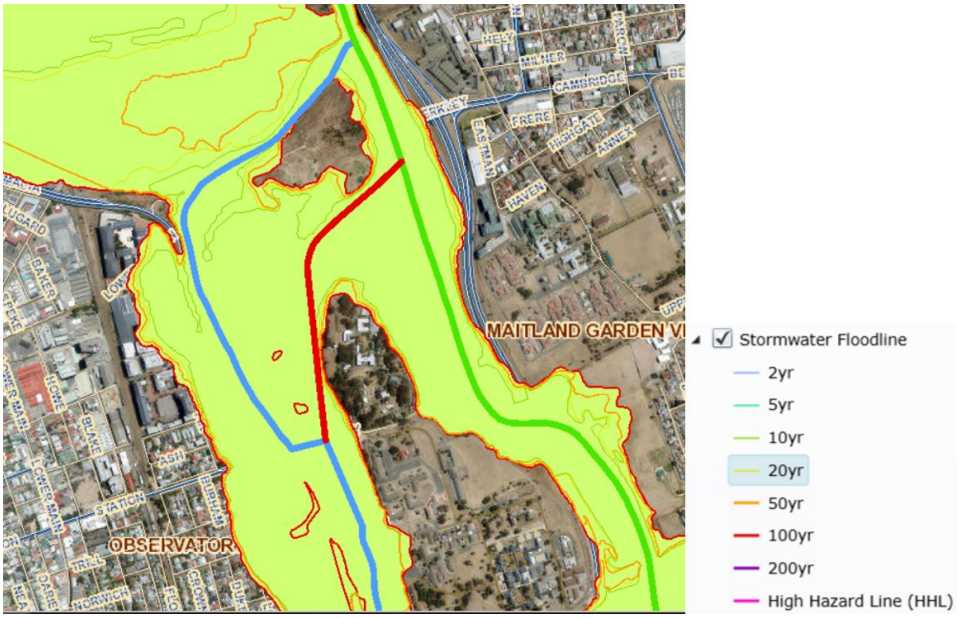

Figure 2.1: Various Flood planes (i.e. Stormwater Floodlines) of the River Club site and vicinity

2.2. Ecology

The information presented below is obtained from two reports, the ecological assessment report of Royal Haskoning DHV and the ecological assessments of the River Club consultant SRK. In case the information seemed to be contradictory, the RH DHV report was followed. This reasoning behind this is that the River Club has a larger incentive, mostly financial, to build the proposed developments. The RH DHV assessment therefore is likely to have a more objective approach. However, where possible the statements of both assessments have been verified. The TRUP site is intensively modified over the years and currently it is estimated that roughly 90% of the area is not in its original state anymore. However, the area still has ecological value for flora and fauna [28].

2.2.0. Flora

The TRUP site is situated in both the West Coast Renosterveld bioregion and the Southwest Fynbos bioregion. Both these bioregions are critically endangered on a national level and have conservation targets, which so far are not close to being met [28]. According to the environmental assessment of the RH DHV, filling the original Liesbeek River will increase the inundation frequency of the renosterveld area in the TRUP site. This will most likely have negative consequences for the critically endangered renosterveld [28]. Additionally, the original Liesbeek River has a protected status in perpetuity, because it is part of the cities biodiversity network in both flora and fauna. One critically endangered plant species is the 'Blouooguintjie', a small flower which can only be found in the neighbourhood of Observatory, Cape Town [28].

2.2.1. Fauna

Since fauna is more mobile than flora, the terminology is changed to 'might occur'. The fauna will not continuously be present on the TRUP site. On the TRUP site 29 indigenous mammal, 32 indigenous reptile and 8 indigenous amphibian species might occur. Most of these species have been listed by the IUCN Conservation Status of least concern. However, three species are an exception. The African Clawless Otter is near threatened, the Cape Dwarf Chameleon is listed as vulnerable and lastly, the Western Leopard Toad is endangered [28].

2.3. Amenity

For the purpose of this report amenity consists of aesthetics, heat stress and odour. All three factors promote the pleasantness of the site.

2.3.0. Aesthetics

The development of the River Club site will most likely increase the aesthetics of the major part of the currently barren area. However, it is chosen to fill the original Liesbeek River to replace it with a bioswale. This bioswale is needed in case heavy rain events will cause inundation of the site to store, infiltrate and transport the water. After the rain event the flow rate will decrease, which in turn decreases the capability to transport litter and suspended particles which stormwater most often contains. Since the drainage pipes will transport the water into the bioswale, the bioswale will become the place where both the litter and suspended particles are deposited. This will cause pollution of the scene and is unattractive. Additionally, the non-continuous flow and warm climate in summer will deteriorate water quality, as these are good places for bacteria to grow. The likelihood of non-flowing water body to produce odours is large. This will lead to a decrease in aesthetics perception by the residents.

2.3.1. Heat stress

In cities, the Urban Heat Island Effect (UHIE) has much been researched. It has been found to influence ecology, public health and the economy [16]. To mitigate for the UHIE, green roofs, water roofs, water bodies and many more solutions have been investigated [16]. The idea is to reduce the sensible heat flux by increasing the latent heat flux or increasing reflectivity which diminishes the reabsorbed solar radiation. Vegetation increases the latent heat flux by transpiration. Water bodies on the other hand have a higher heat capacity and therefore reduce the sensible heat flux during the day and release the sensible heat during the night. The original Liesbeek River is a large water body which is able to ‘store’ a lot of energy. The vegetation along the Liesbeek has an additional cooling effect. These benefits will not be realised if the original Liesbeek River is filled up with sand.

2.4. Objectives of the city

The city of Cape Town has written several strategies committed to ensuring the long-term the long term sustainability of the city in order to protect the economic and social benefits that the natural environment provides continue to be accessible to all, and to be preserved for future generations. An overview of the most important objectives regarding water and environmental management as suggested by the government in its strategy reports ([5, 9, 8, 14]) are stated below, and must be included in the design process.

2.4.0. A city for everyone

"The city of Cape Town recognises that the natural environment is an irreplaceable resource, which provides a myriad of ecosystem goods and services with a host of associated economic and social benefits to the citizens of Cape Town" [9].

- "Recreational activities such as hiking, picnicking, birdwatching, and water sports; educational and scientific research opportunities; and spiritual, cultural and religious benefits offer the opportunity for diverse communities to come together in shared outdoor spaces and are essential for maintaining the social and cultural character of an inclusive city. Most importantly, Cape Town’s natural environment is a collective resource that belongs to all citizens of Cape Town, which must remain accessible and deliver benefits to all citizens."
- The fourth objective of the ’Floodplain and River Corridor Management Policy’ states the policies should ”Facilitate the beneficial integration of watercourses into the urban landscape by creating an aesthetically pleasing public resource which will ultimately allow for the social and economic up-liftment of communities adjacent to watercourses and wetlands” [8].

2.4.1. Climate resilience

A resilient city is defined by the OECD as "cities that have the ability to absorb, recover and prepare for future shocks (economic, environmental, social and institutional). Resilient cities promote sustainable development, well-being and inclusive growth."

Climatic 'shocks' in the context of Cape Town include droughts, floods and heatwaves. The following bullet points clarify the adaptive strategies described in the fifth commitment (Water Sensitive Urban Design) of Cape Town's 2019 Water Strategy [5].

- Protect and enhance natural water systems.
- Improve the quality of water draining from urban area.
- Use stormwater treatment systems in the landscape for multiple uses and with multiple benefits such as water quality treatment, wildlife habitat, public open space, recreational and visual amenity.
- Reduce peak flows by onsite temporary storage measures (with potential for reuse) and minimise impervious areas.
- Minimise the drainage infrastructure cost of development.
- Use stormwater as a resource through capture and reuse for non-potable purposes (toilet flushing, garden irrigation, laundry etc.).

The city is highlighting the importance of searching and using methods for increasing water inflow such as groundwater, water reuse and desalination. These methods will be developed both alongside and integrated with the existing water systems [5].

2.4.2. Protect natural systems

- "The need to conserve natural and cultural heritage in a rapidly growing and ever-changing city, while also ensuring the effective provision of services and amenities to all citizens." [9]
- The city's By-law relating to Stormwater Management defines the stormwater system to both the natural and constructed systems, which includes water courses and their associated floodplains. The 'Framework for the Assessment of Proposals' describes the requirements or conditions for which the activity of filling an area with sand, dirt, soil, rock or any other construction material in floodplain zones is or is not permitted [8]. The 'original', historic Liesbeek River course along the west of the River Club lies within the 1/10 year flood recurrence zone. The 'Framework for the Assessment of Proposals' specifically describes infilling zones of flood frequency between 2 and 50 years as 'unpermitted' . The 'original' Liesbeek River course has had the same alignment since at least 1945, if not earlier. This can be seen in the aerial photograph below. The canal to the east of the River Club was constructed in 1980.

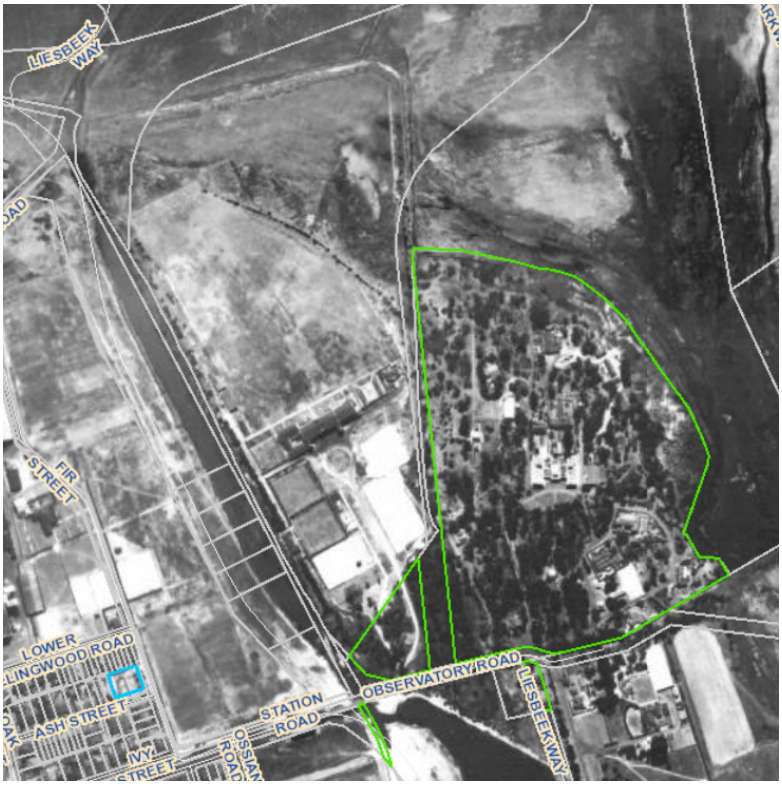

Figure 2.2: Establishment of the new Liesbeek canal in 1945 east of the present River Club.

Figure 2.3: The old Liesbeek river channel in 1905

3

Design

The design proposed is an alternative for infilling the original Liesbeek River course to the west of the River Club. This is in line with the Island Concept Alternative proposed by SRK. The original, currently ill-maintained river course can be transformed into a livable urban wetland that improves water quality, manages water quantity, stimulates ecology and enhances its amenity features. In Figure 3.1 the current situation is shown, which gives a good overview of the current stormwater pipes and the inlet of stormwater into the old Liesbeek channel.

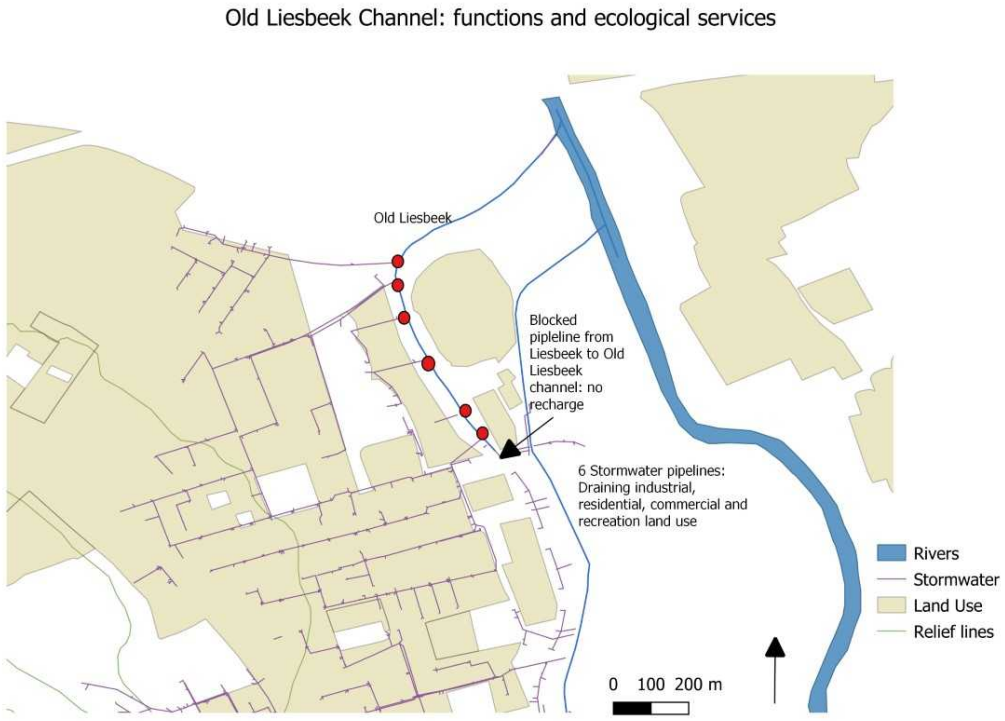

Figure 3.1: The current functions and ecological services of the old Liesbeek Channel with the stormwater pipes visible.

3.0. Design suggestions for improving water quality

As mentioned in section 2.0, increasing the ecological and recreational value of the old Liesbeek River channel must mitigate the negative impact of stormwater. To prevent litter entering the river, litter traps in form of

steel cages are installed at the pipe outlets. Those fences are meant to hold of most of the litter such as plastic bags and plastic bottles. The litter that escapes the traps will travel on the west side of the river and be diverted by a semi permeable barrier built from wooden poles. The barrier is designed to let water flow between the poles, while collecting litter at the same time (see figure 3.2). After the litter barrier on the west bank of the river a pond system can be implemented to increase the hydraulic residence time and thus increase nutrient uptake by plants. The ponds also offer breeding opportunities for birds which is further discussed in section 3.1.

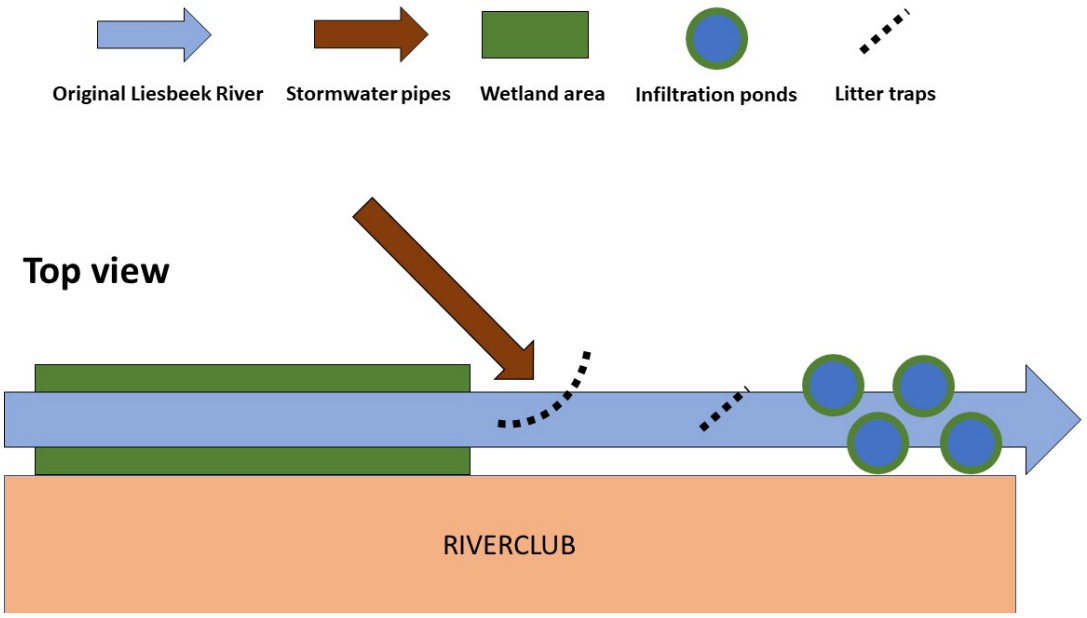

Figure 3.2: Design suggestion of the authors for the original Liesbeek River channel to improve the water quality

In the beginning of the original Liesbeek river run a series of small wetlands with suitable vegetation as proposed by Belcher and Grobler [3] will increase the water quality of the water. Terraced wetlands are used to store phosphate, nitrate and toxicants in the plants. By terracing the wetland the water gets aerated when flowing to the next wetland which also removes ammonia. Where the stormwater pipes enter the river, the terraced wetland will continue on the east bank of the river. Whereas on the left side of the river a steeper river section is meant to increase the flow velocity and thus decreasing the water head during stormwater events to prevent litter flowing in the wetland. This will reduce maintenance and protects the wetlands.

3.1. Design suggestions for improving ecology

With the developments plans proposed by the River Club, the whole ecology of the Original Liesbeek river is imperilled. The solutions focus on the flora and fauna that are endangered, the design however tries to enable benefits for the majority of the flora and fauna. Firstly, the possible solutions for the flora will be explored. After which the habitat conditions for the three previously mentioned fauna species will be specified.

3.1.0. Flora

Cape Town is located within the Cape Floresitc Region (CFR) and recognised as one of the planet's 25 most-threatened ecosystems. The region is home to 9600 plant species, of which over 70% are found nowhere else in the world. This rich biodiversity must be conserved and integrated into present and future spatial planning of the city's objectives [9]. The proposed design consist of a wetland, with a soil that is waterlogged and anaerobic. Vegetation in these wetlands need to be specially adapted to survive. Typical wetland plants include emergent plants like reeds, rushes and sedges, rooted plants with floating leaves such as waterblommetjies and floating plants that are not rooted in the mud. However, there are no indigenous plants in the latter category and many wetlands in South Africa are invaded by these alien plants, such as the water hyacinth. Restoring the indigenous vegetation is therefore one of the most important design objectives. The

following indigenous species are suitable for the Liesbeek river, both for the wetland as the non wetland area [4].

Emergent plants Suitable indigenous vegetation to plant in the region are reeds, rushes and sedges and perform a number of important functions. They assist in slowing down overland runoff and allows the rain to infiltrate in the ground and a restore the groundwater table. The roots of these plans help to bind the soil and therefore reduce the erosion on the banks. Also, this vegetation helps to intercept and trap sediment and silt from runoff from the land, ensures the cleaning of the water and regulating the flow [22].

Fynbos Fynbos is characterised by plant with small and fine leaves and the dominance of shrubs and Cape reeds. A distinction can be made between mountain and lowlands fynbos, the latter is suitable to plant in the non-wetland region: *Cape Flats Sand Fynbos* This vegetation type has the ability to drain soils easily and is therefore suitable for housing and urban areas development [6]. *Peninsula Granite Fynbos* This vegetation thrives well on gentle slopes with deep, fertile, sandy-loam soil and is well suitable for agriculture as well as urban development. It is a very popular vegetation type for recreational activities such as hiking, cycling and dog walking [7].

In order to make appropriate choices for the vegetation types, specialists need to be consulted. An example for a (livable) wetland with a high ecological value is the Edith Stephens Wetland Park, consisting of a seasonal wetland, a flood retention pond with a bird hide and an indigenous plant nursery run by Working for Wetlands. cooperation with these or similar parties is advisable.

3.1.1. Fauna

African Clawless Otter: The first a far most important criterium for the otter is a fresh water source. So much as a water pool that persist in the dry season is found to be enough [19]. Furthermore a preference for reed beds, boulders and overhanging vegetation which provides shading has been encountered [25]. The introduction of weirs does not necessarily effect the otter directly negatively, it however does inhibit their prey to swim upstream. Consequently, this will likely influence the distribution of the otter in the system [19]. On the other hand, weirs can be used to provide the otter with permanent fresh water pools. Cape Dwarf Chameleon: The chameleon needs a wide variety of vegetation including the indigenous restios reed, vegetation which provides low coverage foliage such as riparian vegetation and water ponds [30]. They can however also been prevail in gardens under the condition that there is a wide variety of vegetation. Domestic cats are the main predator of the chameleon in urban areas, the safety of urban wetlands is therefore of increased importance [30].

Western Leopard Toad: This species resides in proximity of permanent fresh water but does not need to reside there permanently. They use the non-flowing water bodies as breeding ground however [21]. Therefore the presence of such water bodies is essential for their survival. They prefer dry sandy and loamy soils with Fynbos (or Strandveld) as a habitat, but as mentioned above the Fynbos vegetation is degrading. The toads are more and more observed in suburban gardens, resting in drains and compost heaps [21]. These areas do however not provided the needed quality of habitat needed to restore the specie.

For both the chameleon and toad species the lack of migration possibilities due to roads, canalised rivers and walls cause major problems [30, 18]. The design will therefore aim to improve the mobility possibilities. Besides that the necessity of persistent water ponds has been pointed out and lastly a wide variety of vegetation such reeds and foliage providing trees has been highlighted.

A species that has not been touched upon so far is birds. The nearby Raapenberg bird sanctuary shows the high potential for birds in this area, might the Original Liesbeek river be rehabilitated.

Figure 3.3: Left: current situation. Right: proposed redesign of the original Liesbeek river course. Made by the Authors

3.2. Design suggestion managing water quantity

The increased risk of flooding of the SAAO, Valkenberg Wetland, Malta Sports Field plus anticipated increase in peak flow at the Black River due to the filling of the Original Liesbeek river can be avoided by retaining the open character of the river and possibly be mitigated by openly connecting the Liesbeek Canal with the Liesbeek River. The design, see 3.3, proposes to connect the Liesbeek canal and original Liesbeek river course with a trench (blue circle) and to widen the northern part of the Original Liesbeek River course (red rectangle). This creates an additional water buffer and discharge during storm events, following the example of the 'Room for the Rivers' project. An example is the inland levee replacement at Lent and construction of an additional trench in 2005. The effect of this intervention is a 34cm water level decrease during high water discharge events [15]. See Figure 3.4 for the infographic of the project. By moving the levee and constructing a trench not only flooding is avoided but also an island is created right in front of the historical centre of the city Nijmegen. The island and trench offer unprecedented opportunities for living, working, water sport and nature development. It has become a unique river park where people experience the dynamics of the river [15]. Figure 3.5 shows an impression of the intervention zone.

In addition, the biggest concern reported by LSDF [17] is the increased risk of flooding in the study area, which is upstream of Paarden Eiland. However, LSDF [17] also reports that it was demonstrated that upstream flooding is caused by flow constrictions at the rail bridge that crosses the Salt River Canal. It was found that the proposed development of the River Club would have minimal impact on the extent or nature of the floodplain, provided that international Best Management Practices are implemented [17]. This proposed design is likely to increase buffer capacity and contribute to the overall discharge. Therefore, positively impacting the floodplain. Still it is recommended to redesign the rail bridge or construct an additional trench around the bridge to decrease flow constrictions.

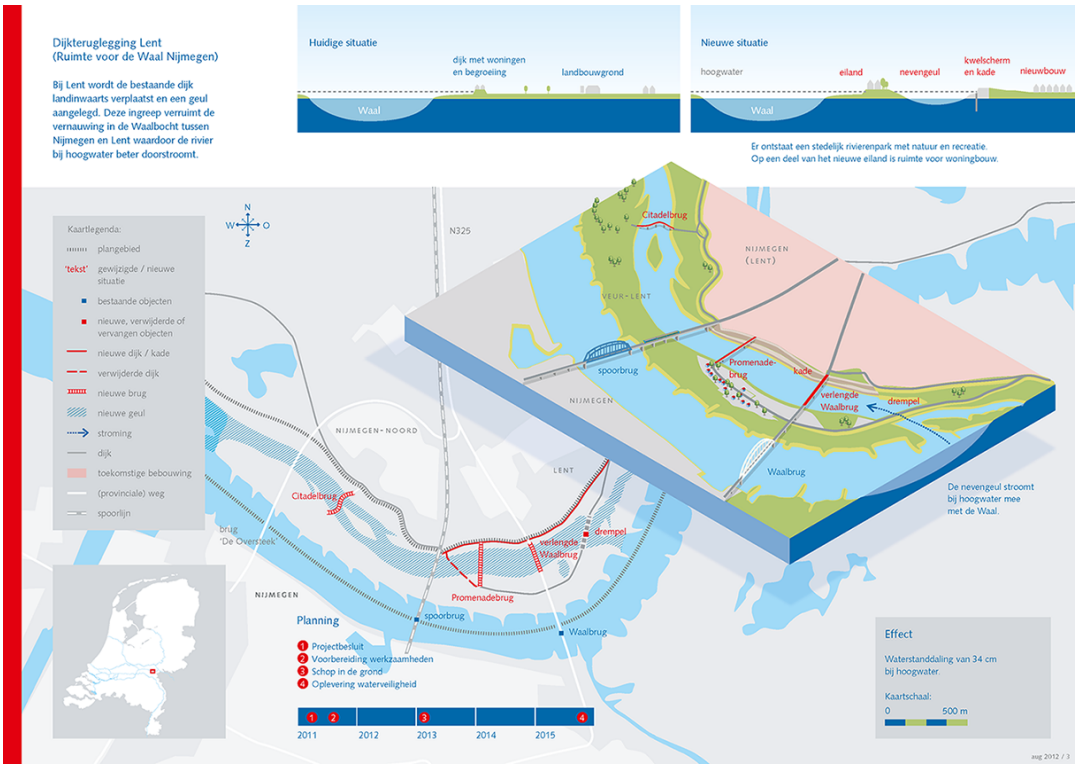

Figure 3.4: Infographic 'Room for the River' inland levee replacement at Lent [15]

Figure 3.5: Example implemented 'Room for the River' solution at Lent the Netherlands [23]

3.3. Public access

The area between Liesbeek River and the Black River quickly became an area of conflict when the first Dutch colonists settled in the Cape and claimed land for themselves. The Khoikhoi and the Dutch initially had a peaceful relationship. However, this changed when they were displaced by the Dutch and forced to move in less fertile lands [20]. The area between Liesbeek River and the Black River then became a fortified line with watchtowers which was meant to keep the Khoikhoi and San away [24]. Filling up the original Liesbeek River and the construction of fenced property would likely reduce the public access between the East and West of Capetown in the Liesbeek River area. This has a negative connotation in the historical context and could easily provoke resentment. Opening the Liesbeek River area and transforming it into a public recreational space, formed by the original Liesbeek River and the Liesbeek River channel, could positively impact the public accessibility and bring people together instead of excluding them.

3.4. Design suggestions for improving amenity value

A raised wetland boardwalk through the urban wetland has a number of benefits. Figure 3.6 displays an example of such a construction The aesthetic value of wetland boardwalks increases real estate value of the proposed residential developments. In addition, a public board walk stimulates interaction amongst visitors and allows them to get into close contact with nature. A raised path accommodates both wet and dry conditions.

Figure 3.6: Raised Boardwalk through Wetland [13]

Figure 3.7: Stepping Stones [29]

Figure 3.8: Beach [2]

Playful features such as stepping stones and small beaches can add to the recreational value of the wetland. Stepping stones can be placed throughout the wetland for children to play on. A sand patch along the side of the river can function as an urban beach. Thorough water quality tests are required before such access can be granted to the public. Alternatives to swimming include kayaking or rowing. See figures 3.7 and 3.8 above.

4

Conclusion

In this report an attempt is made to give the best possible recommendations for the design of the original Liesbeek River area, in line with the objectives of the city of Cape Town. The proposed adjustments include solutions for the water quality, quantity, ecology and amenity which all add more value to the area. In figure 4.1 a comparison is made between the developments proposed by the Riverclub and of this report , based on the three objectives.

	River club development		**Liveable wetlands**			
Objective of the city	Filling stream	Housing	Water quality	Water quantity	Ecology	Amenity
City for everyone		✓	✓			✓
Climate resilience				✓	✓	
Protect natural systems			✓		✓	

Figure 4.1: The comparison of the objectives of the city for the two designs

The advantage of the design proposed by the River Club is the expansion of residential area. However, the other two objectives are not met and the value of the Liesbeek River area for it's potential to reduced flood risk and maintaining a natural ecosystems are not included. Therefore, we suggest to create a liveable wetland area at proximity of the Original Liesbeek River. As such, the 3 objectives are included and the natural ecosystem is sustained. The litter traps and natural wetlands will improve the quality of the water and thereby also the amenity, since it will create a recreational environment. The design will increase the city's climate resilience, since the managed flow of water during a storm event prevents the risk of flooding. A more natural area results in less heat flux and stimulates the ecological services. A healthy flora and fauna protects of natural systems and contributes to an improvement in the water quality. The suggested design provides additional benefits in terms of real-estate value of the proposed residential area and creates a more healthy living environment.

Bibliography

[1] Aurecon South African (Pty). *Proposed River Club Redevelopment Investigation into the impact of the proposed redevelopment of the River Club on flooding and flood abatement in the Salt River Catchment*. March 2018.

[2] ANWB. *Beach*. [Online; accessed November 22, 2019]. URL: https://www.anwbcamping.nl/nederland/gelderland/camping-de-grote-altena.

[3] T. Belcher and D. Grobler. "Aquatic and water quality assessment: Specialist report of the Two Rivers Urban Park Development Framework, Cape Town". In: (2016).

[4] Plantet Botany. *Cape Town wetland*.

[5] City of Cape Town. *Cape Town draft water strategy*. January 2019.

[6] City of Cape Town. *Cape Town's Unique Biodiversity Endemix Ecosystems - Cape Flats Sand Fynbos*.

[7] City of Cape Town. *Cape Town's Unique Biodiversity Endemix Ecosystems- Peninsula Granite Fynbos*.

[8] City of Cape Town. *Floodplain and River Corridor Management Policy*. 27 May 2019. URL: https://www.westerncape.gov.za/assets/departments/transport-public-works/Documents/floodplain_and_river_corridor_management_policy.pdf.

[9] City of Cape Town and TDA Cape Town. *City of Cape Town state of the environment 2018 Report*. July 2018.

[10] SRK Africa Consultancy. *Appendix J: Impact Assessment*. July 2019.

[11] SRK Africa Consultancy. *Executive summary: Basic Assessment Report River Club Redevelopment, Cape Town*. July 2019.

[12] SRK Africa Consultancy. *River Club Redevelopment Pre-Application BAR*. July 2019.

[13] ConteCompany. *Wetland Boardwalk*. [Online; accessed November 22, 2019]. 2017. URL: https://contecompany.com/wp-content/uploads/2017/07/173_160811_Quequechan_River_Rail_Trail.jpg.

[14] Republic of South-Africa Department water affairs. *National Water Resource Strategy*. June 2013. URL: http://www.dwa.gov.za/documents/Other/Strategic%20Plan/NWRS2-Final-email-version.pdf.

[15] Royal Hashkoning DHV. *Ruimte voor de Waal - dijkverlegging Lent/Nijmegen*. [Online; accessed 18 November 2019]. URL: https://www.royalhaskoningdhv.com/nl-nl/nederland/projecten/ruimte-vd-waal-dijk-lent-nijmegen/945.

[16] L Kleerekoper, M Van Esch, and TB Salcedo. "How to make a city climate-proof, addressing the urban heat island effect". In: *Resources, Conservation and Recycling* 64 (2012), pp. 30–38.

[17] Two Rivers LSDF. *Draft: Two Rivers (LSDF) Local Spatial Development Framework*. October 2019.

[18] GJ Measey and KA Tolley. "Investigating the cause of the disjunct distribution of Amietophrynus pantherinus, the Endangered South African western leopard toad". In: *Conservation Genetics* 12.1 (2011), pp. 61–70.

[19] N Okes et al. "A conservation assessment of Aonyx capensis". In: (2010).

[20] South African History Online. *The Dutch and the Khoikhoi*. 2017 (accessed November 26, 2019). URL: https://www.sahistory.org.za/article/dutch-and-khoikhoi.

[21] T Rebelo et al. "Biodiversity management plan for the Western Leopard Toad Amietophrynus pantherinus". In: *Unpublished report prepared for the City of Cape Town, SANParks and the Department of Environmental Affairs and Development Planning, Cape Town* (2004).

[22] LT Richards. *A Guide to Wetland identification, delineation and wetland function*. January 2001.

[23] Dutch Central Goverment Rijksoverheid. *Eiland van Nijmegen feestelijk onthuld*. [Online; accessed 18 November 2019]. URL: http://mirt2016.mirtoverzicht.nl/mirt_overzicht_2016/mirtnieuws/eiland-van-nijmegen152016-23705-pm.aspx.

[24] L Schietecatte and T Hart. "First frontier: An assessment of the pre-colonial and proto-historical significance of the wo Rivers Urban Park site, Cape Town, Western Cape Province". In: *prepared for Atwell Associates* (2015).

[25] M J Somers and JAJ Nel. "Habitat selection by the Cape clawless otter (Aonyx capensis) in rivers in the Western Cape Province, South Africa". In: *African Journal of ecology* 42.4 (2004), pp. 298–305.

[26] Republic of South Africa. "National Water Act (Act No. 36 of 1998)". In: *Government Gazette* 19182 (1998).

[27] A Spath. *A Fun Run along the Lieesbeek River*. [Online; accessed 18 November 2019]. URL: http://www.thewatershedproject.co.za/a-fun-run-along-the-lieesbeek-river/.

[28] T Steenkamp. "Summary of environmental structuring elements, Two Rivers Urban Park". In: (2018).

[29] *Stepping Stones*. [Online; accessed November 22, 2019]. 2015. URL: https://christchurchwalks.wordpress.com/walks/avon-river/lincoln-wetlands/lincoln-wetlands-stepping-stones/.

[30] KA Tolley et al. "Chameleons on the move: survival and movement of the Cape dwarf chameleon, Bradypodion pumilum, within a fragmented urban habitat". In: *African Zoology* 45.1 (2010), pp. 99–106.